PHYSIOLOGY

FACULTY OF PHARMACEUTICAL SCIENCES

DR. AMJAAD ZUHIER ALROSAN

LECTURE 15: GASTROINTESTINAL SYSTEM

Objectives

1. Discuss **the digestive system.**

2. Describe **neural innervation of the GI tract.**

3. Explore **gastrointestinal motility, chewing and swallowing.**

(Pages 886- 901 of the reference)

THE DIGESTIVE SYSTEM

from mouth to anus

three ??

The digestive system contributes to homeostasis by **breaking down food** into forms that can be **absorbed** and used by body cells. It also absorbs water, vitamins, and minerals, and it **eliminates** wastes from the body.

lipid → fatty acid, protein → amino acid, carbohydrate → monosaccharide

starch (polysaccharide) → disaccharide → monosaccharide

- The food we eat consists of molecules that are too large to be used by body cells. Therefore, **foods must be broken down into molecules that are small enough to enter body cells, a process known as digestion.** (main function of digestive system)

all organ between mouth and anus is the organ of digestive system

- **It extends from the mouth to the anus, forms an extensive surface area in contact with the external environment,** and **is closely associated with the cardiovascular system.** 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.**

the structure divide into two main group:-

main organ

الحركي

Organs of the gastrointestinal tract include the mouth, most of the pharynx, esophagus, stomach, small intestine, and large intestine.

ingestion

the parts of pharynx between respiratory and digestive

THE DIGESTIVE SYSTEM

- The accessory digestive organs include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

→ accessory organ in mouth

→ then esophagus (main), stomach (main)

→ three accessory digestive organ between stomach and small intestine

FUNCTIONS OF THE DIGESTIVE SYSTEM → to maintain homeostases

→ the first function to maintain homeostases balance

1. Ingestion: taking food into mouth.
2. Secretion: release of water, acid, buffers, and enzymes into lumen of GI tract. → saliva + food + lingual lipase
3. Mixing and propulsion: churning and movement of food through GI tract. → esophagus

→ secretion + contraction to smooth muscle

4. Digestion: mechanical and chemical breakdown of food. → very fluid mass → in stomach → 90% digestion
5. Absorption: passage of digested products from GI tract into blood and lymph. → happen mainly in small intestine and complete in large intestine
6. Defecation: elimination of feces from GI tract. → عملية الإخراج (output) from the anus

two type of gland in mouth?
① saliva gland → saliva
② lingual gland → lingual lipase

Figure 24.2 **Layers of the gastrointestinal tract.** Variations in this basic plan may be seen in the esophagus (Figure 24.9), stomach (Figure 24.12), small intestine (Figure 24.19), and large intestine (Figure 24.24).

The four layers of the GI tract, from deep to superficial, are the mucosa, submucosa, muscularis, and serosa.

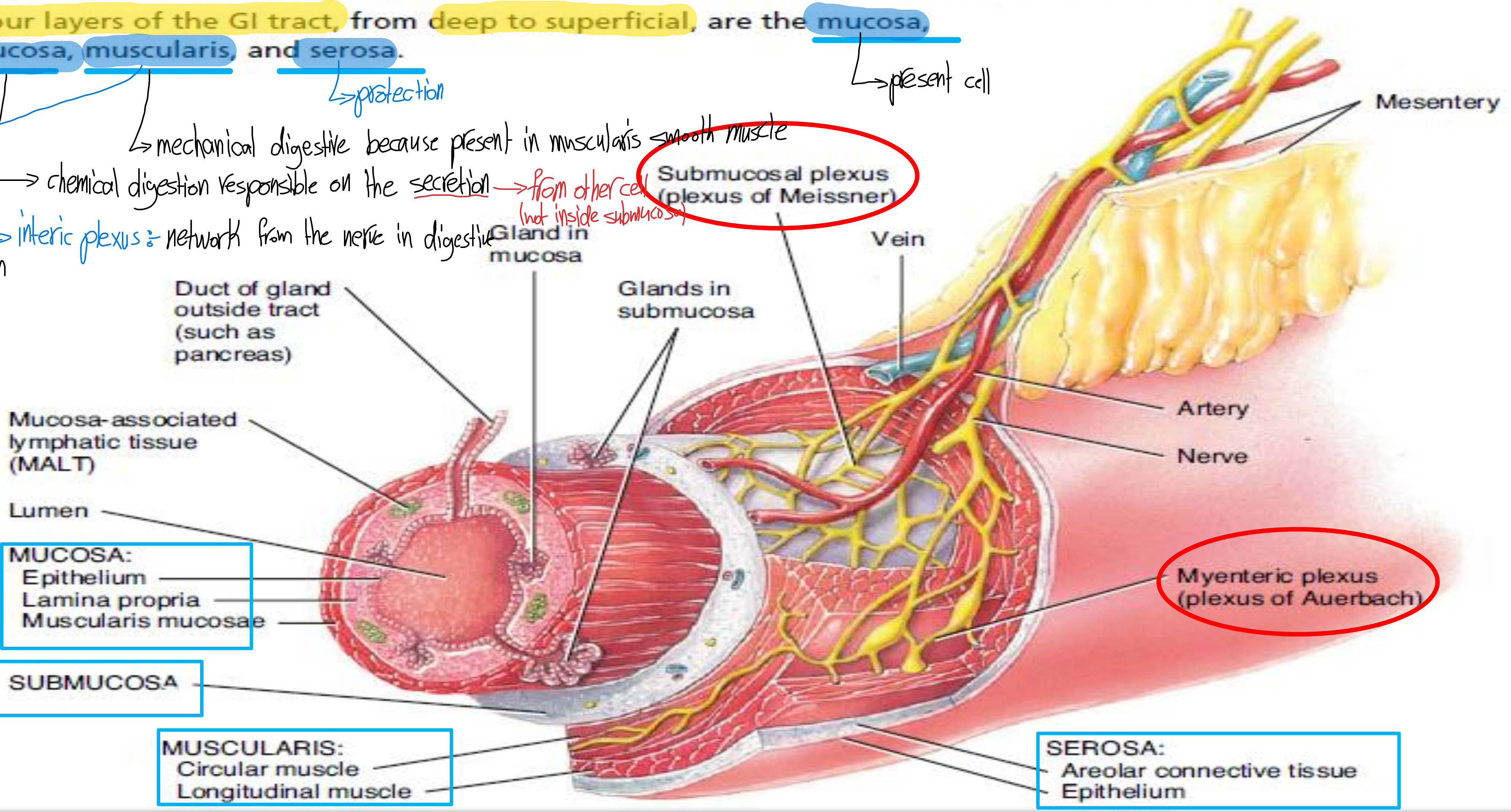
mucosa → present cell

serosa → protection

muscularis → mechanical digestive because present in muscularis smooth muscle

submucosa → chemical digestion responsible on the secretion → from other cell (not inside submucosa)

→ interic plexus : network from the nerve in digestive system



NEURAL INNERVATION OF THE GI TRACT

- The gastrointestinal tract is regulated by an intrinsic set of nerves known as the ① enteric nervous system and by an extrinsic set of nerves that are part of the ② autonomic nervous system. ~> the digestive system controled by these nervous system

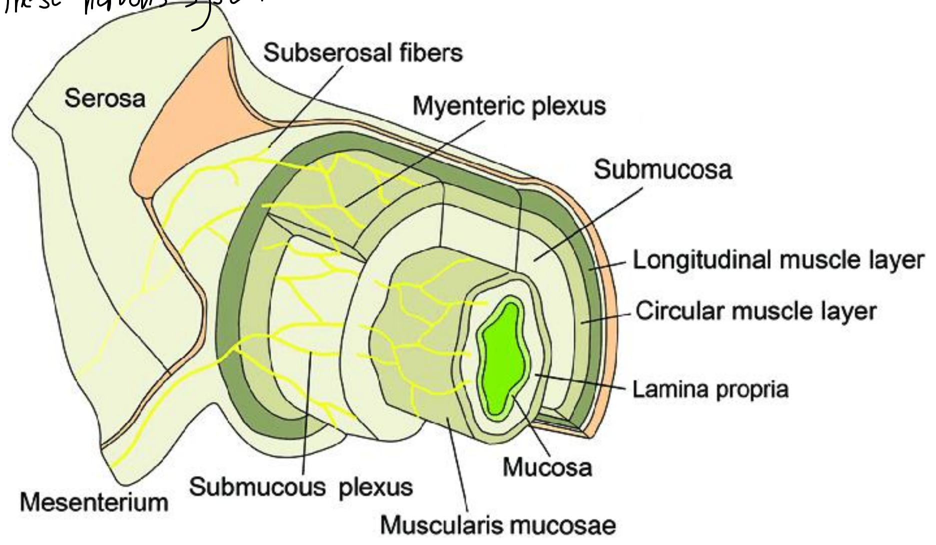
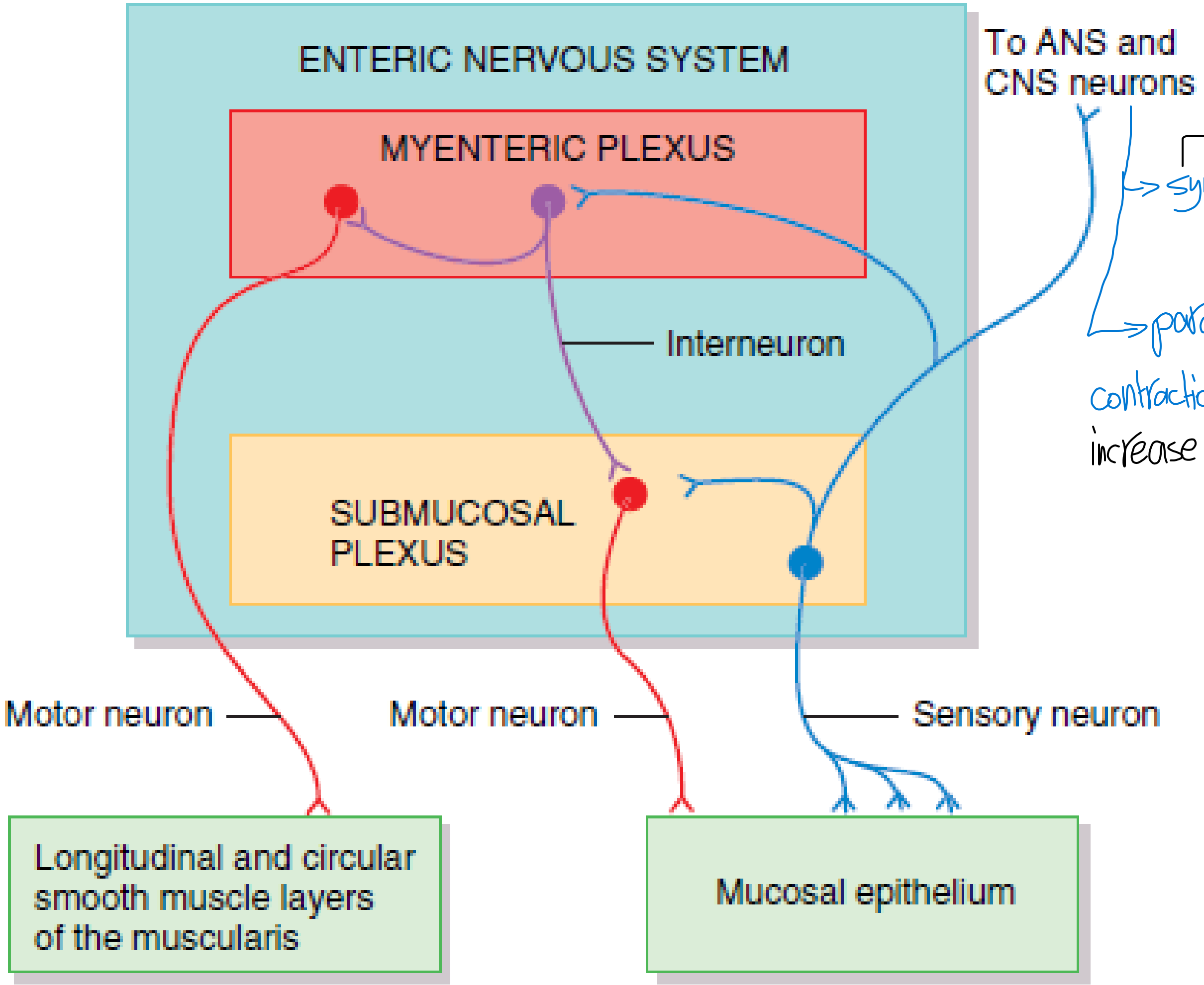


Figure 24.3 Organization of the enteric nervous system.

The enteric nervous system consists of neurons arranged into the myenteric and submucosal plexuses.



~> bind with these plexus by extrinsic nerve

→ decrease chemical and mechanical break down

↳ sympathatic affect → decrease secretion and contraction to GI system.

↳ parasympathatic affect → increase secretion and contraction to GI system = increase digestion because increase from chemical and mechanical break down

ENTERIC NERVOUS SYSTEM

enteric plexus (group of neurons): trans information by sensory receptor → sensory neurons → inter neuron in brain → motor neurons (to response)

the motor neurons

- **The neurons of the ENS are arranged into two plexuses: the myenteric plexus and submucosal plexus.**

in submucosa layer (GI secretion) to make the bolus → part of fluidity

in muscularis layer (GI contraction)

The myenteric plexus is located between the longitudinal and circular smooth muscle layers of the muscularis.

The submucosal plexus is found within the submucosa.

- **The plexuses of the ENS consist of motor neurons, interneurons, and sensory neurons.**

chemoreceptor → submucosal plexus (secretion) → chemical break down

mechanoreceptor → myentric plexus (contraction) → mechanical break down

ENTERIC NERVOUS SYSTEM

- Because the motor neurons of the myenteric plexus supply the longitudinal and circular smooth muscle layers of the muscularis, this plexus mostly controls GI tract motility (movement), particularly the frequency and strength of contraction of the muscularis.

controlling contraction and relaxation to smooth muscle in muscularis layer (responsible on the movement)

- The motor neurons of the submucosal plexus supply the secretory cells of the mucosal epithelium, controlling the secretions of the organs of the GI tract.

→ secretion (submucosal plexus)

- The interneurons of the ENS interconnect the neurons of the myenteric and submucosal plexuses. The wall of the GI tract contains two major types of sensory receptors: (1) chemoreceptors, which respond to certain chemicals in the food present in the lumen, and (2) mechanoreceptors, such as stretch receptors, that are activated when food distends (stretches) the wall of a GI organ.

→ example on mechanoreceptor

→ contraction or relaxation by myenteric plexus

AUTONOMIC NERVOUS SYSTEM

- ✓ Although the neurons of the ENS can function independently, they are subject to regulation by the neurons of the autonomic nervous system.
- ✓ **The vagus (X) nerves supply parasympathetic fibers to most parts of the GI tract, with the exception of the last half of the large intestine, which is supplied with parasympathetic fibers from the sacral spinal cord.**
- ✓ The parasympathetic nerves that supply the GI tract form neural connections with the ENS.

AUTONOMIC NERVOUS SYSTEM

- **In general, stimulation of the parasympathetic nerves that innervate the GI tract causes an increase in GI secretion and motility by increasing the activity of ENS neurons.**

  movement

  enteric nervous system

- **In general, the sympathetic nerves that supply the GI tract cause a decrease in GI secretion and motility by inhibiting the neurons of the ENS. Emotions such as anger, fear, and anxiety may slow digestion because they stimulate the sympathetic nerves that supply the GI tract.**

  decrease activation of entric nervous system

MOUTH

two type of gland

salivary gland

saliva

salivary amylase

break down the carbohydrate to saccharide

first nutrient start the break down from the mouth to monosaccharide

lingual gland

lingual lipase

break down the lipids

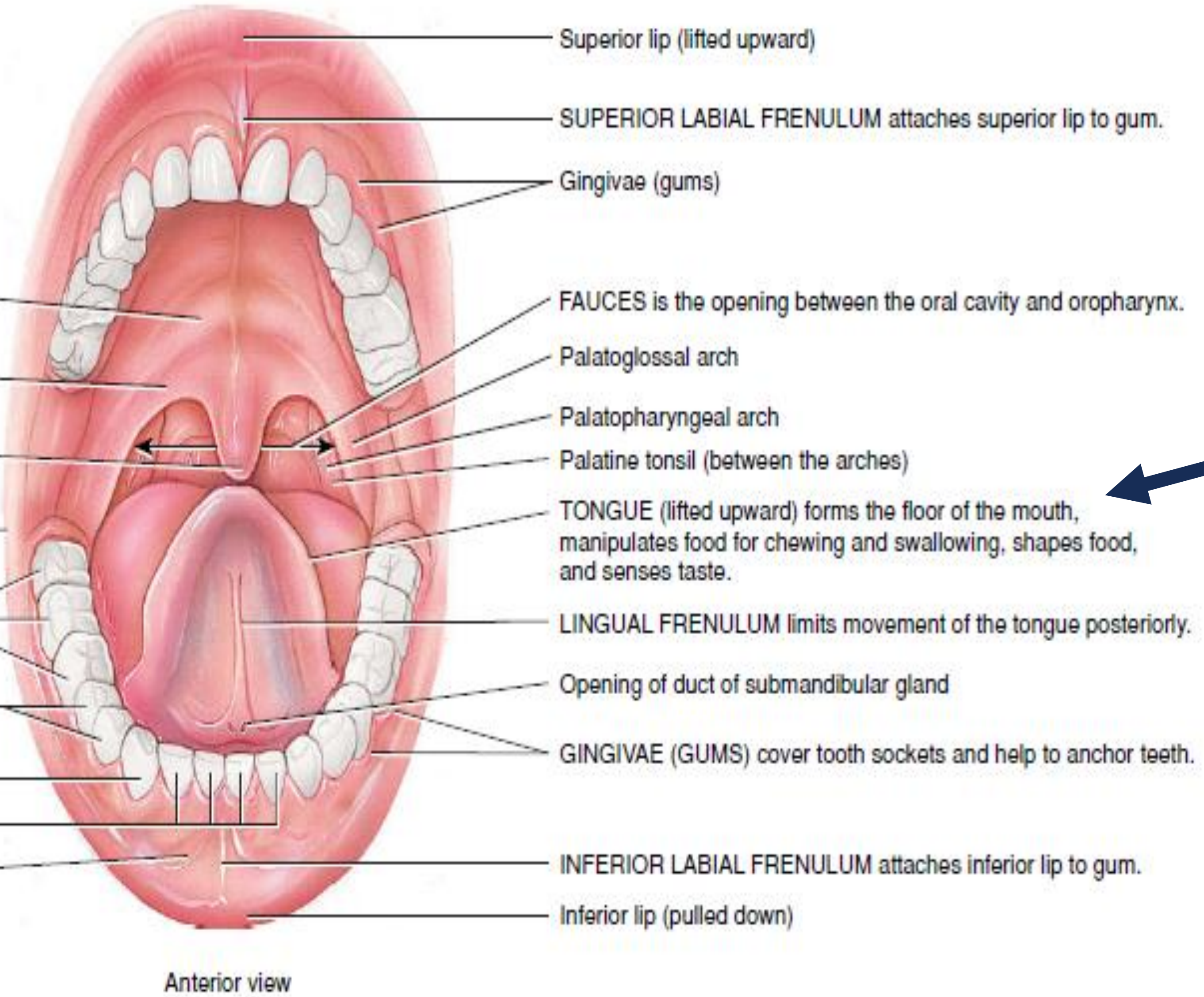


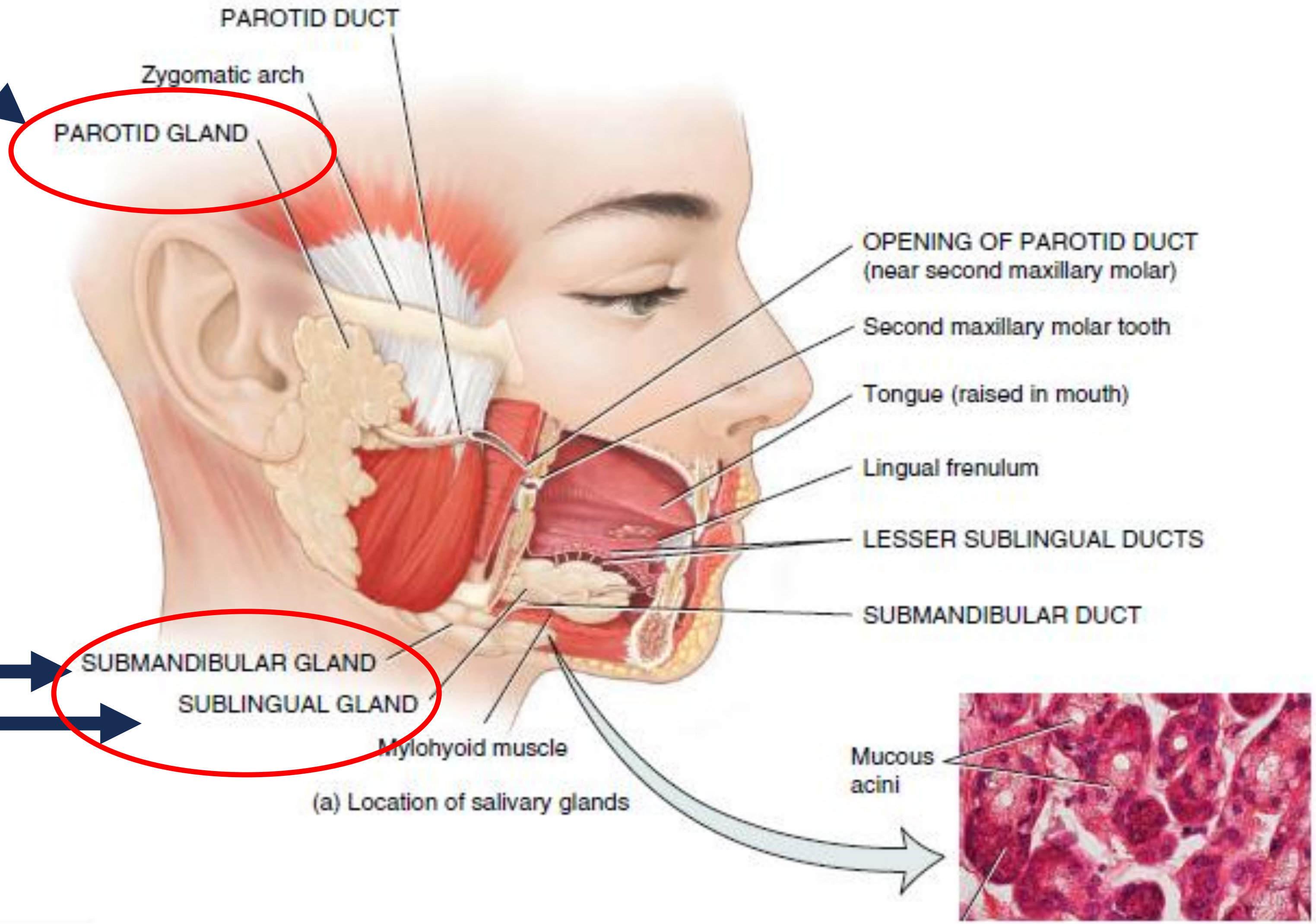
Figure 24.5 Structures of the mouth (oral cavity).

The mouth is formed by the cheeks, hard and soft palates, and tongue.

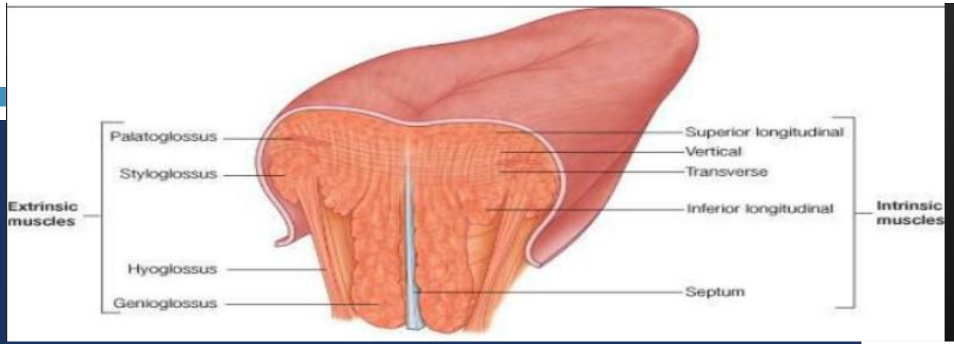
⇒ the differ between salivary amylase and lingual lipase? two is break down but lingual lipase become active in stomach and break down the lipid in stomach (more acidic media, ph is low)

Figure 24.6 The three major salivary glands—parotid, sublingual, and submandibular. The submandibular glands, shown in the light micrograph (b), consist mostly of serous acini (serous fluid–secreting portions of gland) and a few mucous acini (mucus-secreting portions of gland); the parotid glands consist of serous acini only; and the sublingual glands consist of mostly mucous acini and a few serous acini.

- Saliva lubricates and dissolves foods and begins the chemical breakdown of carbohydrates and lipids.

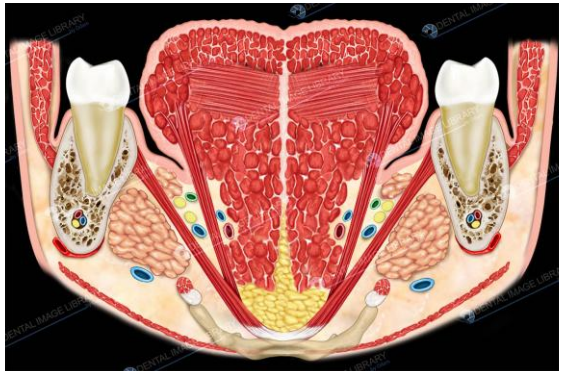


(a) Location of salivary glands



TONGUE

- **The tongue is an accessory digestive organ composed of skeletal muscle covered with mucous membrane.**
- **Together with its associated muscles, it forms the floor of the oral cavity.**
- **The extrinsic muscles of the tongue**, which originate outside the tongue (attach to bones in the area) and insert into connective tissues in the tongue. two type of muscle in the tunge?



- **The extrinsic muscles** move the tongue from side to side and in and out to maneuver food for chewing, shape the food into a rounded mass, and force the food to the back of the mouth for swallowing. They also form the floor of the mouth and hold the tongue in position.

→ orginate outside the tunge and insert inside the tunge contribute to change the shape of tunge and swallowing process

- **The intrinsic muscles** of the tongue originate in and insert into connective tissue within the tongue. They alter the shape and size of the tongue for speech and swallowing.

→ orginate and insert inside tunge and contribute in speech and swallowing

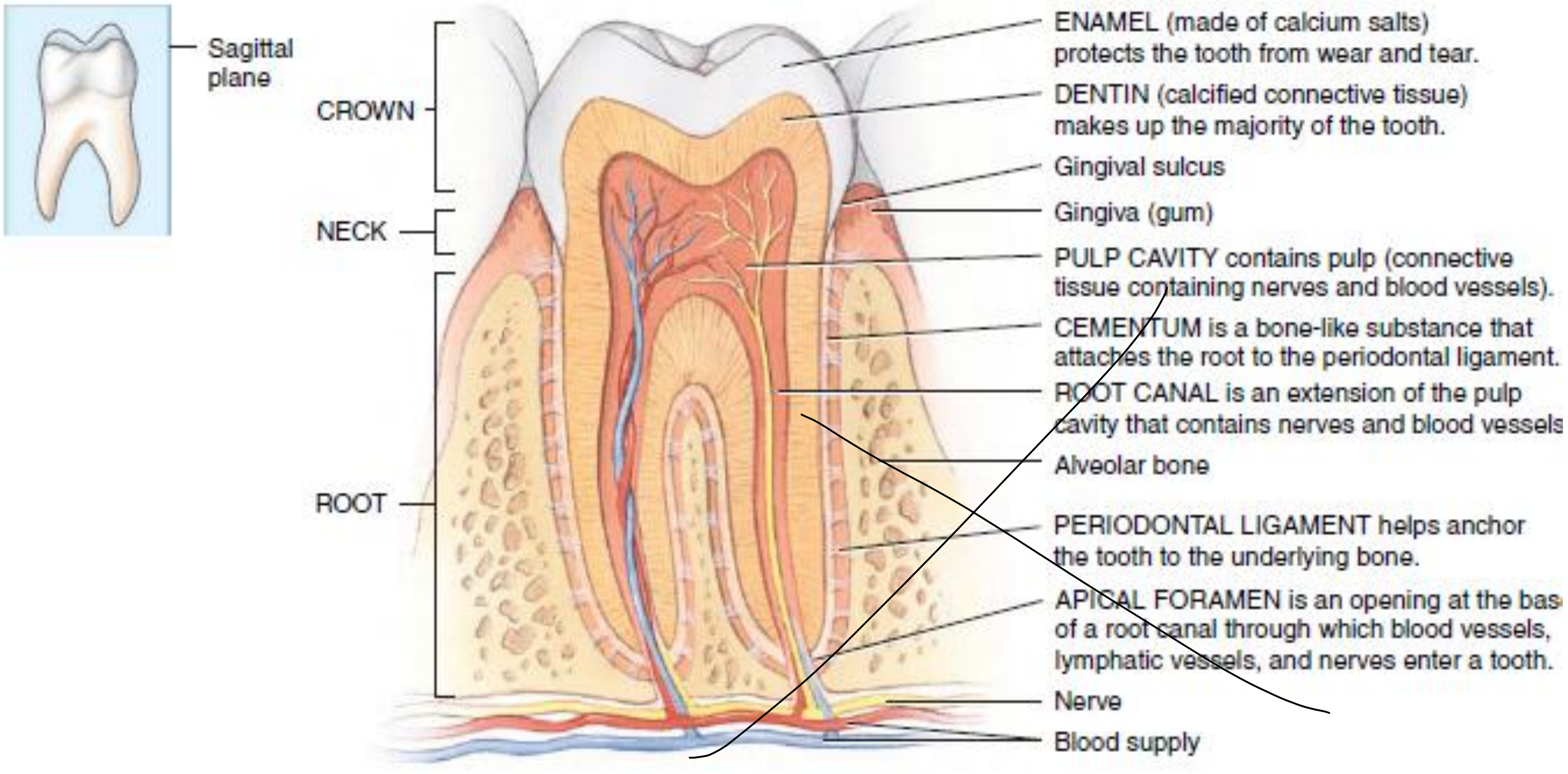
the intrinsic and extrinsic muscle contribute in swallowing

TEETH

- A typical tooth has three major external regions: the crown, root, and neck.

Figure 24.7 A typical tooth and surrounding structures.

Teeth are anchored in sockets of the alveolar processes of the mandible and maxillae.



Sagittal section of a mandibular (lower) molar

MECHANICAL AND CHEMICAL DIGESTION IN THE MOUTH

عبارة عن حركة

- Mechanical digestion in the mouth results from chewing, or mastication, in which food is manipulated by the tongue, ground by the teeth, and mixed with saliva.

  ↳ mechanich break down

  - As a result, the food is reduced to a soft, flexible, easily swallowed mass called a bolus.

  saliva amylase

  - Food molecules begin to dissolve in the water in saliva, an important activity because enzymes can react with food molecules in a liquid medium only.

Function:-

- Two enzymes, salivary amylase and lingual lipase, contribute to chemical digestion in the mouth.
- Salivary amylase, which is secreted by the salivary glands, initiates the breakdown of starch. Dietary carbohydrates are either monosaccharide and disaccharide sugars or complex polysaccharides such as starches. Most of the carbohydrates we eat are starches, but only monosaccharides can be absorbed into the bloodstream. Thus, ingested disaccharides and starches must be broken down into monosaccharides.

MECHANICAL AND CHEMICAL DIGESTION IN THE MOUTH

triglyceride → diglyceride → fatty acid

- Saliva also contains **lingual lipase**, which is secreted by lingual glands in the tongue. **This enzyme becomes activated in the acidic environment of the stomach and thus starts to work after food is swallowed. It breaks down dietary triglycerides (fats and oils) into fatty acids and diglycerides. A diglyceride consists of a glycerol molecule that is attached to two fatty acids.**

→ glycerol molecule with two fatty acid

TABLE 24.1

Summary of Digestive Activities in the Mouth

STRUCTURE	ACTIVITY	RESULT
Cheeks and lips	Keep food between teeth.	Foods uniformly chewed during mastication.
Salivary glands	Secrete saliva.	Lining of mouth and pharynx moistened and lubricated. Saliva softens, moistens, and dissolves food and cleanses mouth and teeth. Salivary amylase splits starch into smaller fragments (maltose, maltotriose, and α-dextrins).
Tongue		
Extrinsic tongue muscles	Move tongue from side to side and in and out.	Food maneuvered for mastication, shaped into bolus, and maneuvered for swallowing.
Intrinsic tongue muscles	Alter shape of tongue.	Swallowing and speech.
Taste buds	Serve as receptors for gustation (taste) and presence of food in mouth.	Secretion of saliva stimulated by nerve impulses from taste buds to salivatory nuclei in brain stem to salivary glands.
Lingual glands	Secrete lingual lipase.	Triglycerides broken down into fatty acids and diglycerides.
Teeth	Cut, tear, and pulverize food.	Solid foods reduced to smaller particles for swallowing.

PHARYNX

- When food is first swallowed, it passes from the mouth into the pharynx, a funnel-shaped tube that extends from the (internal nares to the esophagus posteriorly and to the larynx anteriorly.)

- The pharynx is composed of skeletal muscle and lined by mucous membrane, and is divided into three parts: the nasopharynx, the oropharynx, and the laryngopharynx.

- The nasopharynx functions only in respiration, but both the oropharynx and laryngopharynx have digestive as well as respiratory functions.

help proper (pushes) into esophagus (passage way)

- Swallowed food passes from the mouth into the oropharynx and laryngopharynx; the muscular contractions of these areas help propel food into the esophagus and then into the stomach.

ESOPHAGUS

function of esophagus?

- The esophagus ① secretes mucus and ② transports food into the stomach. It does not produce digestive enzymes, and it does not carry on absorption. ~> Just passage way

Figure 24.9 Histology of the esophagus. A higher-magnification view of nonkeratinized stratified squamous epithelium is shown in Table 4.1F.

The esophagus secretes mucus and transports food to the stomach.

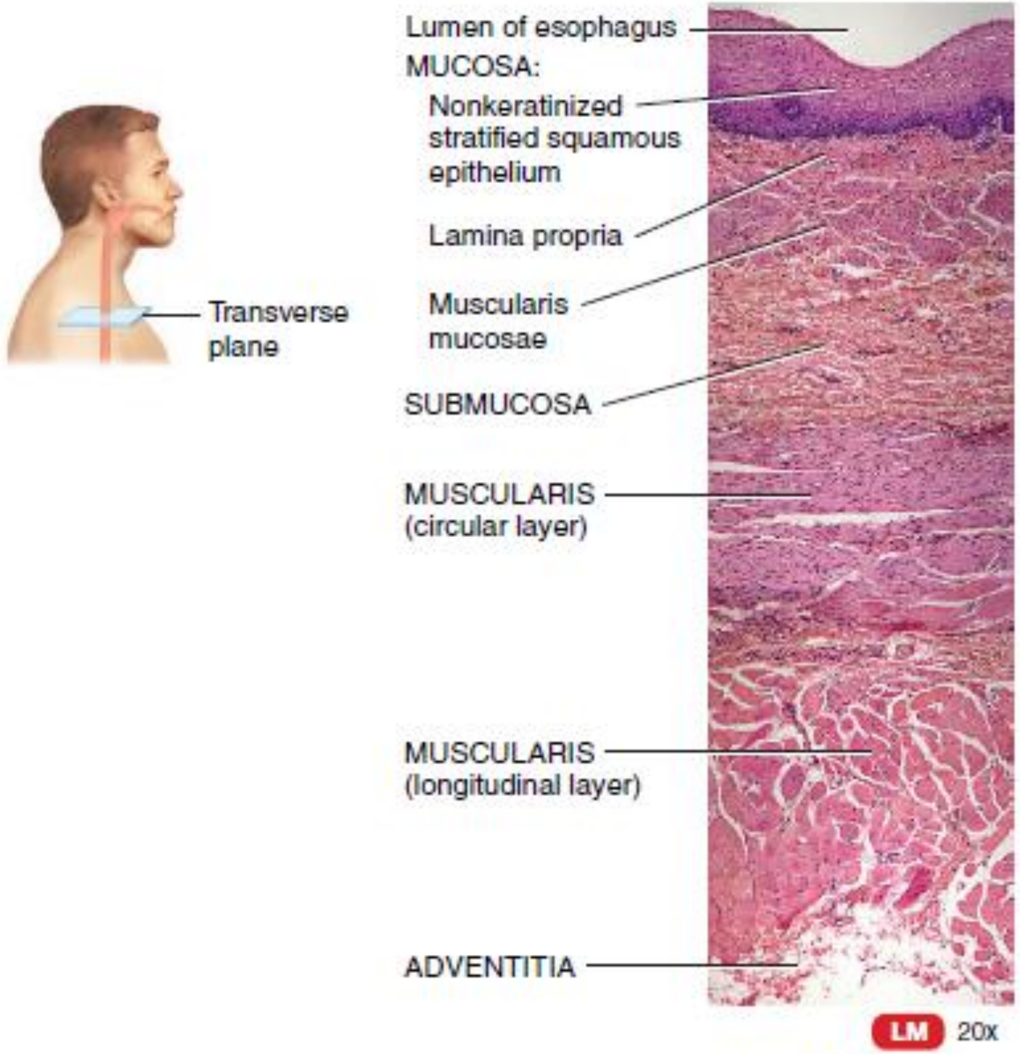
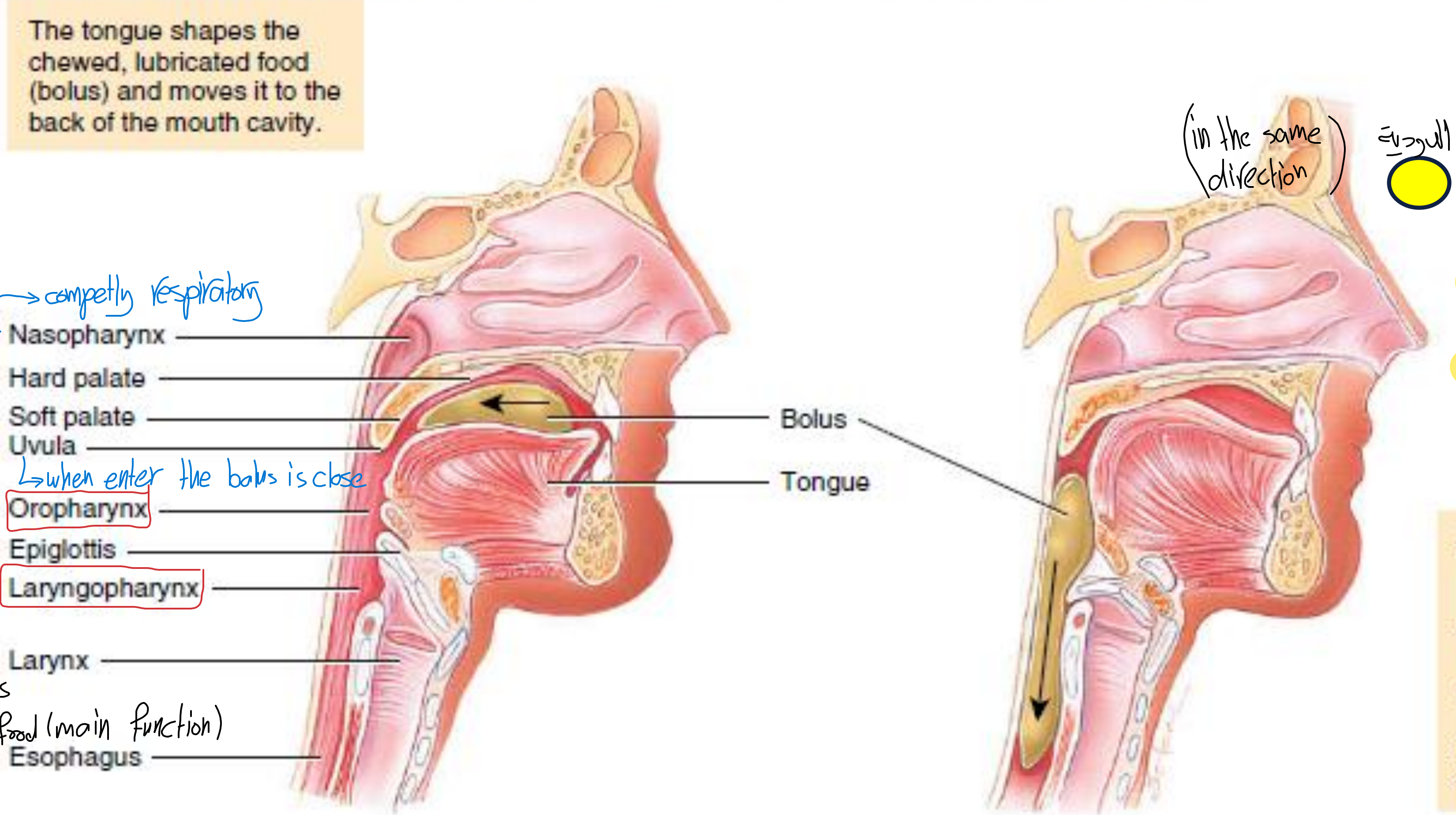


Figure 24.10 **Deglutition (swallowing).** During the pharyngeal stage (b) the tongue rises against the palate, the nasopharynx is closed off, the larynx rises, the epiglottis seals off the larynx, and the bolus is passed into the esophagus. During the esophageal stage (c), food moves through the esophagus into the stomach via peristalsis.

Deglutition is a mechanism that moves food from the mouth into the stomach.



(a) Position of structures during voluntary stage

(b) Pharyngeal stage of swallowing

الحركة الدودية

(mouth, esophagus, stomach, small and large intestine)

Peristalsis, a progression of coordinated contractions and relaxations of the circular and longitudinal layers of the muscularis, pushes the bolus onward.

↳ same direction (باتجاه واحد)

- The tongue rises against the palate and closes the nasopharynx.
- The uvula and palate seal off the nasal cavity.
- The epiglottis covers the larynx.

Breathing is temporarily interrupted.

TABLE 24.2

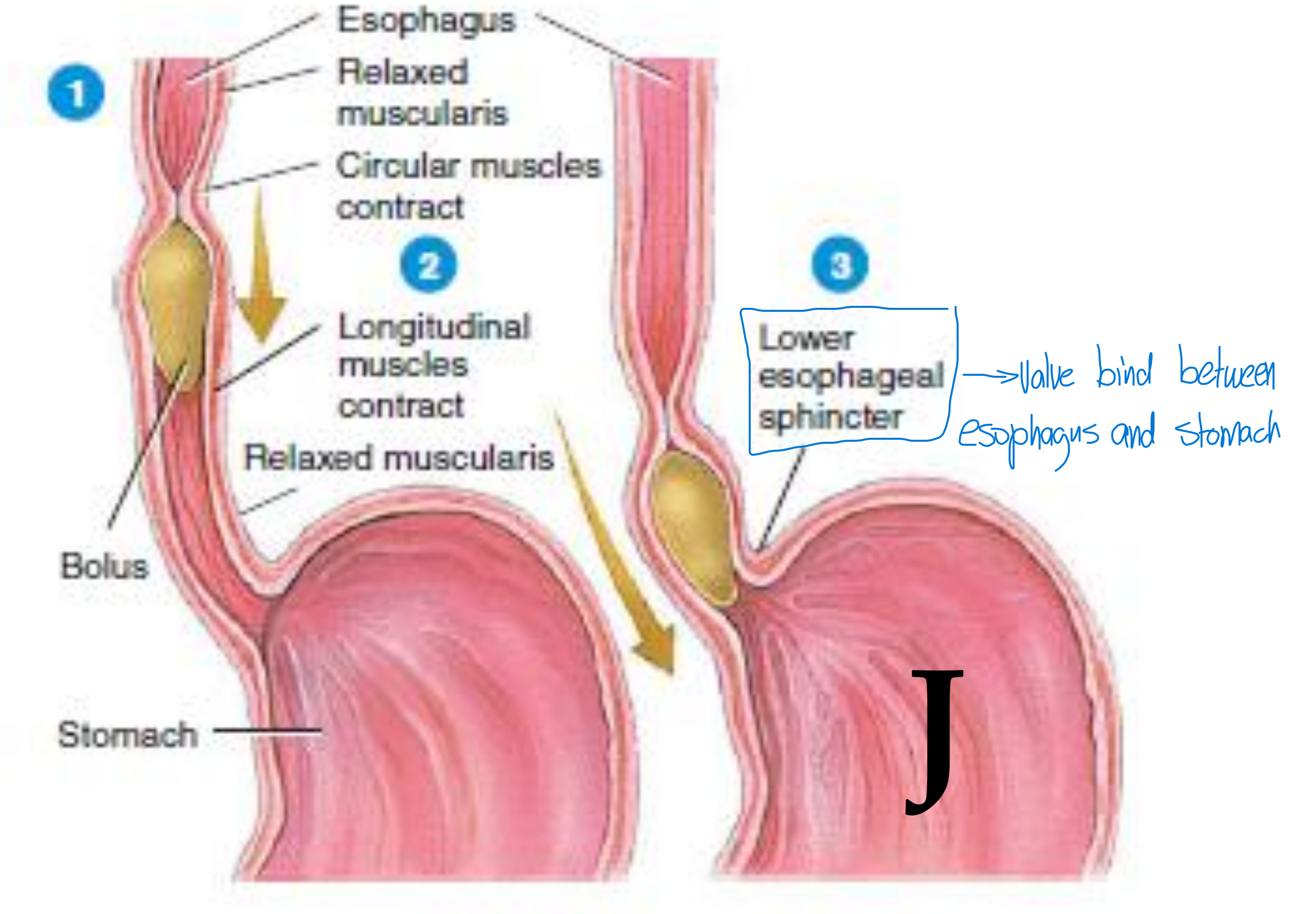
Summary of Digestive Activities in the Pharynx and Esophagus

STRUCTURE	ACTIVITY	RESULT
Pharynx	Pharyngeal stage of deglutition.	Moves bolus from oropharynx to laryngopharynx and into esophagus; closes air passageways.
Esophagus	Relaxation of upper esophageal sphincter.	Permits entry of bolus from laryngopharynx into esophagus.
	Esophageal stage of deglutition (peristalsis).	Pushes bolus down esophagus.
	Relaxation of lower esophageal sphincter.	Permits entry of bolus into stomach.
	Secretion of mucus.	Lubricates esophagus for smooth passage of bolus.

STOMACH

The stomach is a J-shaped enlargement of the GI tract directly inferior to the diaphragm in the abdomen. The stomach connects the esophagus to the duodenum, the first part of the small intestine.

first part of the small intestine



(c) Esophageal stage of swallowing

STOMACH

Because **a meal can be eaten much more quickly than the intestines can digest and absorb it**, one of the functions of the stomach is to serve as a mixing chamber and holding reservoir. خزان مؤقت حل

- At appropriate intervals after food is ingested, the stomach forces a small quantity of material into the first portion of the small intestine.
  dudenum
- **The position and size of the stomach vary continually**; the diaphragm pushes it inferiorly with each inhalation and pulls it superiorly with each exhalation. Empty, it is about the size of a large sausage, but it is the most distensible part of the GI tract and can accommodate a large quantity of food.
  سحب تقانق تمدداً

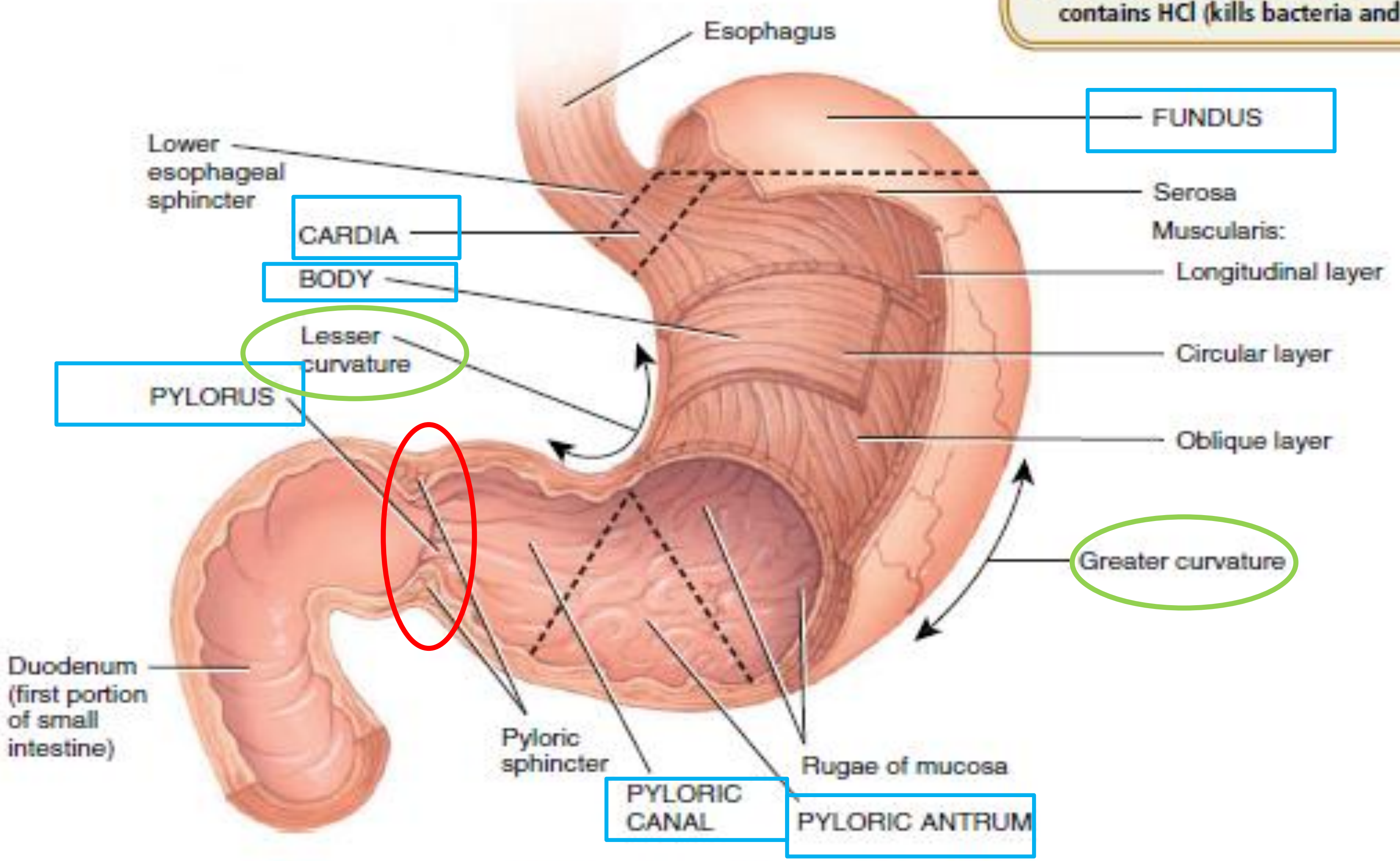
In the stomach, digestion of starch and triglycerides continues, digestion of proteins begins, the semisolid bolus is converted to a liquid, and certain substances are absorbed.
such as b12

Figure 24.11 **External and internal anatomy of the stomach.**

The four regions of the stomach are the cardia, fundus, body, and pyloric part.

FUNCTIONS OF THE STOMACH → important

1. Mixes saliva, food, and gastric juice to form chyme.
2. Serves as reservoir for food before release into small intestine.
3. Secretes gastric juice, which contains HCl (kills bacteria and denatures proteins), pepsin (begins the digestion of proteins), intrinsic factor (aids absorption of vitamin B_{12}), and gastric lipase (aids digestion of triglycerides).
4. Secretes gastrin into blood.



(a) Anterior view of regions of stomach

The pylorus communicates with the duodenum of the small intestine via a smooth muscle sphincter called the pyloric sphincter.

The concave medial border of the stomach is called the lesser curvature; the convex lateral border is called the greater curvature.

STOMACH

- The stomach wall is composed of the same basic layers as the rest of the GI tract, with certain modifications. The surface of the mucosa is a layer of simple columnar epithelial cells called surface mucous cells. → secretion mucous (basic) and mucous neck cell

⟹ degradation to carbohydrate in mouth by saliva amylase → degradation to lipid by active lingual lipase in stomach → degradation to protein by pepsin in stomach

- **Parietal cells** produce intrinsic factor (needed for absorption of vitamin B12) and hydrochloric acid. → (HCl)

↳ absorption vitamine b12

↳ the first part become absorption (small amount) in stomach by intrensic factor that produce by parietal cell

⟹ G-cell :- produce gastrin that make control of HCl level

- The **chief cells** secrete pepsinogen and gastric lipase. . → three lipase responsible to break down the lipid?

↳ inactive form of pepsin
↳ in acidic media become active (pepsin) → break down protein

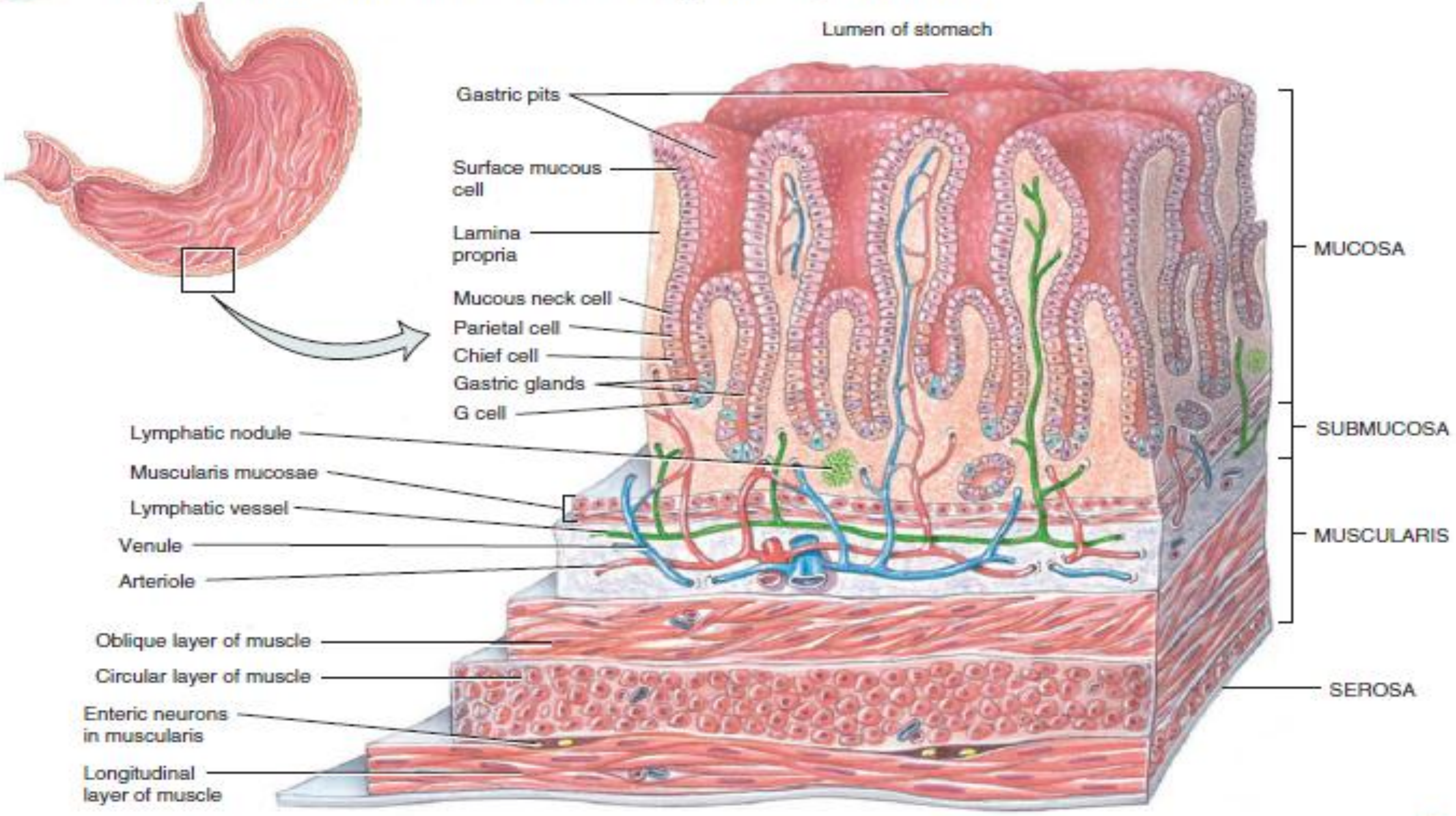
① lingual lipase in the tunge ② gastric lipase in stomach ③ pancreatic lipase in pancreas

- The secretions of the mucous, parietal, and chief cells form **gastric juice**, which totals 2000–3000 mL per day.

↳ secretion of chief cell, parietal cell and mucous cell

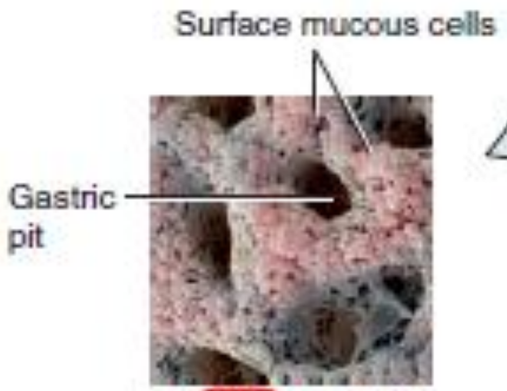
Figure 24.12 **Histology of the stomach.**

Gastric juice is the combined secretions of mucous cells, parietal cells, and chief cells.

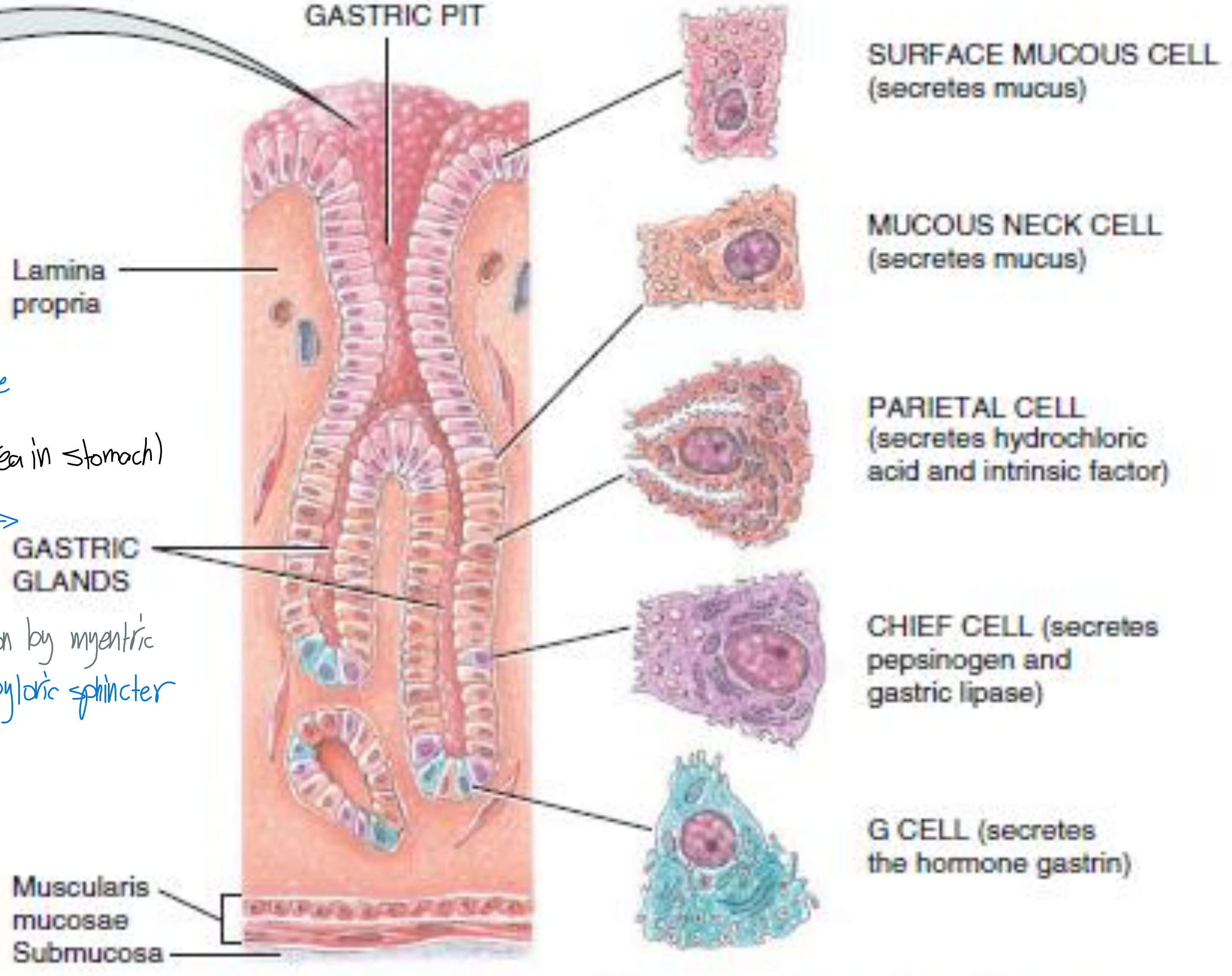


(a) Three-dimensional view of layers of stomach

FIGURE 24.12 CONTINUES



SEM about 40x
Stomach mucosa



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

⇒ pressure on the lower esophageal sphincter → enter the food in stomach (إذا ما رجع للوحة، يرجع أكثر) → cardia (the first area in stomach) → fundus (storage area) (remain in these area some time → body (when secretion become aviable from submucosal plexus) mixing the food with these secretion then will happen contraction by myentric plexus and begun digestion processes → pyloric canal → pyloric sphincter (opening between stomach and small intestine)

MECHANICAL AND CHEMICAL DIGESTION IN THE STOMACH

- ✓ Several minutes after food enters the stomach, waves of peristalsis pass over the stomach every 15 to 25 seconds.
- ✓ Few peristaltic waves are observed in the fundus, which primarily has a storage function.
- ✓ Instead, most waves begin at the body of the stomach and intensify as they reach the antrum.
- ✓ Each peristaltic wave moves gastric contents from the body of the stomach down into the antrum, a process known as propulsion.
- ✓ The pyloric sphincter normally remains almost, but not completely, closed. Because most food particles in the stomach initially are too large to fit through the narrow pyloric sphincter, they are forced back into the body of the stomach, a process referred to as retropulsion.

MECHANICAL AND CHEMICAL DIGESTION IN THE STOMACH

type of the movement in stomach

- **Another round of propulsion then occurs, moving the food particles back down into the antrum. If the food particles are still too large to pass through the pyloric sphincter, retropulsion occurs again as the particles are squeezed back into the body of the stomach. Then yet another round of propulsion occurs, and the cycle continues to repeat.** the movement of the large particle from food to back to the body in the stomach

- **The net result of these movements is that gastric contents are mixed with gastric juice, eventually becoming reduced to a soupy liquid called chyme. Once the food particles in chyme are small enough, they can pass through the pyloric sphincter, a phenomenon known as gastric emptying.** Gastric emptying is a slow process: only about 3 mL of chyme moves through the pyloric sphincter at a time. the amount of food that exit from stomach via pyloric sphinctor to small intestine

MECHANICAL AND CHEMICAL DIGESTION IN THE STOMACH

Foods may remain in the fundus for about an hour without becoming mixed with gastric juice. During this time, digestion by salivary amylase from the salivary glands continues. Soon, however, the churning action mixes chyme with acidic gastric juice, inactivating salivary amylase and activating lingual lipase.

in acidic inviroment become inactive and lingual lipase become active

Figure 24.13 Secretion of HCl (hydrochloric acid) by parietal cells in the stomach.

Proton pumps, powered by ATP, secrete the H^+; Cl^- diffuses into the stomach lumen through Cl^- channels.

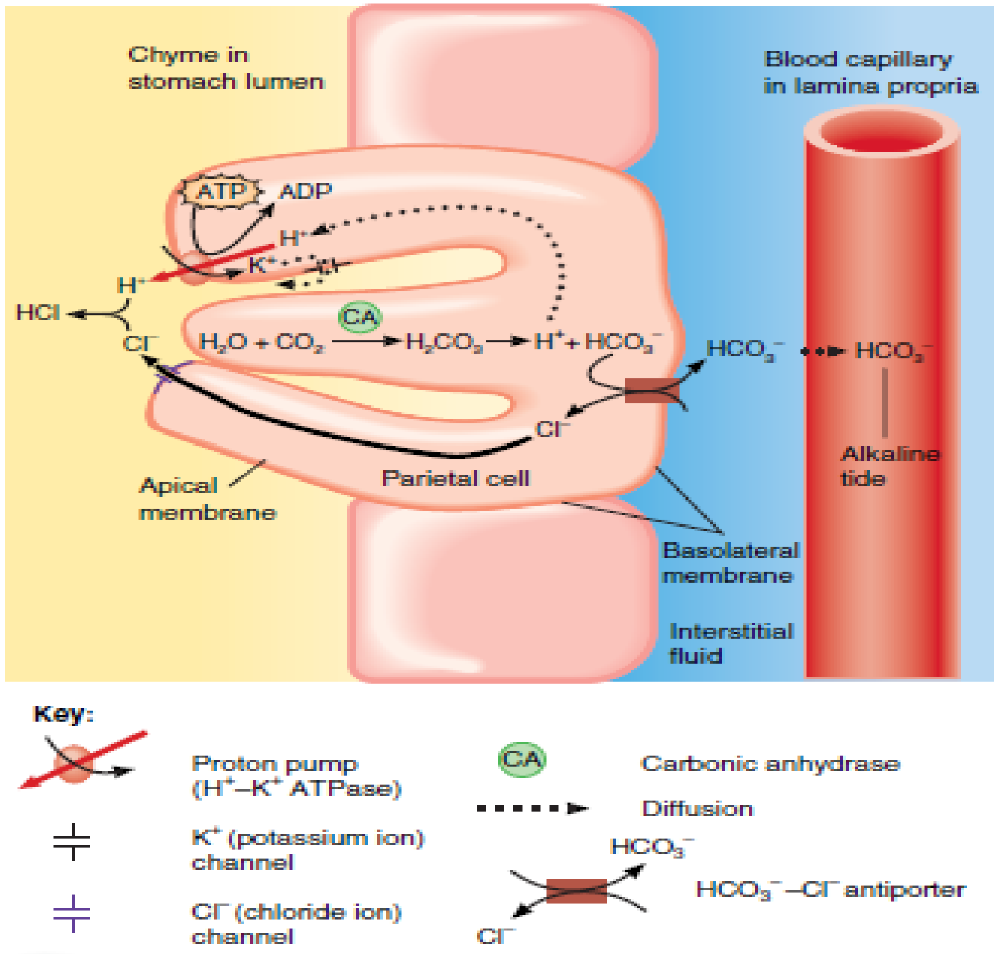
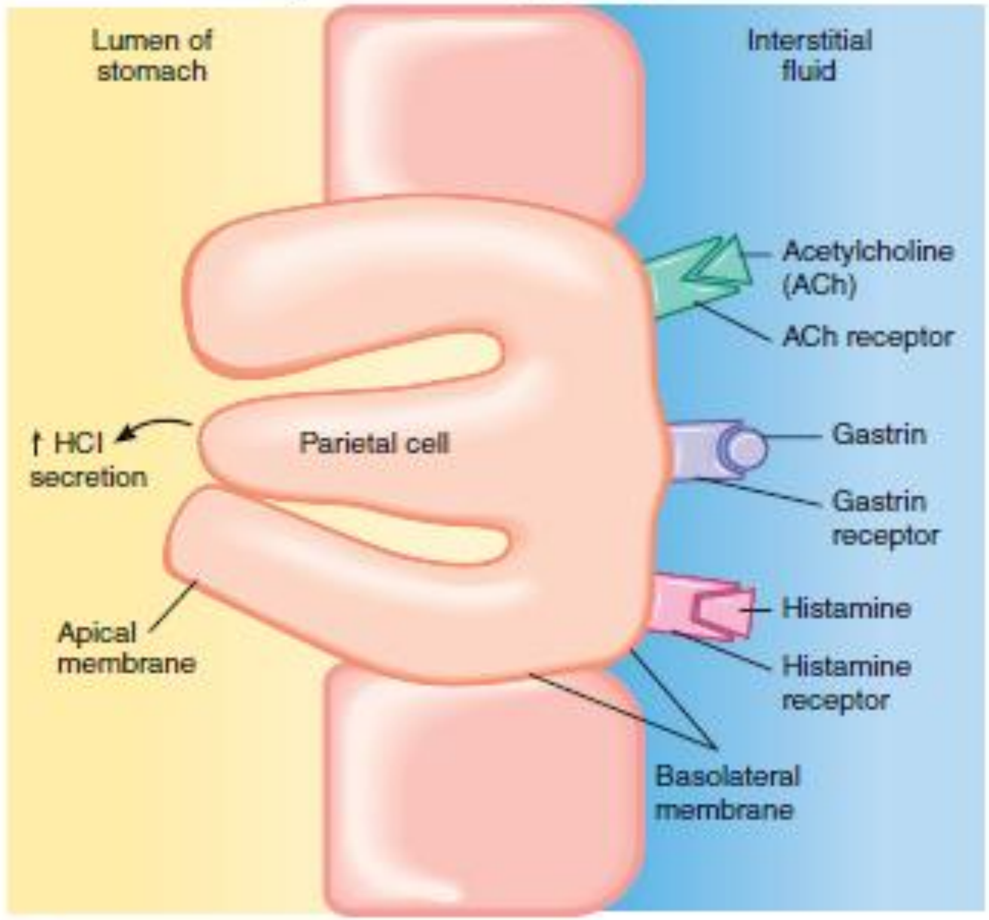


Figure 24.14 Regulation of HCl secretion.

HCl secretion by parietal cells can be stimulated by several sources: acetylcholine (ACh), gastrin, and histamine.



REGULATION OF HCL SECRETION

→ three receptor in the surface area

HCl secretion by parietal cells can be stimulated by several sources:

1. **Acetylcholine (ACh)** is released by parasympathetic neurons.
2. **Gastrin** secreted by G cells. → in pyloric antrum in stomach
3. **Histamine**, which is a paracrine substance released by mast cells in the nearby lamina propria.

→ these three make controling to level of HCl → stimulate produce HCl when bind with their receptor on the surface of the parietal cell

- Acetylcholine and gastrin stimulate parietal cells to secrete more HCl in the presence of histamine. **In other words, histamine acts synergistically, enhancing the effects of acetylcholine and gastrin. Receptors for all three substances are present in the plasma membrane of parietal cells.**

REGULATION OF HCL SECRETION

- The strongly acidic fluid of the stomach kills many microbes in food. يقتل
- HCl partially denatures (unfolds) proteins in food and stimulates the secretion of hormones that promote the flow of bile and pancreatic juice. Function HCl in stomach? (inhancing)
- Enzymatic digestion of proteins also begins in the stomach. and lingual lipase that break down the lipid
- The only proteolytic (protein-digesting) enzyme in the stomach is pepsin, which is secreted by chief cells. only enzyme in stomach to protein digestion
- Pepsin severs certain peptide bonds between amino acids, breaking down a protein chain of many amino acids into smaller peptide fragments. cut
- Pepsin is most effective in the very acidic environment of the stomach (pH 2); it becomes inactive at a higher pH.

WHAT KEEPS PEPSIN FROM DIGESTING THE PROTEIN IN STOMACH CELLS ALONG WITH THE FOOD?

- **First**, **pepsin is secreted in an inactive form called pepsinogen**; in this form, it cannot digest the proteins in the chief cells that produce it.

produce in cheif cell and the unactive form of pepsin

- **Pepsinogen is not converted into active pepsin until it comes in contact with hydrochloric acid** secreted by parietal cells or active pepsin molecules.

secreted by parietal cell or active pepsin molecules

and thick serosa layer

- **Second**, **the stomach epithelial cells are protected from gastric juices by a layer 1–3 mm thick of alkaline mucus secreted by** surface mucous cells and mucous neck cells.

these give protection to stomach epithelium from acid

REGULATION OF HCL SECRETION

- Another enzyme of the stomach is gastric lipase, which splits triglycerides (fats and oils) in fat molecules (such as those found in milk) into fatty acids and monoglycerides.

  secretion by chief cell and break down the lipid to fatty acid

- This enzyme, which has a limited role in the adult stomach, operates best at a pH of 5–6. More important than either lingual lipase or gastric lipase is pancreatic lipase, an enzyme secreted by the pancreas into the small intestine.

  also break down the lipid

- Within 2 to 4 hours after eating a meal, the stomach has emptied its contents into the duodenum. Foods rich in carbohydrates spend the least time in the stomach; high-protein foods remain somewhat longer, and emptying is slowest after a fat-laden meal containing large amounts of triglycerides.

TABLE 24.3

Summary of Digestive Activities in the Stomach

STRUCTURE	ACTIVITY	RESULT
Mucosa		
Surface mucous cells and mucous neck cells	Secrete mucus.	Forms protective barrier that prevents digestion of stomach wall.
	Absorption.	Small quantity of water, ions, short-chain fatty acids, and some drugs enter bloodstream.
Parietal cells	Secrete intrinsic factor.	Needed for absorption of vitamin B_{12} (used in red blood cell formation, or erythropoiesis).
	Secrete hydrochloric acid.	Kills microbes in food; denatures proteins; converts pepsinogen into pepsin.
Chief cells	Secrete pepsinogen.	Pepsin (activated form) breaks down proteins into peptides.
	Secrete gastric lipase.	Splits triglycerides into fatty acids and monoglycerides.
G cells	Secrete gastrin.	Stimulates parietal cells to secrete HCl and chief cells to secrete pepsinogen; contracts lower esophageal sphincter, increases motility of stomach, and relaxes pyloric sphincter.
Muscularis	Mixing waves (gentle peristaltic movements).	Churns and physically breaks down food and mixes it with gastric juice, forming chyme. Forces chyme through pyloric sphincter.
Pyloric sphincter	Opens to permit passage of chyme into duodenum.	Regulates passage of chyme from stomach to duodenum; prevents backflow of chyme from duodenum to stomach.

PANCREAS

- From the stomach, chyme passes into the small intestine. Because chemical digestion in the small intestine depends on activities of the pancreas, liver, and gallbladder, we first consider the activities of these accessory digestive organs and their contributions to digestion in the small intestine.

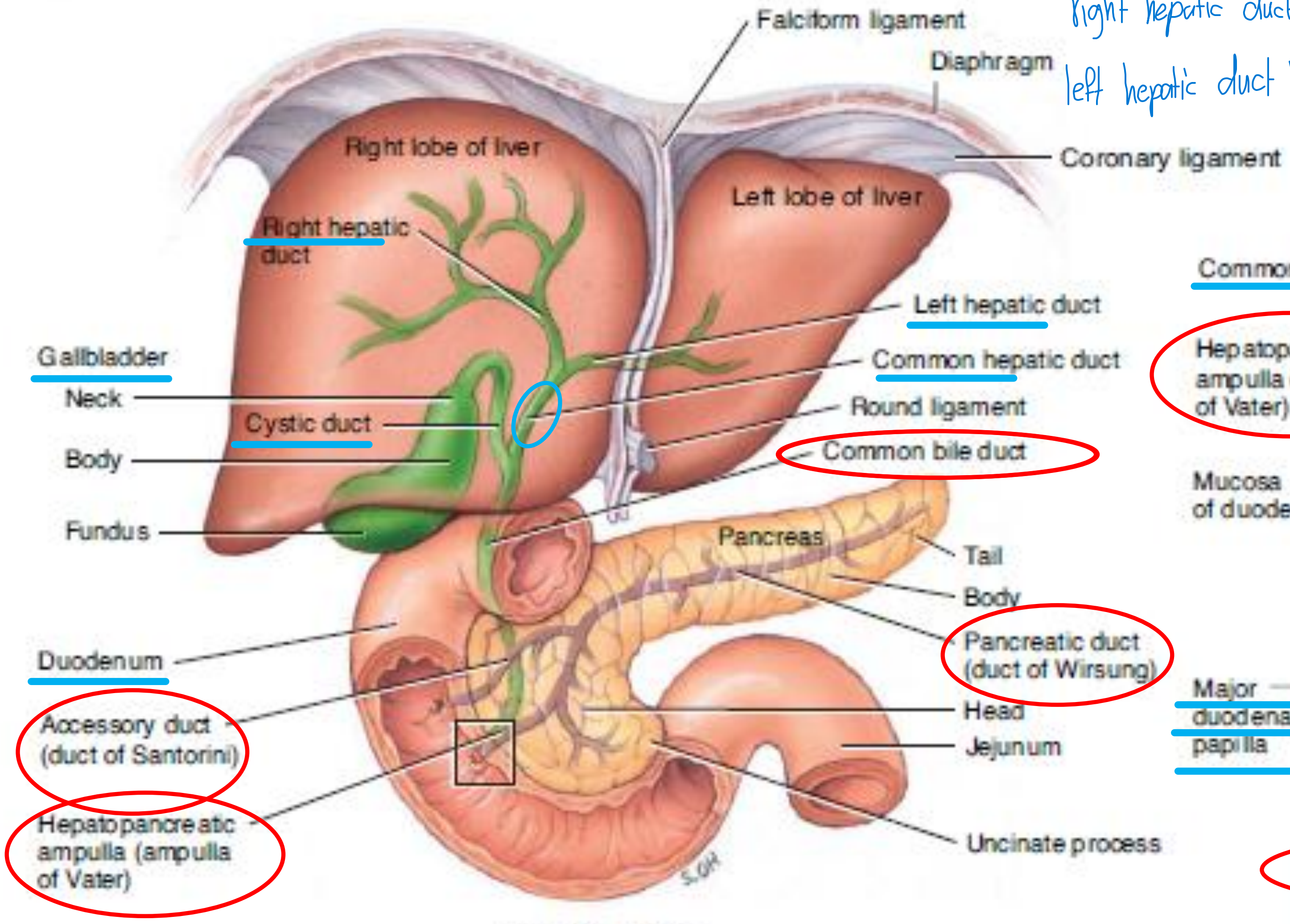
→ accessory organ between stomach and small intestine

accessory organ بتجيب الأشياء الي بتعمل هضم الأمعاء الدقيقة

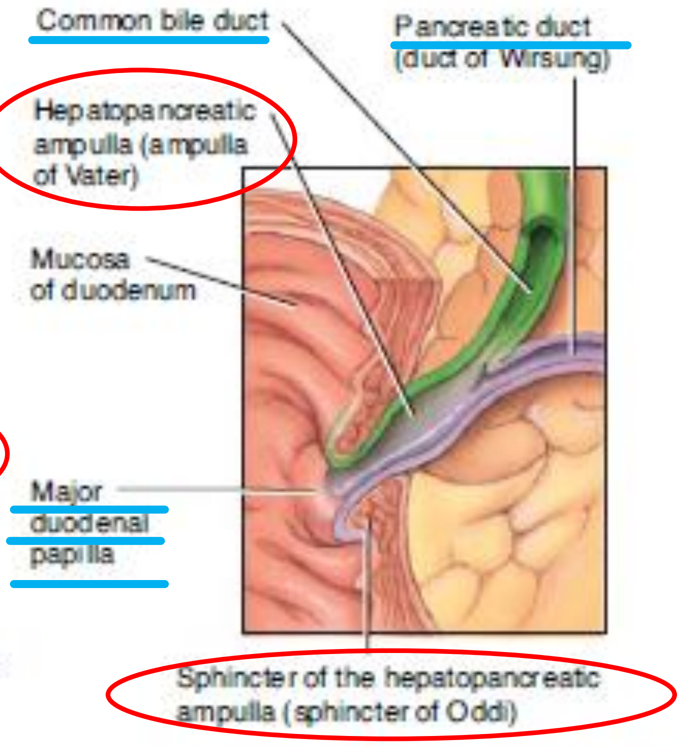
Figure 24.15 **Relationship of the pancreas to the liver, gallbladder, and duodenum.** The inset (b) shows details of the common bile duct and pancreatic duct forming the hepatopancreatic ampulla and emptying into the duodenum.

Pancreatic enzymes digest starches (polysaccharides), proteins, triglycerides, and nucleic acids.

right hepatic duct in right lobe of liver
left hepatic duct in left lobe of liver
→ common hepatic duct + cystic duct
→ common bile duct + pancreatic duct
→ formation duct pour in small intestine



(a) Anterior view



(b) Details of hepatopancreatic ampulla

PANCREAS

طولها

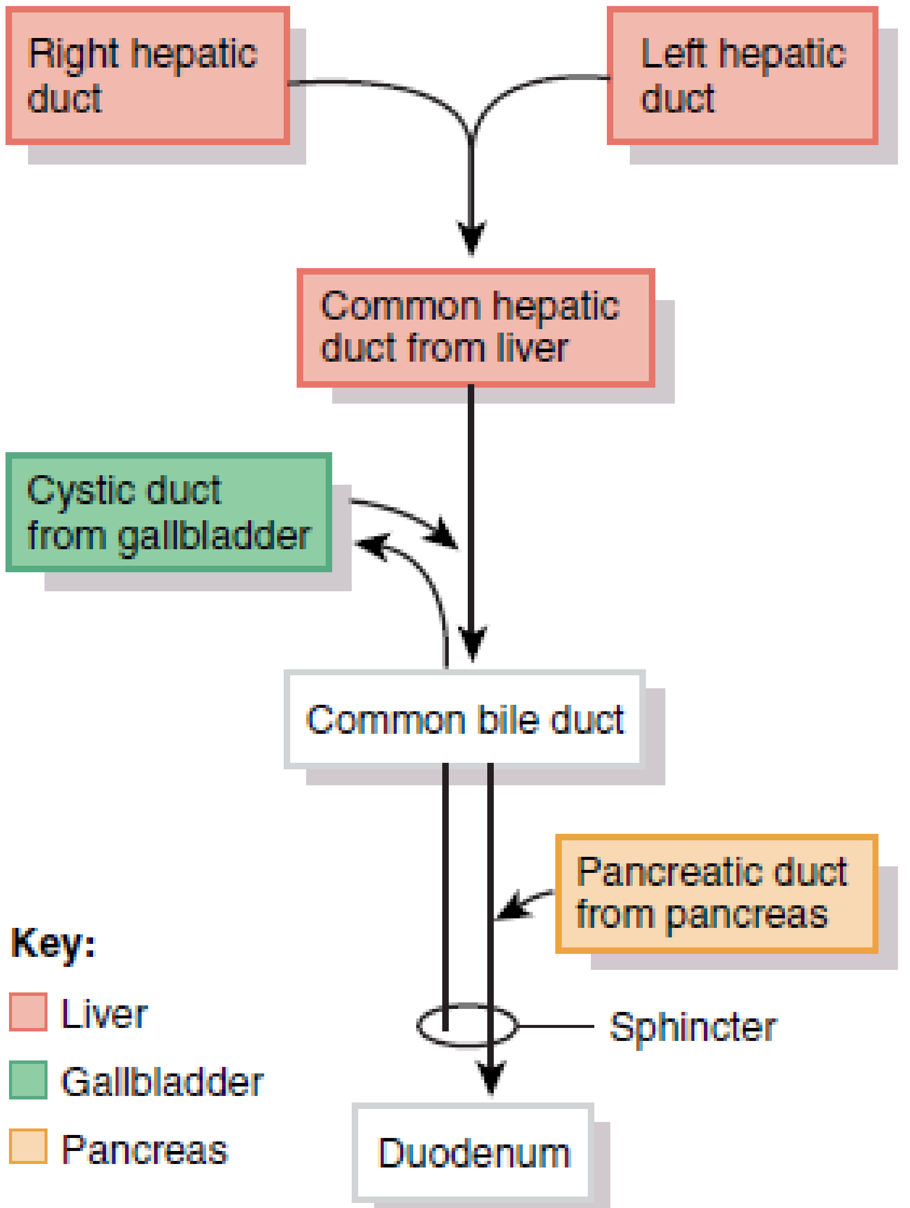
- **The pancreas, a retroperitoneal gland that is about 12–15 cm (5–6 in.) long and 2.5 cm (1 in.) thick, lies posterior to the greater curvature of the stomach.**

  عرضها

- **The pancreas consists of a head, a body, and a tail and is usually connected to the duodenum by two ducts.**

  Main and accessory pancreatic duct

- **The head is the expanded portion of the organ near the curve of the duodenum; superior to and to the left of the head are the central body and the tapering tail.**



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

PANCREAS

- **The protein-digesting enzymes of the pancreas are produced in an inactive form just as pepsin is produced in the stomach as pepsinogen. Because they are inactive, the enzymes do not digest cells of the pancreas itself.** → secretion pencreatic lipase that break down lipase → not active in pancreas

- **Trypsin is secreted in an inactive form called trypsinogen.**
  → the form trypsinogen in small intestine → become active
  → break down protein to peptide
  → inactive form from trypsin

- **Pancreatic acinar cells also secrete a protein called trypsin inhibitor that combines with any trypsin formed accidentally in the pancreas or in pancreatic juice and blocks its enzymatic activity.**

→ present peptidases to break peptide to nuclopeptide

- **When trypsinogen reaches the lumen of the small intestine, it encounters an activating brush-border enzyme called enterokinase, which splits off part of the trypsinogen molecule to form trypsin.**
  → nucleopeptidase to break (NP) to amino acid
  example
  → present in surface area of small intestine (related with cilia) secretion by intestinal cell in small intestine (example:- entrokinase that activation to trypsinogen)

Reminder (for protein digestion)
in stomach: Pepsinogen → pepsin (active form) by HCL
in intestine: Trypsinogen → trypsin (active form) by enterokinase

LIVER AND GALLBLADDER

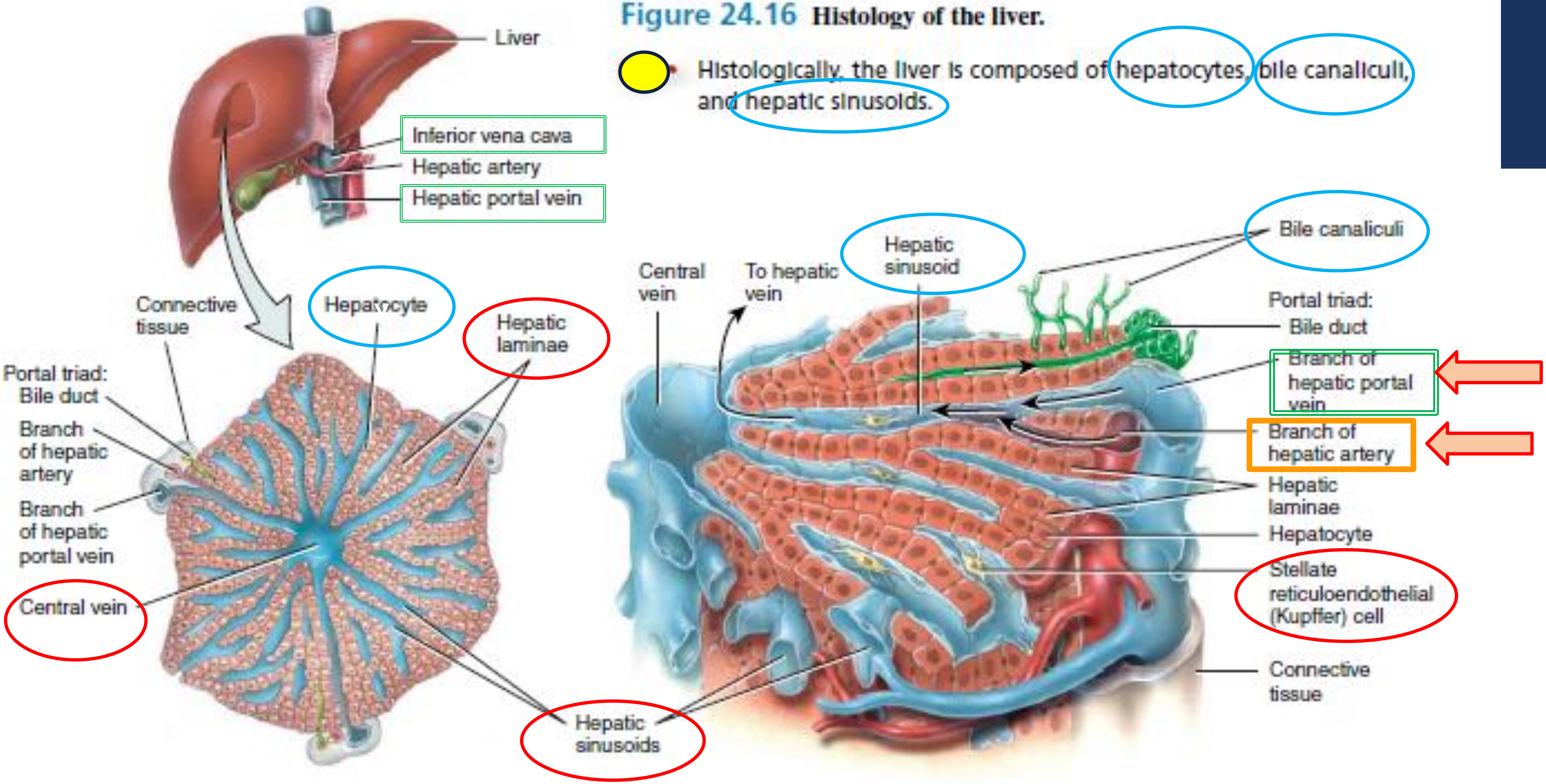
deoxitifation organ

- <u>The liver</u> is the heaviest gland of the body, weighing about 1.4 kg (about 3 lb) in an average adult. Of all of the organs of the body, it is second only to the skin in size.
- The liver is inferior to the diaphragm and occupies most of the right hypochondriac and part of the epigastric regions of the abdominopelvic cavity.

- <u>The gallbladder</u> is a pear-shaped sac that is located in a depression of the posterior surface of the liver. It is 7–10 cm (3–4 in.) long and typically hangs from the anterior inferior margin of the liver.

Figure 24.16 Histology of the liver.

- Histologically, the liver is composed of hepatocytes, bile canaliculi, and hepatic sinusoids.

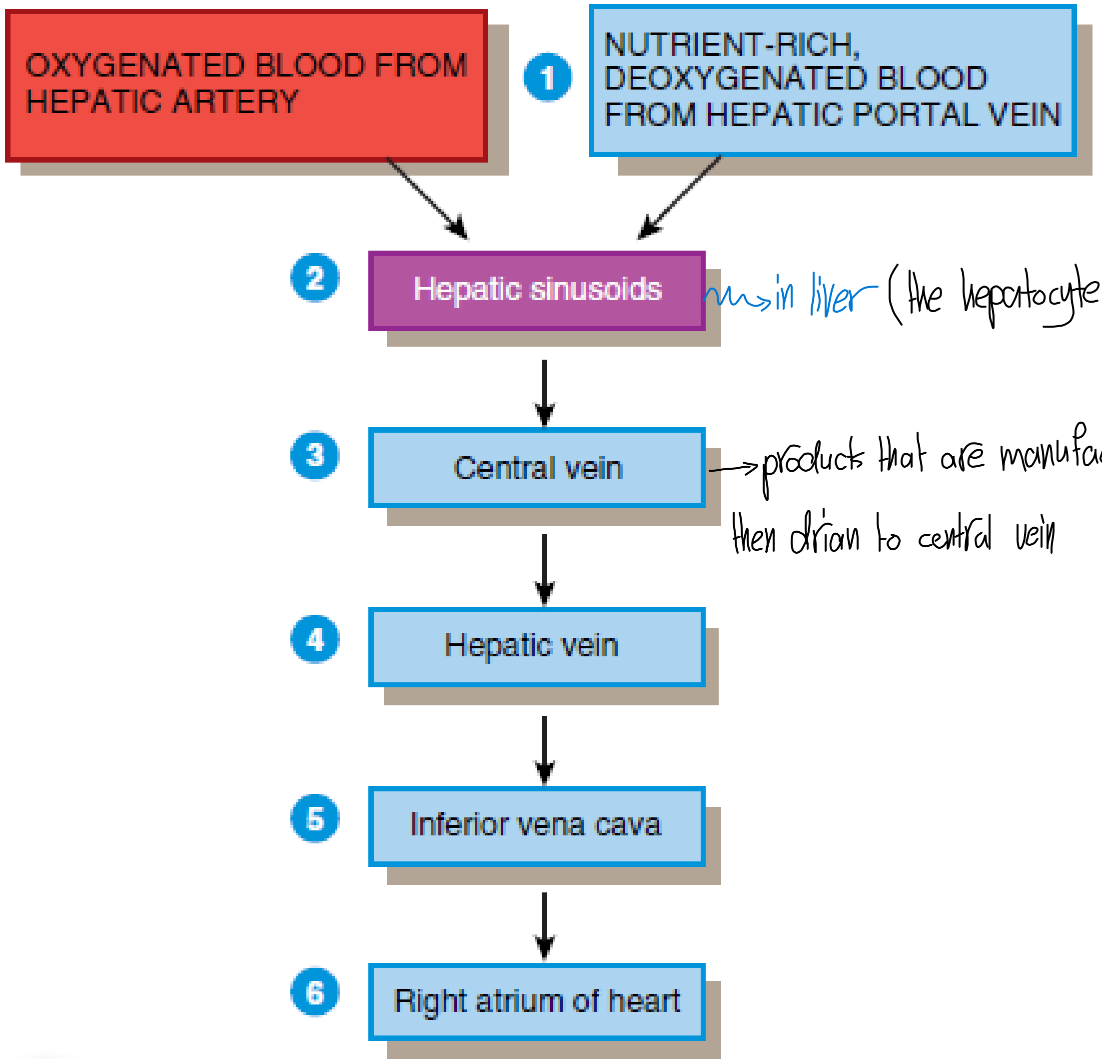


(a) Overview of histological components of liver

(b) Details of histological components of liver

Figure 24.17 **Hepatic blood flow: sources, path through the liver, and return to the heart.**

The liver receives oxygenated blood via the hepatic artery and nutrient-rich deoxygenated blood via the hepatic portal vein.



in liver (the hepatocyte absob nutrient, O_2 and toxic compound)

→ product that are manufactured by hepatocyte secreted into blood and then drian to central vein

LIVER AND GALLBLADDER

Kupffer cell

hepatocytes :- produce bile

- **From the hepatic artery it obtains oxygenated blood, and from the hepatic portal vein it receives deoxygenated blood containing newly absorbed nutrients, drugs, and possibly microbes and toxins from the gastrointestinal tract.**

- **Branches of both the hepatic artery and the hepatic portal vein carry blood into hepatic sinusoids, where oxygen, most of the nutrients, and certain toxic substances are taken up by the hepatocytes.**

- **Products manufactured by the hepatocytes and nutrients needed by other cells are secreted back into the blood, which then drains into the central vein and eventually passes into a hepatic vein.**

- **Because blood from the gastrointestinal tract passes through the liver as part of the hepatic portal circulation, the liver is often a site for metastasis of cancer that originates in the GI tract.** why ??

FUNCTIONS OF THE LIVER AND GALLBLADDER

elimination detoxification substance

- Each day, hepatocytes secrete 800–1000 mL (about 1 qt) of bile, a yellow, brownish, or olive-green liquid. It has a pH of 7.6–8.6 and consists mostly of water, bile salts, cholesterol, a phospholipid called lecithin, bile pigments, and several ions. bile that secrete by hepatocyte cell
- The principal bile pigment is bilirubin.
- The phagocytosis of aged red blood cells liberates iron, globin, and bilirubin (derived from heme).
- The iron and globin are recycled; the bilirubin is secreted into the bile and is eventually broken down in the intestine. One of its breakdown products—stercobilin—gives feces their normal brown color.

➢ Bile is partially an excretory product and partially a digestive secretion.

- Bile salts, which are ① sodium salts and ② potassium salts of bile acids play a role in emulsification, the breakdown of large lipid globules into a suspension of small lipid globules.

➢ The small lipid globules present a very large surface area that allows pancreatic lipase to more rapidly accomplish digestion of triglycerides. Bile salts also aid in the absorption of lipids following their digestion.

GALLBLADDER REMOVAL

- Impact of Gallbladder Removal: When the gallbladder is removed, bile flows directly from the liver into the small intestine. This can lead to difficulties in digesting fats, especially fatty meals.

is drug

- Bile Salt Supplements: Bile salt supplements contain bile acids, which aid in fat emulsification and absorption. These supplements can help improve fat digestion and reduce symptoms like diarrhoea, bloating, and gas that may occur after gallbladder removal

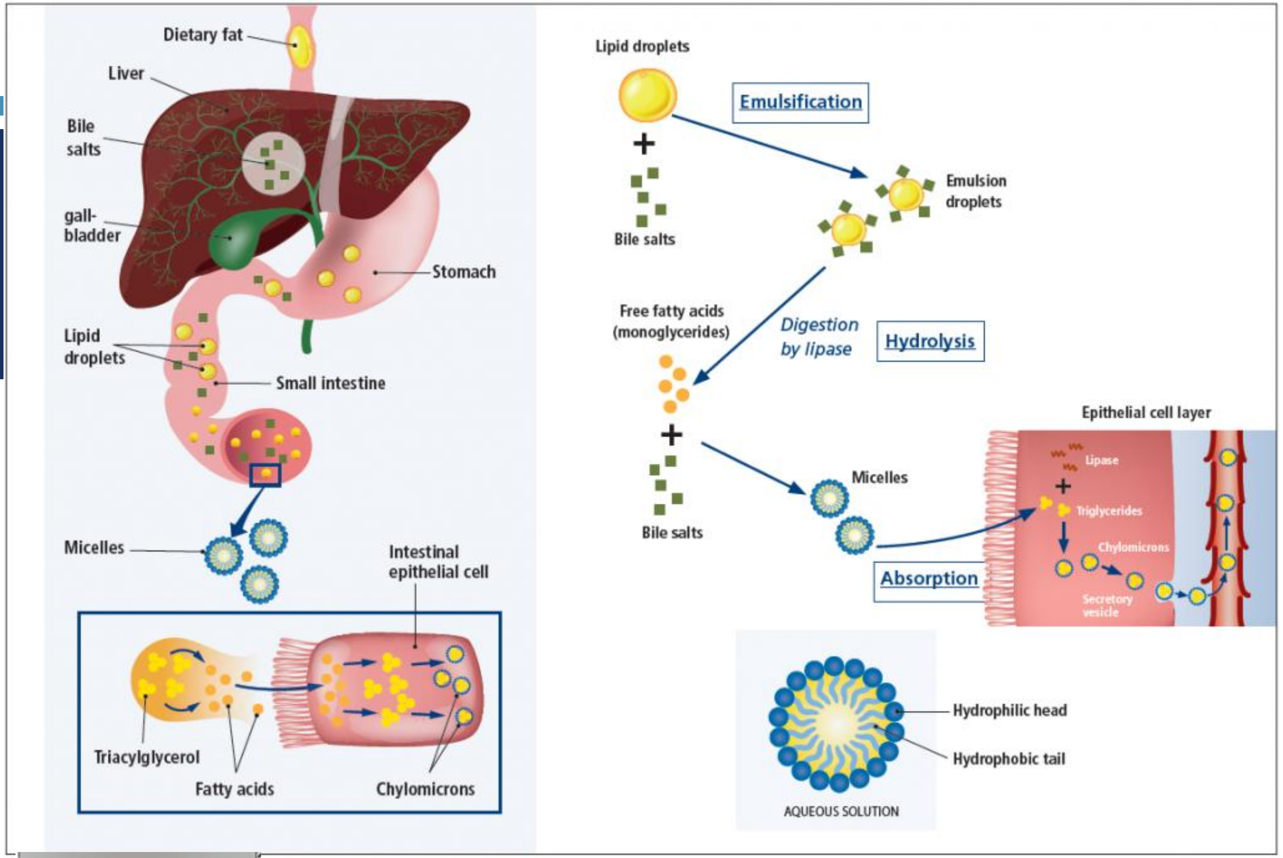
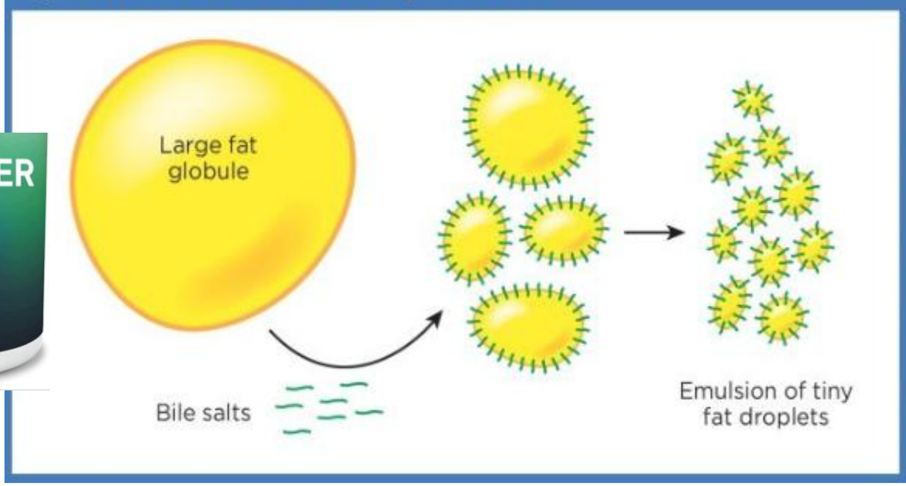


Fig 3. Emulsification of fat by bile salts



FUNCTIONS OF THE LIVER AND GALLBLADDER

- Digestion and absorption continue in the small intestine, bile release increases. contribute in digestion to lipid

- Between meals, after most absorption has occurred, bile flows into the gallbladder for storage because the sphincter of the hepatopancreatic ampulla closes off the entrance to the duodenum. The sphincter surrounds the hepatopancreatic ampulla.

the bile produces in liver by hepatocyte and storage in gallbladder (not produce in gallbladder)

FUNCTIONS OF THE LIVER AND GALLBLADDER

- In addition to secreting bile, which is needed for absorption of dietary fats, the liver performs many other vital functions.

more glucose level → storage at form glycogen and triglycerides to storage
less glucose level → break the glycogen to form glucose and release into bloodstream

1. **Carbohydrate metabolism:** The liver is especially important in maintaining a normal blood glucose level. When blood glucose is low, the liver can break down glycogen to glucose and release the glucose into the bloodstream. When blood glucose is high, as occurs just after eating a meal, the liver converts glucose to glycogen and triglycerides for storage.

2. **Lipid metabolism:** Hepatocytes store some triglycerides, synthesize cholesterol; and use cholesterol to make bile salts. → degradation of lipid
→ synthase lipoprotein that trans cholesterol

3. **Protein metabolism:** Hepatocytes deaminate (remove the amino group, NH_2, from) amino acids, the resulting toxic ammonia (NH_3) is then converted into the much less toxic urea, which is excreted in urine. Hepatocytes also synthesize most plasma proteins, such as alpha and beta globulins, albumin, prothrombin, and fibrinogen.

→ protein synthase and protein catabolism

Representation of α Amino Acid

FUNCTIONS OF THE LIVER AND GALLBLADDER

- In addition to secreting bile, which is needed for absorption of dietary fats, the liver performs many other vital functions.

detoxification organ

4. Processing of drugs and hormones: The liver can detoxify substances such as alcohol and excrete drugs such as penicillin, erythromycin, and sulfonamides into bile. It can also chemically alter or excrete thyroid hormones and steroid hormones such as estrogens and aldosterone.

resultant from phagocytosis to blood

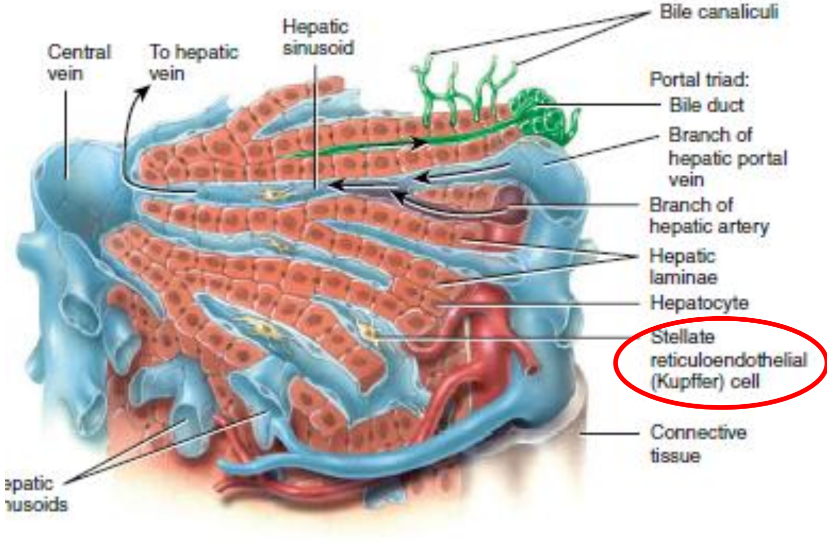
5. Excretion of bilirubin: As previously noted, bilirubin, derived from the heme of aged red blood cells, is absorbed by the liver. Most of the bilirubin in bile is metabolized in the small intestine by bacteria and eliminated in feces.

6. Synthesis of bile salts: Bile salts are used in the small intestine for the emulsification and absorption of lipids. sodium and potassium salt

FUNCTIONS OF THE LIVER AND GALLBLADDER

- **In addition to secreting bile, which is needed for absorption of dietary fats, the liver performs many other vital functions.**

7. **Storage: In addition to glycogen, the liver is a prime storage site for certain vitamins (A, B12, D, E, and K) and minerals (iron and copper), which are released from the liver when needed elsewhere in the body.**
8. **Phagocytosis: The stellate reticuloendothelial (Kupffer) cells of the liver phagocytize aged red blood cells, white blood cells, and some bacteria.**
9. **Activation of vitamin D: The skin, liver, and kidneys participate in synthesizing the active form of vitamin D.**



(b) Details of histological components of liver

the same function between kidney and liver?
① synthase cholesterol
② storage glucose

↳ after phagocytoses produces globin, iron and bilirubin
↳ exit to small intestine and when arrive to large intestine (present bacterea work on fermentation the bilirubin to produce stercobilin)
↳ give feces it's brown color

SMALL INTESTINE

- **Most digestion and absorption of nutrients occur in a long tube called the small intestine.**

and brush-border enzyme contribute in absorption of substance

- **Its length alone provides a large surface area for digestion and absorption, and that area is further increased by circular folds, villi, and microvilli.**

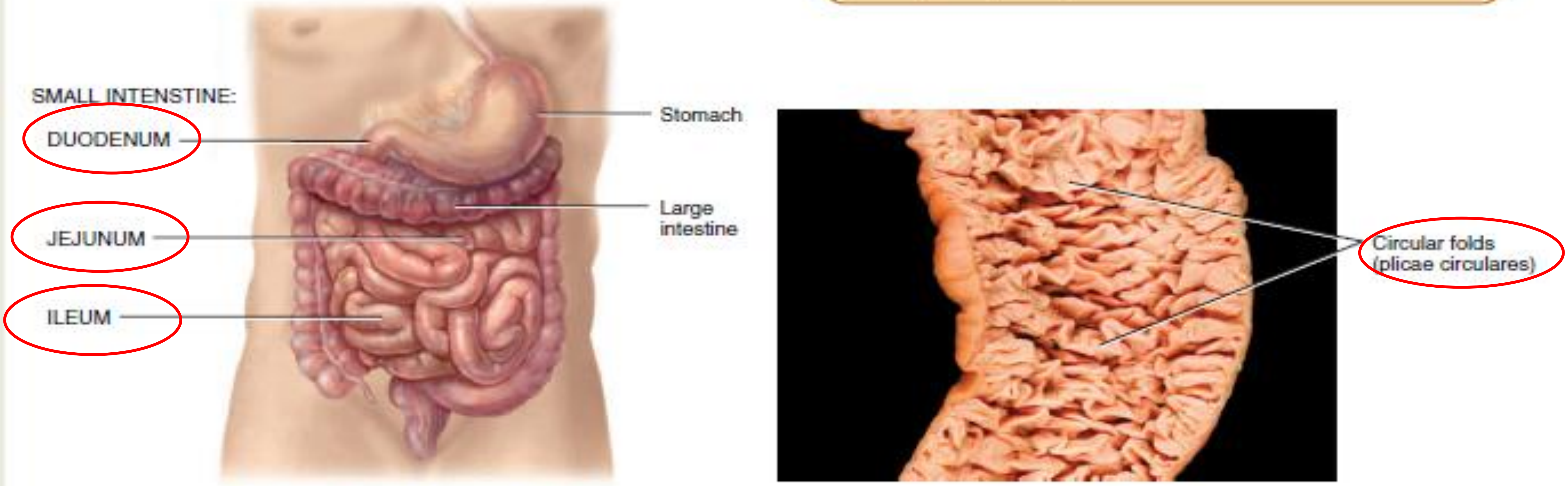
for small intestine?

Figure 24.18 **Anatomy of the small intestine.** (a) Regions of the small intestine are the duodenum, jejunum, and ileum. (b) Circular folds increase the surface area for digestion and absorption in the small intestine.

Most digestion and absorption occur in the small intestine.

FUNCTIONS OF THE SMALL INTESTINE

1. Segmentations mix chyme with digestive juices and bring food into contact with mucosa for absorption; peristalsis propels chyme through small intestine.
2. Completes digestion of carbohydrates, proteins, and lipids; begins and completes digestion of nucleic acids.
3. Absorbs about 90% of nutrients and water that pass through digestive system.



(a) Anterior view of external anatomy

(b) Internal anatomy of jejunum

SMALL INTESTINE

- **Most digestion and absorption of nutrients occur in a long tube called the small intestine.**

- **Its length alone provides a large surface area for digestion and absorption, and that area is further increased by circular folds, villi, and microvilli.**

صور

Figure 24.19 **Histology of the small intestine.**

Circular folds, villi, and microvilli increase the surface area of the small intestine for digestion and absorption.

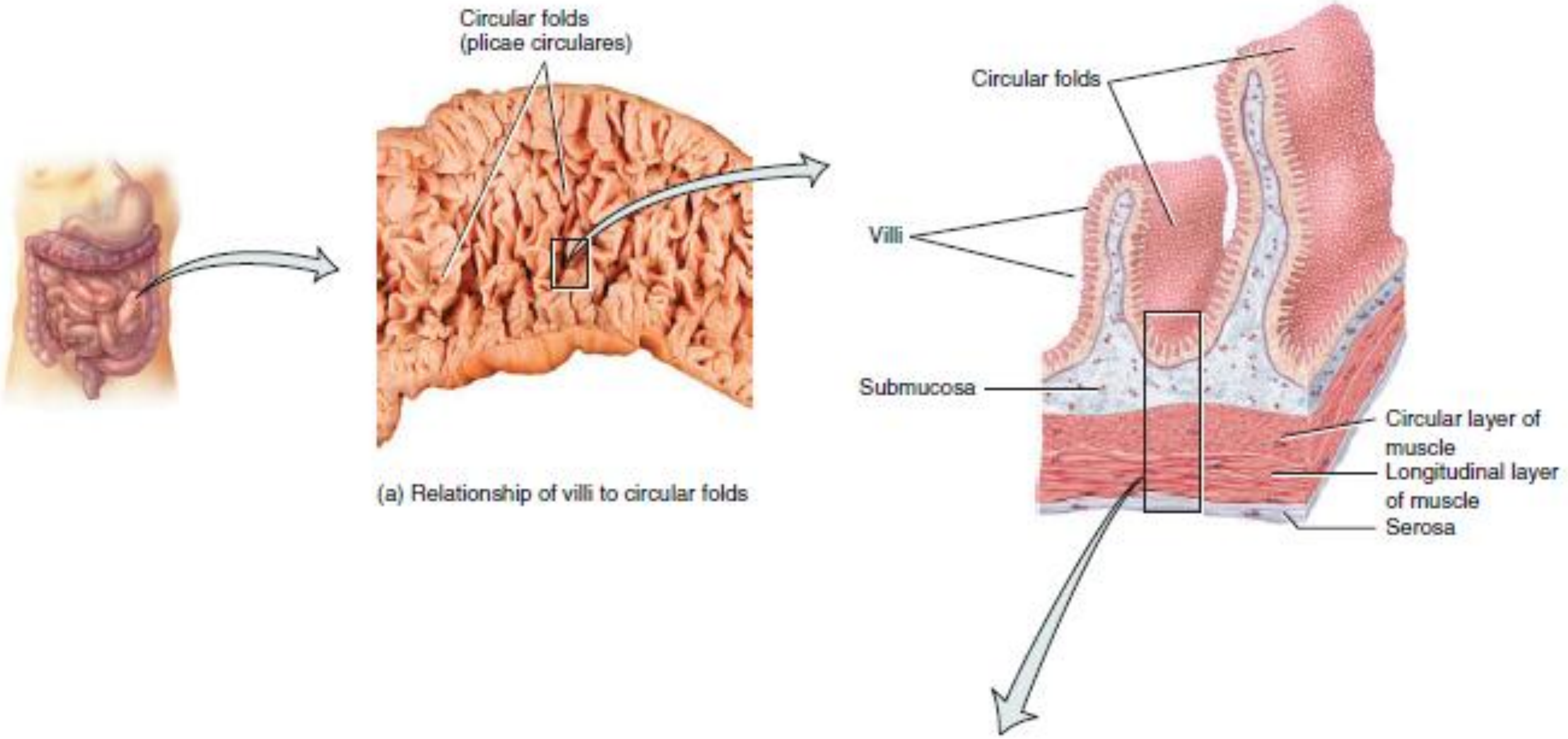
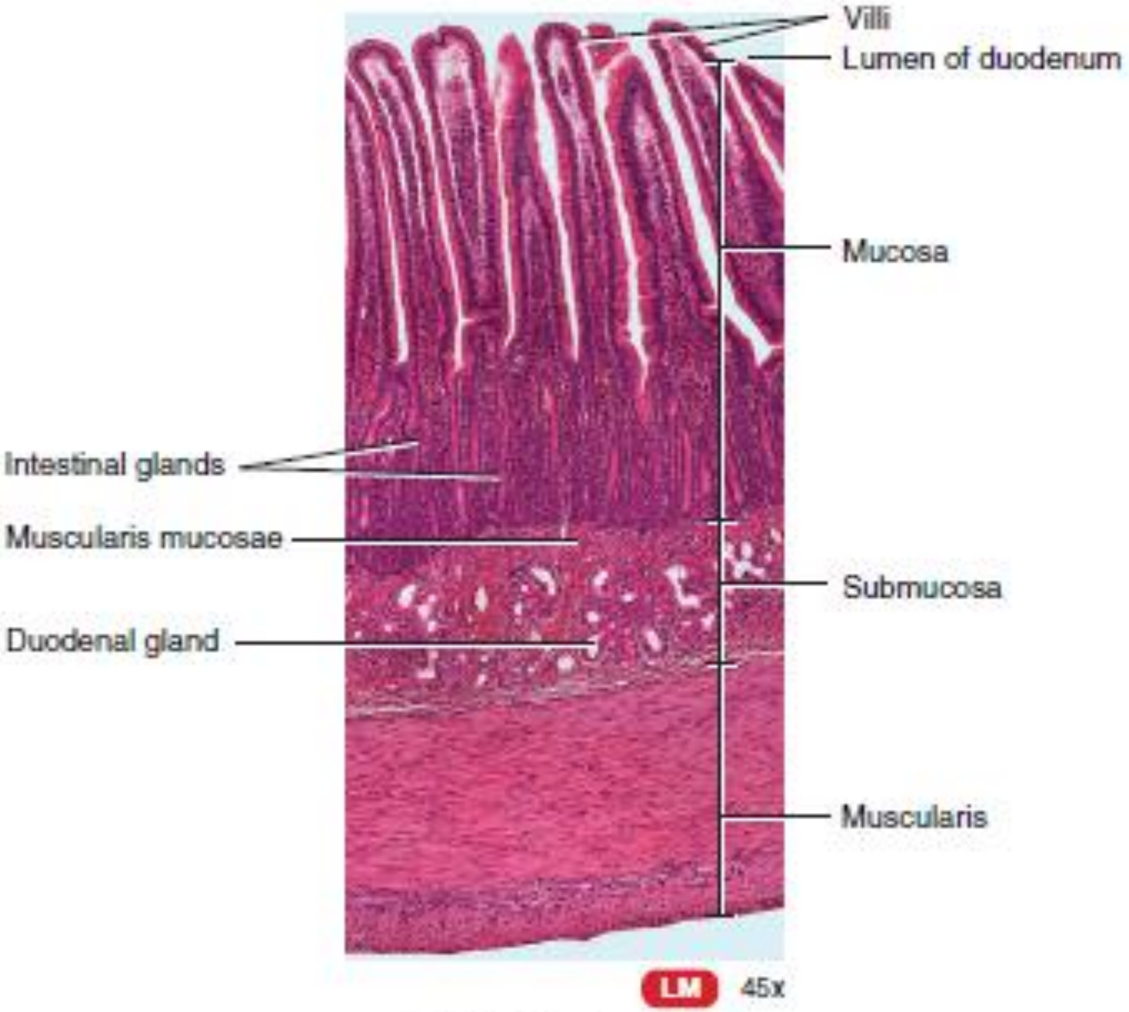


Figure 24.20 **Histology of the duodenum and ileum.**

Microvilli in the small intestine contain several brush-border enzymes that help digest nutrients.



(a) Wall of the duodenum

ROLE OF INTESTINAL JUICE AND BRUSH-BORDER ENZYMES

- **About 1–2 liters of intestinal juice, a clear yellow fluid, is secreted each day. Intestinal juice contains water and mucus and is slightly alkaline (pH 7.6).**

→ because present high amount from bicarbonate ion

- **The alkaline pH of intestinal juice is due to its high concentration of bicarbonate ions.**

→ complete digestion for lipid by liver and pancreas (pancreatic lipase) → start and digestion in small intestine

→ complete digestion for protien by trypsin, peptidases, nucleopeptidases

→ complete digestion for corbohydrate by sucrase, lactose

- **The absorptive cells of the small intestine synthesize several digestive enzymes, called brush-border enzymes, and insert them in the plasma membrane of the microvilli.**

→ interokynase converte pepsinogen to pepsin

→ converted trypsinogen to trypsin

ROLE OF INTESTINAL JUICE AND BRUSH-BORDER ENZYMES

- Thus, some enzymatic digestion occurs at the surface of the absorptive cells that line the villi, rather than in the lumen exclusively, as occurs in other parts of the GI tract. Among the brush-border enzymes are four carbohydrate-digesting enzymes called α-dextrinase, maltase, sucrase, and lactase; protein-digesting enzymes called peptidases (aminopeptidase and dipeptidase); and two types of nucleotide-digesting enzymes, nucleosidases and phosphatases.

MECHANICAL DIGESTION IN THE SMALL INTESTINE

- The two types of movements of the small intestine—segmentations and a type of peristalsis called migrating motility complexes—are governed mainly by the myenteric plexus.

→mixing food + gastric juice from stomach + OH from small intestine + bile from liver and other to form segmintation

↳ the movement along small intestine after mixing

- Segmentations are localized, mixing contractions that occur in portions of intestine distended by a large volume of chyme. Segmentations mix chyme with the digestive juices and bring the particles of food into contact with the mucosa for absorption; they do not push the intestinal contents along the tract.

MECHANICAL DIGESTION IN THE SMALL INTESTINE

- Segmentations occur most rapidly in the duodenum, about 12 times per minute, and progressively slow to about 8 times per minute in the ileum.
- After most of a meal has been absorbed, which lessens distension of the wall of the small intestine, segmentation stops and peristalsis begins.
- The type of peristalsis that occurs in the small intestine, termed a migrating motility complex (MMC), begins in the lower portion of the stomach and pushes chyme forward along a short stretch of small intestine before dying out.
- The MMC slowly migrates down the small intestine, reaching the end of the ileum in 90–120 minutes. Then another MMC begins in the stomach. Altogether, chyme remains in the small intestine for 3–5 hours.

CHEMICAL DIGESTION IN THE SMALL INTESTINE

1. In the mouth, salivary amylase converts starch (a polysaccharide) to maltose (a disaccharide), maltotriose (a trisaccharide), and α-dextrins (short-chain, branched fragments of starch with 5–10 glucose units).
2. In the stomach, pepsin converts proteins to peptides (small fragments of proteins), and lingual and gastric lipases convert some triglycerides into fatty acids, diglycerides, and monoglycerides.
3. Thus, chyme entering the small intestine contains partially digested carbohydrates, proteins, and lipids.
4. The completion of the digestion of carbohydrates, proteins, and lipids is a collective effort of pancreatic juice, bile, and intestinal juice in the small intestine.

ABSORPTION IN THE SMALL INTESTINE

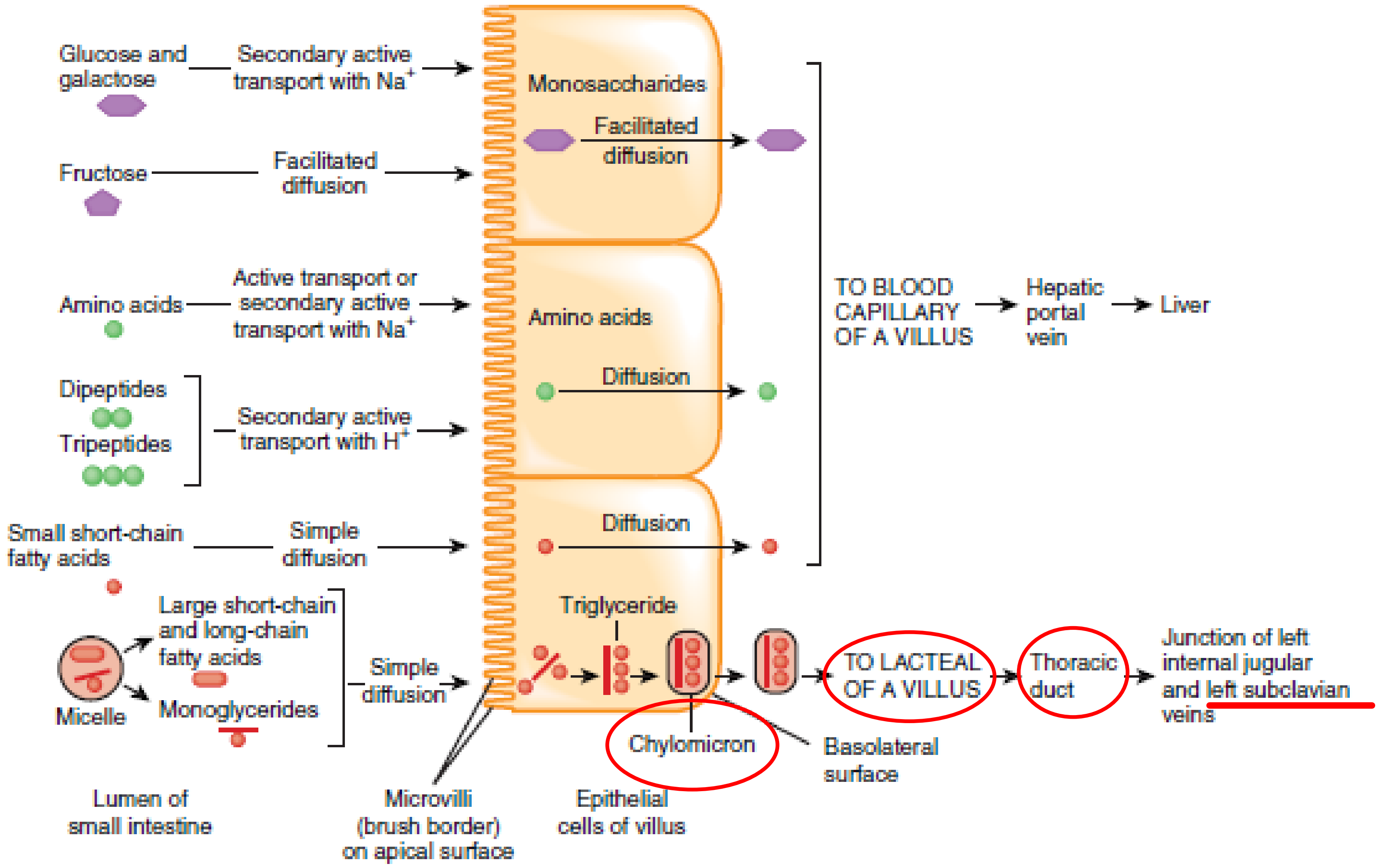
- All of the chemical and mechanical phases of digestion from the mouth through the small intestine are directed toward changing food into forms that can pass through the absorptive epithelial cells lining the mucosa and into the underlying blood and lymphatic vessels.
- These forms are monosaccharides (glucose, fructose, and galactose) from carbohydrates; single amino acids, dipeptides, and tripeptides from proteins; and fatty acids, glycerol, and monoglycerides from triglycerides.
- **Passage of these digested nutrients from the gastrointestinal tract into the blood or lymph is called absorption.**

ABSORPTION IN THE SMALL INTESTINE

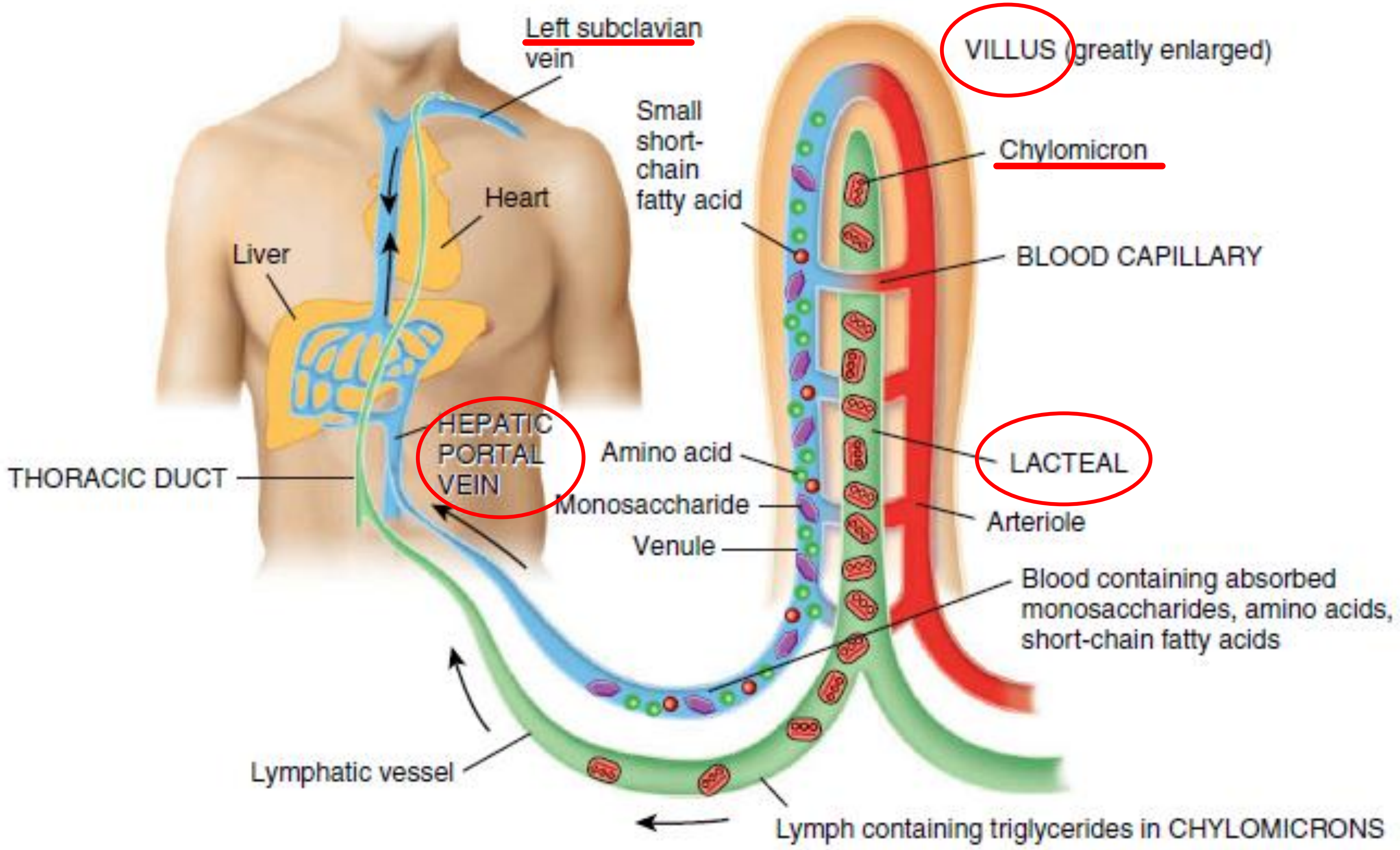
- Absorption of materials occurs via diffusion, facilitated diffusion, osmosis, and active transport.
- About 90% of all absorption of nutrients occurs in the small intestine; the other 10% occurs in the stomach and large intestine.
- Any undigested or unabsorbed material left in the small intestine passes on to the large intestine.

Figure 24.21 Absorption of digested nutrients in the small intestine. For simplicity, all digested foods are shown in the lumen of the small intestine, even though some nutrients are digested by brush-border enzymes.

Long-chain fatty acids and monoglycerides are absorbed into lacteals; other products of digestion enter blood capillaries.



(a) Mechanisms for movement of nutrients through absorptive epithelial cells of villi



(b) Movement of absorbed nutrients into blood and lymph

Figure 24.22 **Daily volumes of fluid ingested, secreted, absorbed, and excreted from the GI tract.**

All water absorption in the GI tract occurs via osmosis.

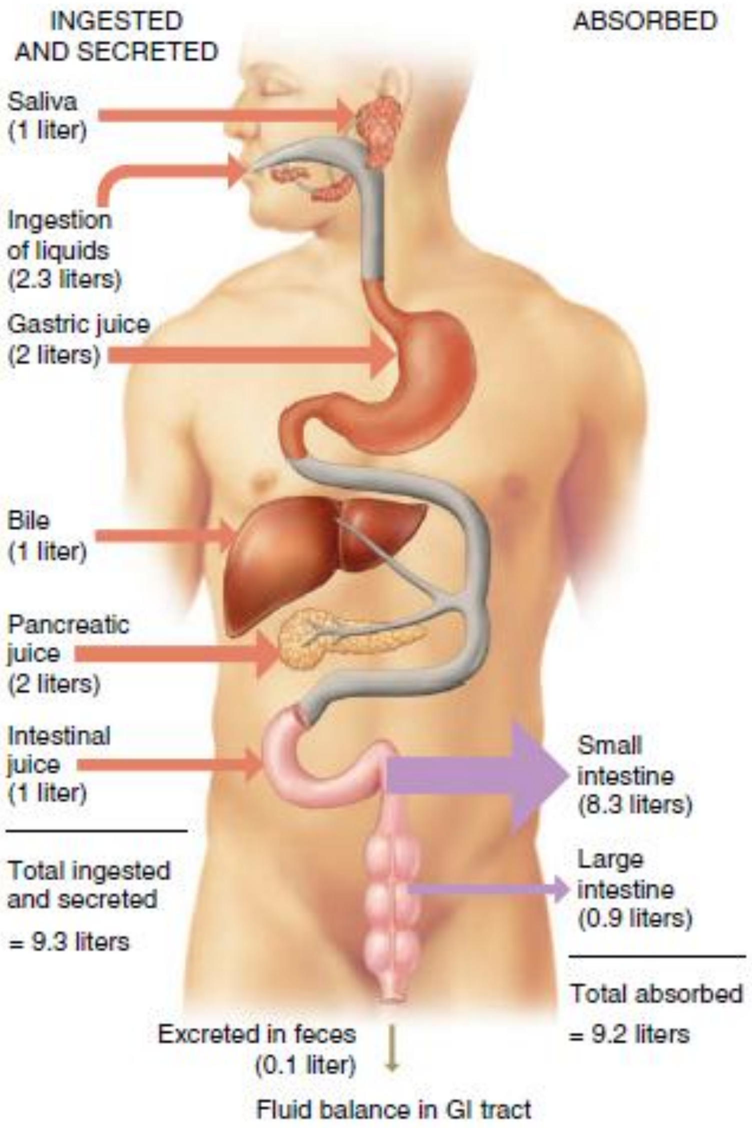


TABLE 24.4

Summary of Digestive Activities in the Pancreas, Liver, Gallbladder, and Small Intestine

STRUCTURE	ACTIVITY
Pancreas	Delivers pancreatic juice into duodenum via pancreatic duct to assist absorption (see Table 24.5 for pancreatic enzymes and their functions).
Liver	Produces bile (bile salts) necessary for emulsification and absorption of lipids.
Gallbladder	Stores, concentrates, and delivers bile into duodenum via common bile duct.
Small intestine	Major site of digestion and absorption of nutrients and water in gastrointestinal tract.
Mucosa/submucosa	
Intestinal glands	Secrete intestinal juice to assist absorption.
Absorptive cells	Digest and absorb nutrients.
Goblet cells	Secrete mucus.
Enteroendocrine cells (S, CCK, K)	Secrete secretin, cholecystokinin, and glucose-dependent insulinotropic peptide.
Paneth cells	Secrete lysozyme (bactericidal enzyme) and phagocytosis.
Duodenal (Brunner's) glands	Secrete alkaline fluid to buffer stomach acids, and mucus for protection and lubrication.
Circular folds	Folds of mucosa and submucosa that increase surface area for digestion and absorption.
Villi	Fingerlike projections of mucosa that are sites of absorption of digested food and increase surface area for digestion and absorption.
Microvilli	Microscopic, membrane-covered projections of absorptive epithelial cells that contain brush-border enzymes (listed in Table 24.5) and that increase surface area for digestion and absorption.
Muscularis	
Segmentation	Type of peristalsis: alternating contractions of circular smooth muscle fibers that produce segmentation and resegmentation of sections of small intestine; mixes chyme with digestive juices and brings food into contact with mucosa for absorption.
Migrating motility complex (MMC)	Type of peristalsis: waves of contraction and relaxation of circular and longitudinal smooth muscle fibers passing the length of the small intestine; moves chyme toward ileocecal sphincter.

TABLE 24.5

Summary of Digestive Enzymes

ENZYME	SOURCE	SUBSTRATES	PRODUCTS
SALIVA			
Salivary amylase	Salivary glands.	Starches (polysaccharides).	Maltose (disaccharide), maltotriose (trisaccharide), and α-dextrins.
Lingual lipase	Lingual glands in tongue.	Triglycerides (fats and oils) and other lipids.	Fatty acids and diglycerides.
GASTRIC JUICE			
Pepsin (activated from pepsinogen by pepsin and hydrochloric acid)	Stomach chief cells.	Proteins.	Peptides.
Gastric lipase	Stomach chief cells.	Triglycerides (fats and oils).	Fatty acids and monoglycerides.
PANCREATIC JUICE			
Pancreatic amylase	Pancreatic acinar cells.	Starches (polysaccharides).	Maltose (disaccharide), maltotriose (trisaccharide), and α-dextrins.
Trypsin (activated from trypsinogen by enterokinase)	Pancreatic acinar cells.	Proteins.	Peptides.
Chymotrypsin (activated from chymotrypsinogen by trypsin)	Pancreatic acinar cells.	Proteins.	Peptides.
Elastase (activated from proelastase by trypsin)	Pancreatic acinar cells.	Proteins.	Peptides.
Carboxypeptidase (activated from procarboxypeptidase by trypsin)	Pancreatic acinar cells.	Amino acid at carboxyl end of peptides.	Amino acids and peptides.
Pancreatic lipase	Pancreatic acinar cells.	Triglycerides (fats and oils) that have been emulsified by bile salts.	Fatty acids and monoglycerides.
Nucleases			
Ribonuclease	Pancreatic acinar cells.	Ribonucleic acid.	Nucleotides.
Deoxyribonuclease	Pancreatic acinar cells.	Deoxyribonucleic acid.	Nucleotides.

TABLE 24.5

Summary of Digestive Enzymes

Nucleases			
Ribonuclease	Pancreatic acinar cells.	Ribonucleic acid.	Nucleotides.
Deoxyribonuclease	Pancreatic acinar cells.	Deoxyribonucleic acid.	Nucleotides.
BRUSH-BORDER ENZYMES IN MICROVILLI PLASMA MEMBRANE			
α-Dextrinase	Small intestine.	α-Dextrins.	Glucose.
Maltase	Small intestine.	Maltose.	Glucose.
Sucrase	Small intestine.	Sucrose.	Glucose and fructose.
Lactase	Small intestine.	Lactose.	Glucose and galactose.
Enterokinase	Small intestine.	Trypsinogen.	Trypsin.
Peptidases			
Aminopeptidase	Small intestine.	Amino acid at amino end of peptides.	Amino acids and peptides.
Dipeptidase	Small intestine.	Dipeptides.	Amino acids.
Nucleosidases and phosphatases	Small intestine.	Nucleotides.	Nitrogenous bases, pentoses, and phosphates.

LARGE INTESTINE

- The large intestine is the terminal portion of the GI tract.

- The overall functions of the large intestine are the completion of absorption, the production of certain vitamins, the formation of feces, and the expulsion of feces from the body. by anus

vitamine b and K that storage in live

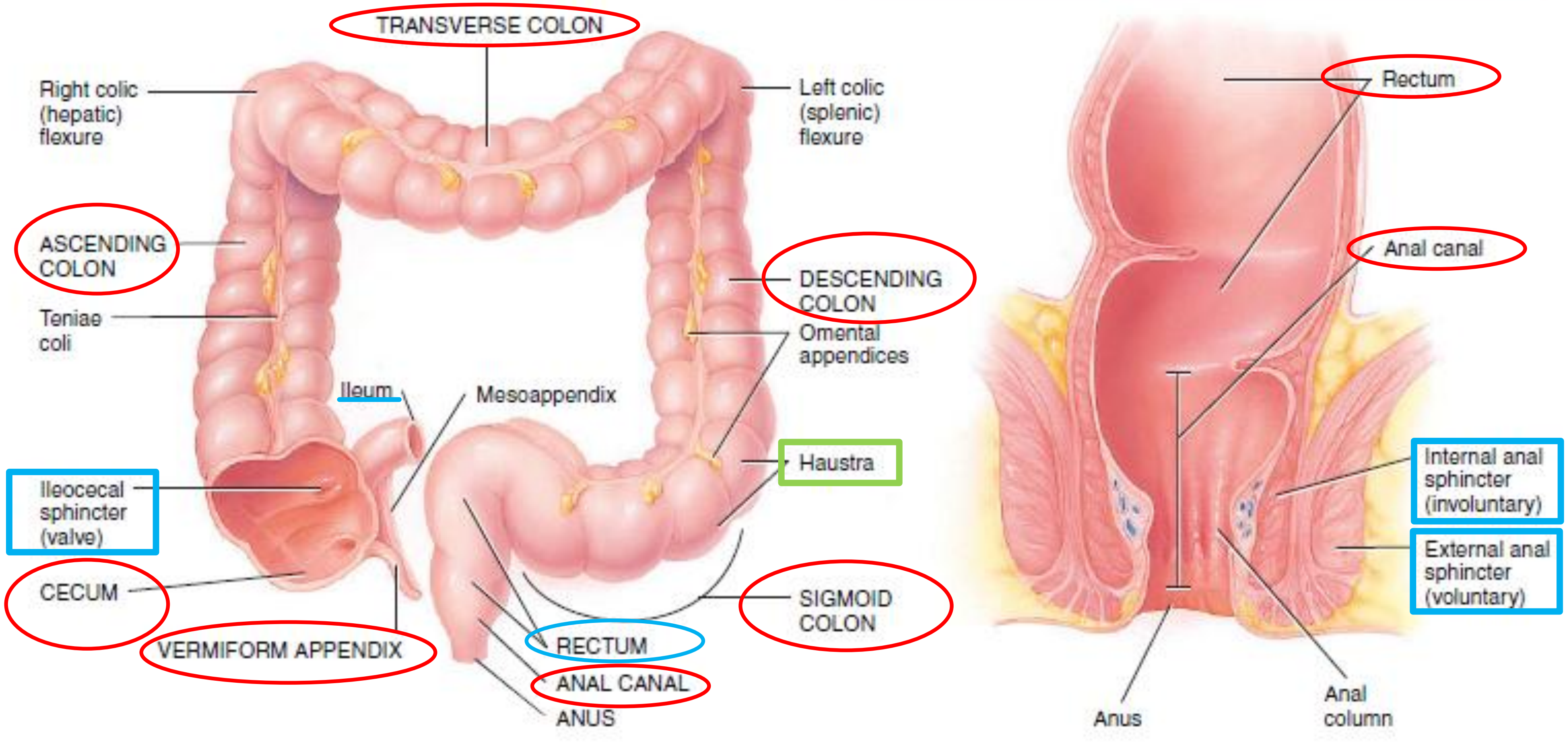
Figure 24.23 Anatomy of the large intestine.

The regions of the large intestine are the cecum, colon, rectum, and anal canal.

⇐ مكونات (large intestine) ؟ موجودين بالدائرة الي لونها أحمر

FUNCTIONS OF THE LARGE INTESTINE

1. Haustral churning, peristalsis, and mass peristalsis drive contents of colon into rectum.
2. Bacteria in large intestine convert proteins to amino acids, break down amino acids, and produce some B vitamins and vitamin K.
3. Absorption of some water, ions, and vitamins.
4. Formation of feces.
5. Defecation (emptying rectum).

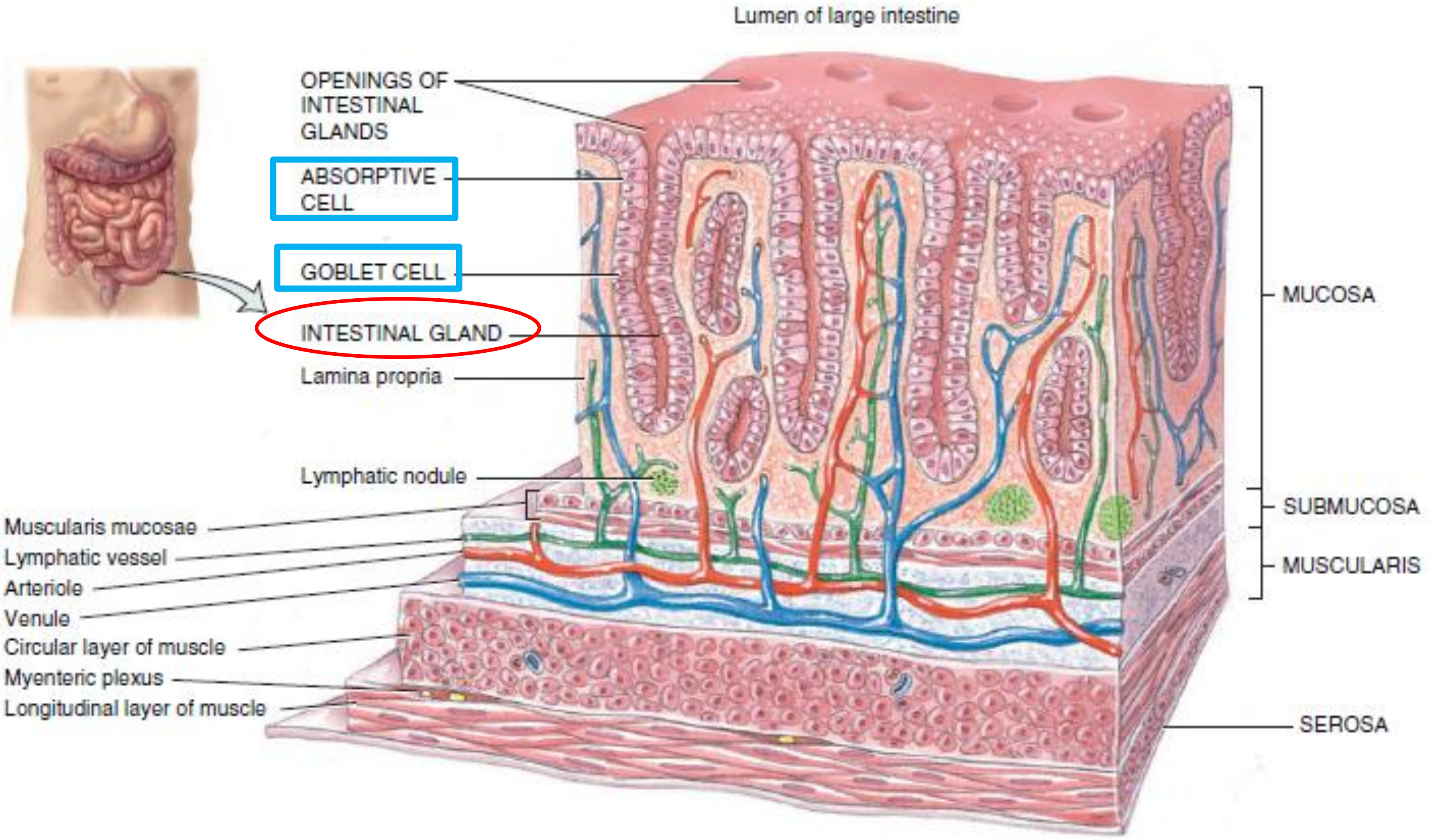


(a) Anterior view of large intestine showing

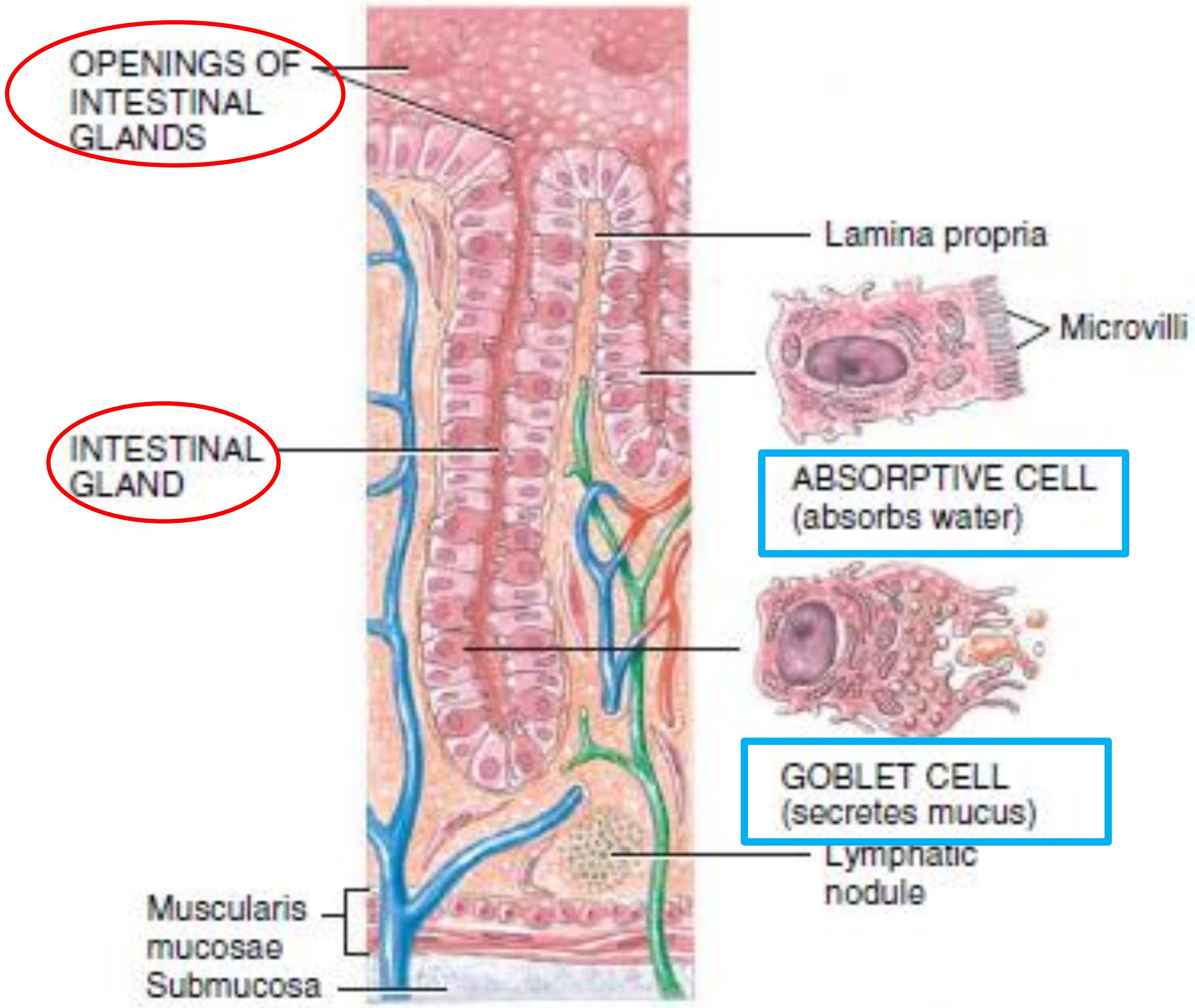
(b) Frontal section of anal canal

Figure 24.24 **Histology of the large intestine.**

Intestinal glands formed by simple columnar epithelial cells and goblet cells extend the full thickness of the mucosa.



(a) Three-dimensional view of layers of large intestine



(b) Sectional view of intestinal glands and cell types

MECHANICAL DIGESTION IN THE LARGE INTESTINE

- **The passage of chyme from the ileum into the cecum is** regulated by the action of the **ileocecal sphincter**.
- Normally, **the valve remains partially closed so that the passage of chyme into the cecum usually occurs slowly.**
- **Immediately after a meal**, **a gastroileal reflex intensifies** peristalsis in the ileum and forces **any chyme into the cecum**.
- **The hormone gastrin** also **relaxes the sphincter**.
- **Whenever the cecum is distended, the degree of contraction of the ileocecal sphincter intensifies.**

strech (امتداد)

depend on

MECHANICAL DIGESTION IN THE LARGE INTESTINE

- Movements of the colon begin when substances pass the ileocecal sphincter.
- Because chyme moves through the small intestine at a fairly constant rate, the time required for a meal to pass into the colon is determined by gastric emptying time.

تراكم

As food passes through the ileocecal sphincter, it fills the cecum and accumulates in the ascending colon. → the begin haustral churning

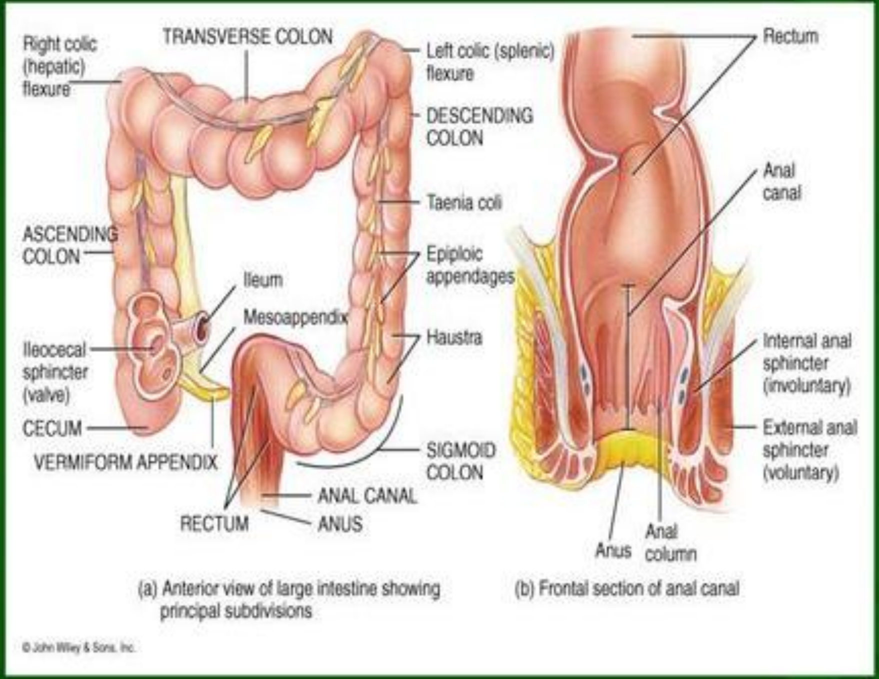
→ digestion remainder substance (begin from ascending to half transverse)

One movement characteristic of the large intestine is haustral churning. In this process, the haustra remain relaxed and become distended while they fill up. When the distension reaches a certain point, the walls contract and squeeze the contents into the next haustrum.

Peristalsis also occurs, although at a slower rate (3–12 contractions per minute) than in more proximal portions of the tract.

→ In some time happen the haustral churning

Haustral churning



- Each segment in large intestine is called a haustra
- Smooth muscle contractions move contents along (type of peristalsis)
- Water is absorbed in large intestine

MECHANICAL DIGESTION IN THE LARGE INTESTINE

(absorption to remainder substance)

- A final type of movement is **mass peristalsis**, a strong peristaltic wave that **begins at about the middle of the transverse colon** → to end **and quickly drives the contents of the colon into the rectum.** segmoid colon

- Because food in the stomach initiates this gastrocolic reflex in the colon, **mass peristalsis usually takes place three or four times a day, during or immediately after a meal.**

CHEMICAL DIGESTION IN THE LARGE INTESTINE

- **The final stage of digestion occurs in the colon through the activity of bacteria that** inhabit the lumen. Mucus is secreted by the glands of the large intestine, but no enzymes are secreted.

- **Chyme is prepared for elimination by the action of bacteria, which ferment any remaining carbohydrates and release hydrogen, carbon dioxide, and methane gases. These gases contribute to flatus (gas) in the colon, termed flatulence when it is excessive.**

- **Bacteria also convert any remaining proteins to amino acids and break down the amino acids into simpler substances**: indole, skatole,hydrogen sulfide, and fatty acids.

- Bacteria also **decompose bilirubin to simpler pigments**, including stercobilin, **which gives feces their brown color.**

- Bacterial products that are absorbed in the colon include **several vitamins needed for normal metabolism, among them some B vitamins and vitamin K.**

called flatulus when excessive fermentation

ABSORPTION AND FECES FORMATION IN THE LARGE INTESTINE

- By the time chyme **has remained in the large intestine 3–10 hours,** **it has become solid or semisolid because of water absorption and is now called feces**.
- Chemically, feces consist of water, inorganic salts, sloughed-off epithelial cells from the mucosa of the gastrointestinal tract, bacteria, products of bacterial decomposition, unabsorbed digested materials, and indigestible parts of food.
- Although 90% of all water absorption occurs in the small intestine, **the large intestine absorbs enough to make it an important organ in maintaining the body's water balance**.
- **The large intestine also absorbs ions, including sodium and chloride, and some vitamins.**

THE DEFECATION REFLEX

- **Mass peristaltic movements** push fecal material from the sigmoid colon into the rectum.

- The resulting distension of the rectal wall stimulates stretch receptors, which initiates a defecation reflex that results in defecation, the elimination of feces from the rectum through the anus.

Function

THE DEFECATION REFLEX

الإطعام الغذائي

- **The amount of bowel movements** that a person has over a given period of time **depends on various factors such as diet, health, and stress**.

الحركة المعوية

- **The normal range of bowel activity varies from two or three bowel movements per day to three or four bowel movements per week.**
- **Diarrhea** is an increase in the frequency, volume, and fluid content of the feces caused by increased motility of and decreased absorption by the intestines.
- **Constipation** refers to infrequent or difficult defecation caused by decreased motility of the intestines.

TABLE 24.6

Summary of Digestive Activities in the Large Intestine

STRUCTURE	ACTIVITY	FUNCTION(S)
Lumen	Bacterial activity.	Breaks down undigested carbohydrates, proteins, and amino acids into products that can be expelled in feces or absorbed and detoxified by liver; synthesizes certain B vitamins and vitamin K.
Mucosa	Secretes mucus.	Lubricates colon; protects mucosa.
	Absorption.	Water absorption solidifies feces and contributes to body's water balance; solutes absorbed include ions and some vitamins.
Muscularis	Haustral churning.	Moves contents from haustrum to haustrum by muscular contractions.
	Peristalsis.	Moves contents along length of colon by contractions of circular and longitudinal muscles.
	Mass peristalsis.	Forces contents into sigmoid colon and rectum.
	Defecation reflex.	Eliminates feces by contractions in sigmoid colon and rectum.

TABLE 24.7

Summary of Organs of the Digestive System and Their Functions

ORGAN	FUNCTION(S)
Tongue	Maneuvers food for mastication, shapes food into a bolus, maneuvers food for deglutition, detects sensations for taste, and initiates digestion of triglycerides.
Salivary glands	Saliva produced by these glands softens, moistens, and dissolves foods; cleanses mouth and teeth; initiates the digestion of starch.
Teeth	Cut, tear, and pulverize food to reduce solids to smaller particles for swallowing.
Pancreas	Pancreatic juice buffers acidic gastric juice in chyme, stops the action of pepsin from the stomach, creates the proper pH for digestion in the small intestine, and participates in the digestion of carbohydrates, proteins, triglycerides, and nucleic acids.
Liver	Produces bile, which is required for the emulsification and absorption of lipids in the small intestine.
Gallbladder	Stores and concentrates bile and releases it into the small intestine.
Mouth	See the functions of the tongue, salivary glands, and teeth, all of which are in the mouth. Additionally, the lips and cheeks keep food between the teeth during mastication, and buccal glands lining the mouth produce saliva.
Pharynx	Receives a bolus from the oral cavity and passes it into the esophagus.
Esophagus	Receives a bolus from the pharynx and moves it into the stomach; this requires relaxation of the upper esophageal sphincter and secretion of mucus.
Stomach	Mixing waves combine saliva, food, and gastric juice, which activates pepsin, initiates protein digestion, kills microbes in food, helps absorb vitamin B_{12}, contracts the lower esophageal sphincter, increases stomach motility, relaxes the pyloric sphincter, and moves chyme into the small intestine.
Small intestine	Segmentation mixes chyme with digestive juices; peristalsis propels chyme toward the ileocecal sphincter; digestive secretions from the small intestine, pancreas, and liver complete the digestion of carbohydrates, proteins, lipids, and nucleic acids; circular folds, villi, and microvilli help absorb about 90% of digested nutrients.
Large intestine	Haustral churning, peristalsis, and mass peristalsis drive the colonic contents into the rectum; bacteria produce some B vitamins and vitamin K; absorption of some water, ions, and vitamins occurs; defecation.

THANK YOU

AMJADZ@HU.EDU.JO