



Physiology of Digestive System

By

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3rd Year/ Lecture 3

The Liver, Gallbladder, and Pancreas

- ▶ Small intestine receives chyme from stomach
- ▶ Also secretions from liver and pancreas
 - ▶ Enter digestive tract near the junction of stomach and small intestine
- ▶ Secretions are so important to the digestive process of the small intestine

The Liver

- ▶ Liver—reddish brown gland located immediately inferior to the diaphragm
- ▶ The body's largest gland
 - ▶ Weighs about 1.4 kg (3 lb)
- ▶ Variety of functions
 - ▶ Secretes bile which contributes to digestion

Gross Anatomy

- ▶ Four lobes—right, left, quadrate, and caudate
 - ▶ Falciform ligament separates left and right lobes
 - ▶ Sheet of mesentery that suspends the liver from the diaphragm
 - ▶ Round ligament (ligamentum teres)—fibrous remnant of umbilical vein
 - ▶ Carries blood from umbilical cord to liver of the fetus
- ▶ From inferior view, squarish quadrate lobe next to the gallbladder and a tail-like caudate lobe posterior to that

Gross Anatomy

- ▶ Porta hepatis—irregular opening between these lobes
 - ▶ Point of entry for the hepatic portal vein and proper hepatic artery
 - ▶ Point of exit for the bile passages
 - ▶ All travel in lesser omentum
- ▶ Gallbladder—adheres to a depression on the inferior surface of the liver, between right and quadrate lobes
- ▶ Bare area on superior surface where it attaches to diaphragm

Gross Anatomy of the Liver

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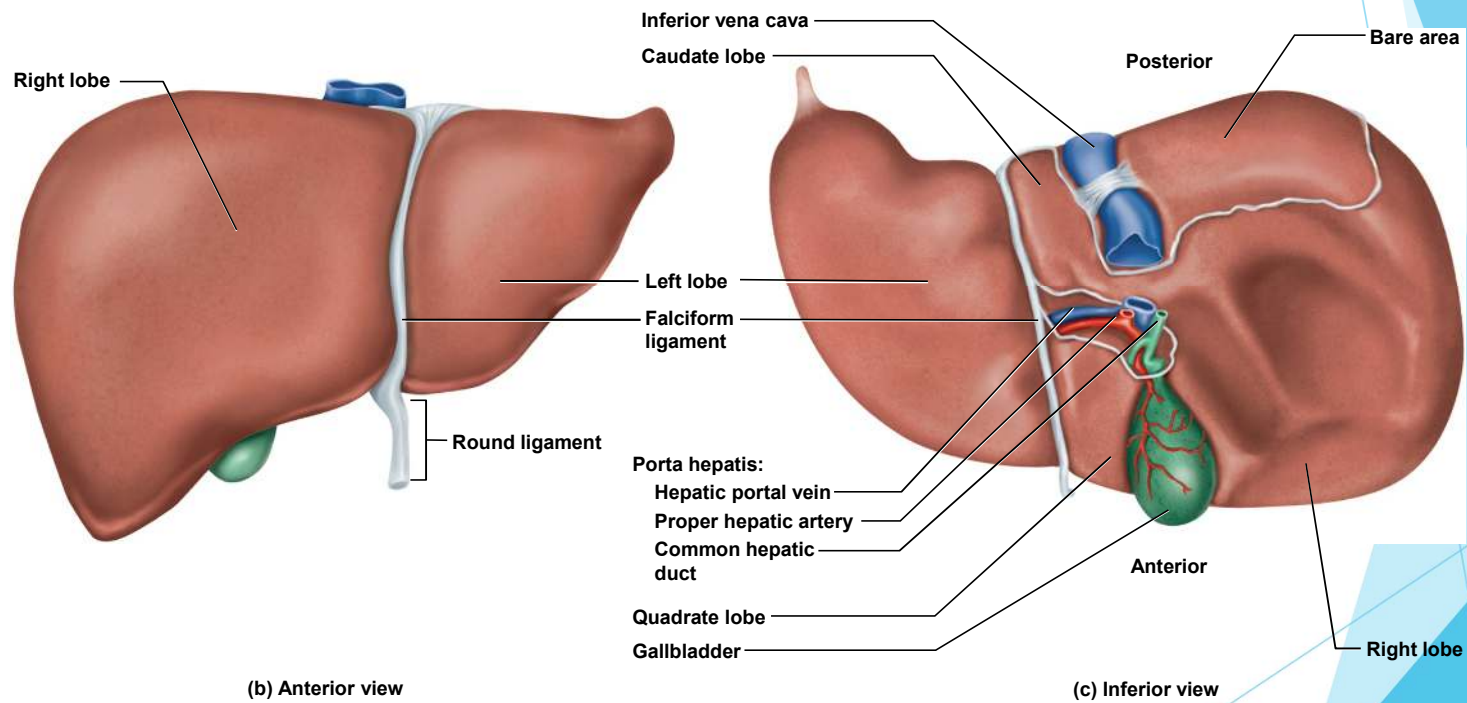


Figure 25.19b,c

Microscopic Anatomy of the Liver

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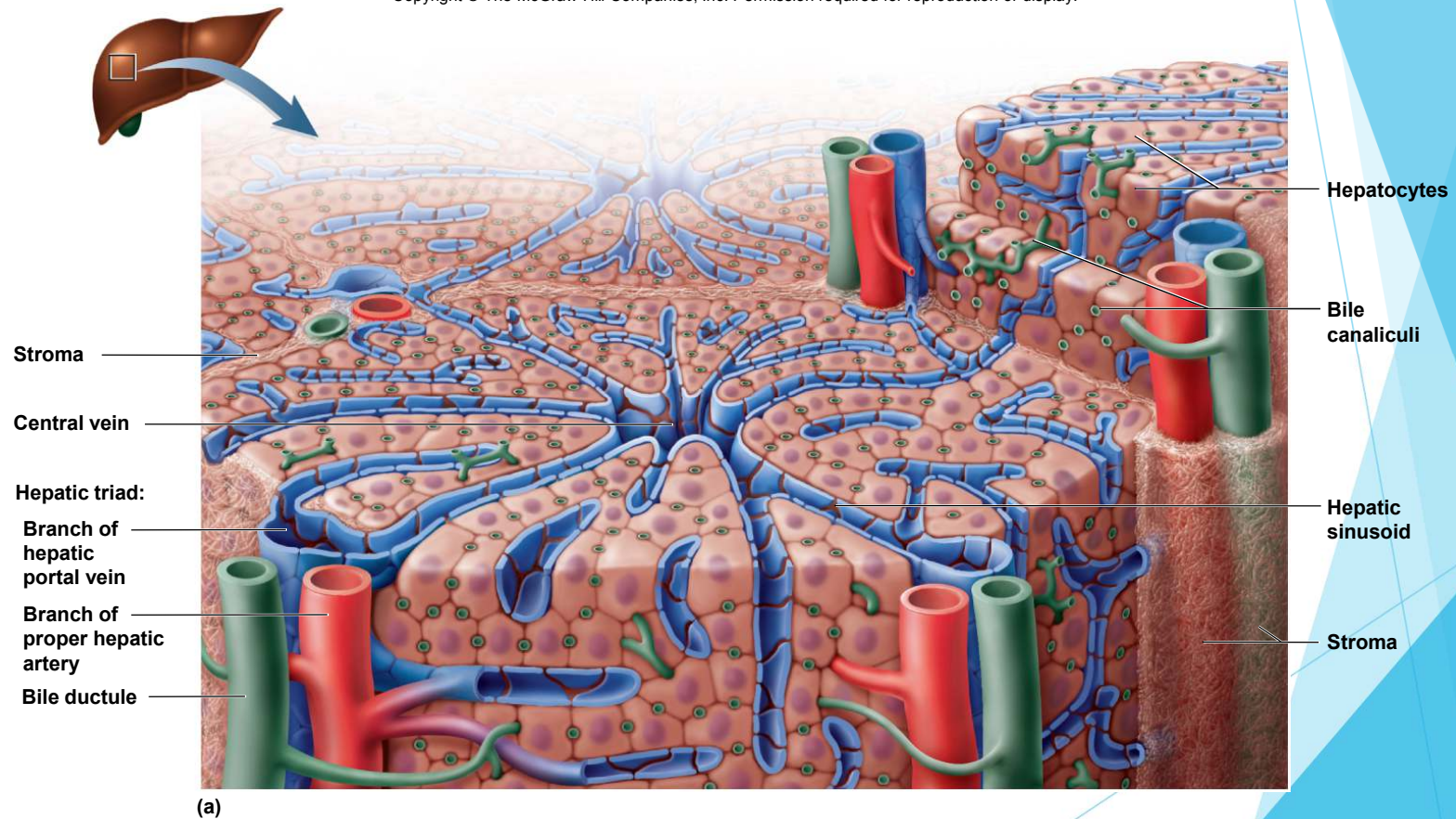


Figure 25.20a

Microscopic Anatomy

- ▶ Hepatic lobules—tiny innumerable cylinders that fill the interior of the liver
 - ▶ About 2 mm long and 1 mm in diameter
 - ▶ Central vein: passing down the core
 - ▶ Hepatocytes: cuboidal cells surrounding central vein in radiating sheets or plates
 - ▶ Each plate of hepatocytes is an epithelium one or two cells thick
- ▶ Hepatic sinusoids: blood-filled channels that fill spaces between the plates
 - ▶ Lined by a fenestrated endothelium that separates hepatocytes from blood cells

Microscopic Anatomy

Cont.

- ▶ Allows plasma into the space between the hepatocytes and endothelium
- ▶ Hepatocytes have brush border of microvilli that project into this space
- ▶ Blood filtered through the sinusoids comes directly from the stomach and intestines
- ▶ Hepatic macrophages (Kupffer cells): phagocytic cells in the sinusoids that remove bacteria and debris from the blood

Microscopic Anatomy

- ▶ After a meal, the hepatocytes absorb from the blood—glucose, amino acids, iron, vitamins, and other nutrients for metabolism or storage
- ▶ Removes and degrades
 - ▶ Hormones, toxins, bile pigments, and drugs
- ▶ Secretes into the blood
 - ▶ Albumin, lipoproteins, clotting factors, angiotensinogen, and other products
- ▶ Between meals, hepatocytes break down stored glycogen and release glucose into the blood

Microscopic Anatomy

- ▶ Hepatic lobules are separated by a sparse connective tissue stroma
- ▶ Hepatic triad of two vessels and a bile ductule, visible in the triangular areas where three or more lobules meet
 - ▶ Small branch of proper hepatic artery

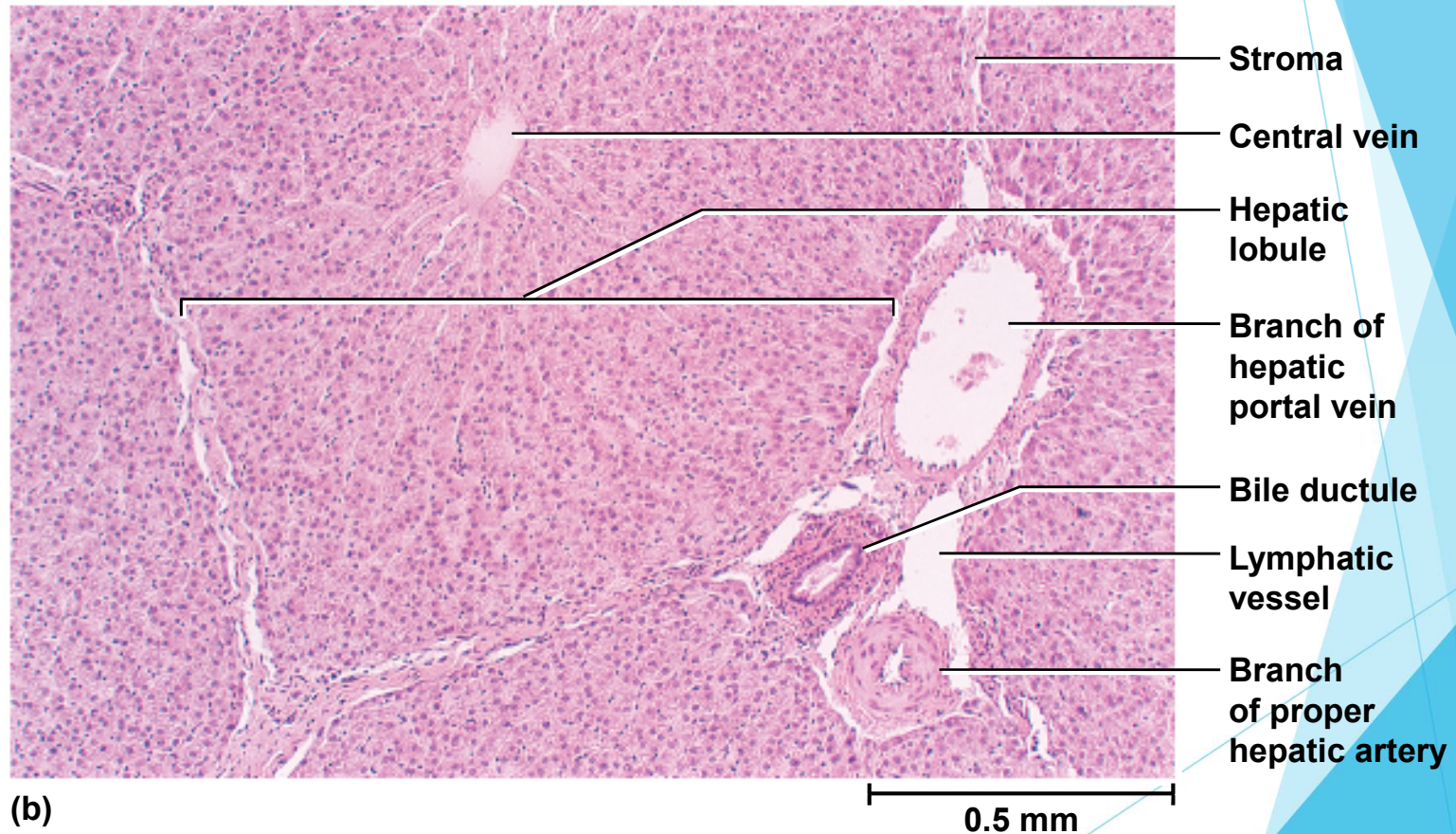
Microscopic Anatomy

cont.

- ▶ Small branch of the hepatic portal vein
 - ▶ Both supply blood to sinusoids which receive a mixture of nutrient-laden venous blood from the intestines, and freshly oxygenated arterial blood from the celiac trunk
 - ▶ After filtering through the sinusoids, the blood is collected in the central vein
 - ▶ Ultimately flows into the right and left hepatic veins
 - ▶ Leave the liver at its superior surface and immediately drain into the inferior vena cava

Microscopic Anatomy

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(b)

Figure 25.20b

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Microscopic Anatomy

- ▶ Bile canaliculi—narrow channels into which the liver secretes bile
 - ▶ Bile passes into bile ductules of the triads
 - ▶ Ultimately into the right and left hepatic ducts
 - ▶ Common hepatic duct: formed from convergence of right and left hepatic ducts on inferior side of the liver
 - ▶ Cystic duct coming from gallbladder joins common hepatic duct
 - ▶ Bile duct: formed from union of cystic and common hepatic ducts
 - ▶ Descends through lesser omentum toward the duodenum

Microscopic Anatomy

Cont.

- ▶ Near duodenum, bile duct joins duct of pancreas
- ▶ Forms expanded chamber: hepatopancreatic ampulla
 - ▶ Terminates in a fold of tissue—major duodenal papilla on duodenal wall
- ▶ Major duodenal papilla contains muscular hepatopancreatic sphincter (sphincter of Oddi)
 - ▶ Regulates passage of bile and pancreatic juice into duodenum
 - ▶ Between meals, sphincter closes and prevents release of bile into the intestines

Gross Anatomy of the Gallbladder, Pancreas, and Bile Passages

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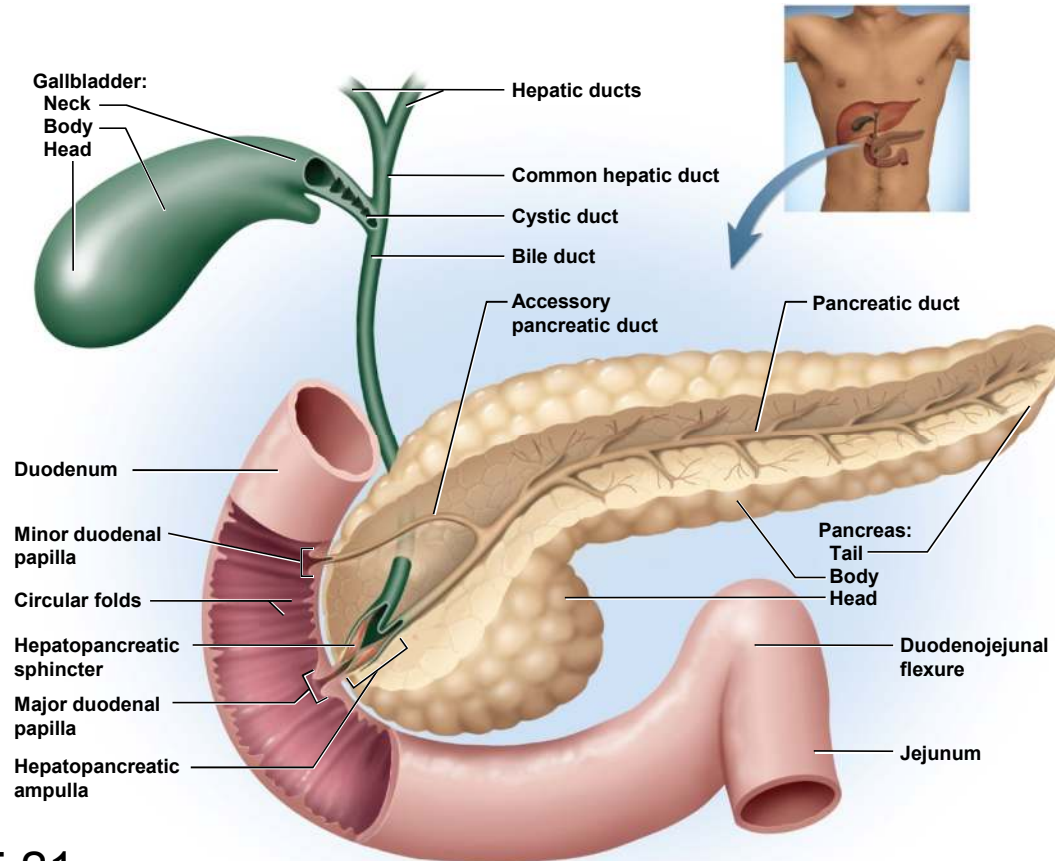


Figure 25.21

The Gallbladder and Bile

- ▶ Gallbladder—a pear-shaped sac on underside of liver
 - ▶ Serves to store and concentrate bile by a factor of 20 by absorbing water and electrolytes
 - ▶ About 10 cm long
 - ▶ Internally lined by highly folded mucosa with simple columnar epithelium
 - ▶ Head (fundus) usually projects slightly beyond inferior margin of liver
 - ▶ Neck (cervix) leads into the cystic duct

The Gallbladder and Bile

- ▶ Bile—yellow-green fluid containing minerals, cholesterol, neutral fats, phospholipids, bile pigments, and bile acids
 - ▶ Bilirubin: principal pigment derived from the decomposition of hemoglobin
 - ▶ Bacteria in large intestine metabolize bilirubin to urobilinogen
 - ▶ Responsible for the brown color of feces
 - ▶ Bile acids (bile salts): steroids synthesized from cholesterol
 - ▶ Bile acids and lecithin, a phospholipid, aid in fat digestion and absorption
 - ▶ Gallstones may form if bile becomes excessively concentrated

The Gallbladder and Bile

Cont.

- ▶ Bile gets to the gallbladder by first filling the bile duct then overflowing into the gallbladder
- ▶ Liver secretes about 500 to 1,000 mL of bile daily
- ▶ 80% of bile acids are reabsorbed in the ileum and returned to the liver
 - ▶ Hepatocytes absorb and resecrete them
 - ▶ Enterohepatic circulation—route of secretion, reabsorption, and resecretion of bile acids two or more times during digestion of an average meal
- ▶ 20% of the bile acids are excreted in the feces
 - ▶ Body's only way of eliminating excess cholesterol
 - ▶ Liver synthesizes new bile acids from cholesterol to replace those lost in feces

The Gallbladder and Bile

- ▶ Gallstones (biliary calculi)—hard masses in either the gallbladder or bile ducts
 - ▶ Composed of cholesterol, calcium carbonate, and bilirubin
- ▶ Cholelithiasis—formation of gallstones
 - ▶ Most common in obese women over 40 due to excess cholesterol

The Gallbladder and Bile

- ▶ Obstruction of ducts
 - ▶ Painful
 - ▶ Cause jaundice: yellowing of skin due to bile pigment accumulation, poor fat digestion, and impaired absorption of fat-soluble vitamins
- ▶ Lithotripsy—use of ultrasonic vibration to pulverize stones without surgery

The Pancreas

- ▶ Pancreas—spongy retroperitoneal gland posterior to the greater curvature of the stomach
 - ▶ Measure 12 to 15 cm long, and 2.5 cm thick
 - ▶ Has head encircled by duodenum, body, midportion, and a tail on the left
 - ▶ Both an endocrine and exocrine gland
 - ▶ Endocrine portion—pancreatic islets that secrete insulin and glucagon
 - ▶ Exocrine portion—99% of pancreas that secretes 1,200 to 1,500 mL of pancreatic juice per day
 - ▶ Secretory acini release their secretion into small ducts that converge on the main pancreatic duct

The Pancreas

Cont.

- ▶ Pancreatic duct runs lengthwise through the middle of the gland
 - ▶ Joins the bile duct at the hepatopancreatic ampulla
 - ▶ Hepatopancreatic sphincter controls release of both bile and pancreatic juice into the duodenum
- ▶ Accessory pancreatic duct: smaller duct that branches from the main pancreatic duct
 - ▶ Opens independently into the duodenum
 - ▶ Bypasses the sphincter and allows pancreatic juice to be released into duodenum even when bile is not

The Pancreas

Cont.

- ▶ Pancreatic juice: alkaline mixture of water, enzymes, zymogens, sodium bicarbonate, and other electrolytes
 - ▶ Acini secrete the enzymes and zymogens
 - ▶ Ducts secrete bicarbonate
 - ▶ Bicarbonate buffers HCl arriving from the stomach

Microscopic Anatomy of the Pancreas

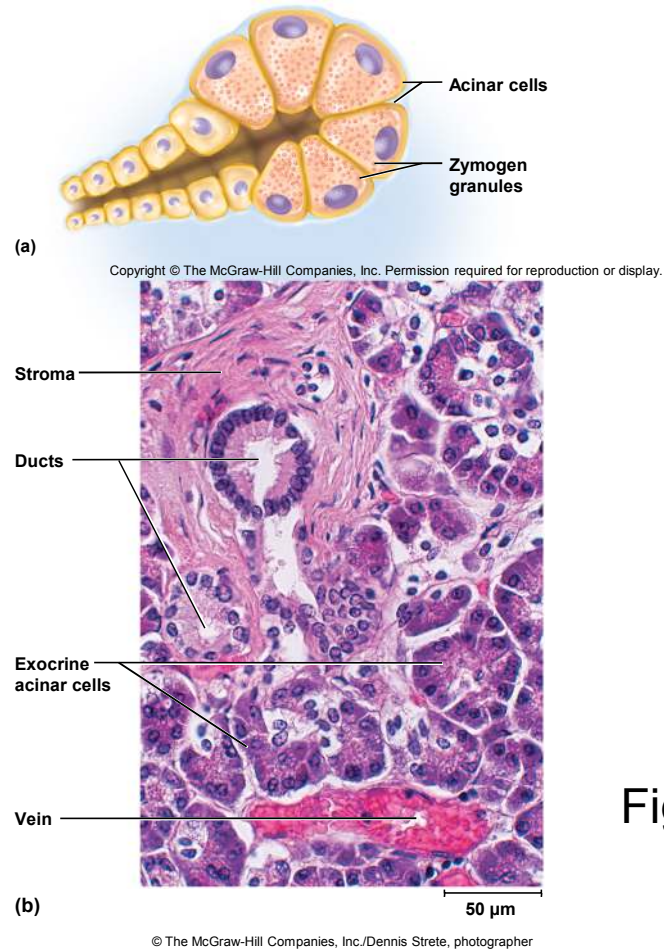


Figure 25.22a,b

The Pancreas

- ▶ Pancreatic zymogens are:
 - ▶ Trypsinogen
 - ▶ Secreted into intestinal lumen
 - ▶ Converted to trypsin by enterokinase, and enzyme secreted by mucosa of small intestine
 - ▶ Trypsin is autocatalytic—converts trypsinogen into still more trypsin
 - ▶ Chymotrypsinogen: converted to trypsinogen by trypsin
 - ▶ Procarboxypeptidase: converted to carboxypeptidase by trypsin

The Pancreas

- ▶ Other pancreatic enzymes
 - ▶ Pancreatic amylase: digests starch
 - ▶ Pancreatic lipase: digests fat
 - ▶ Ribonuclease and deoxyribonuclease: digest RNA and DNA respectively

The Activation of Pancreatic Enzymes in the Small Intestine

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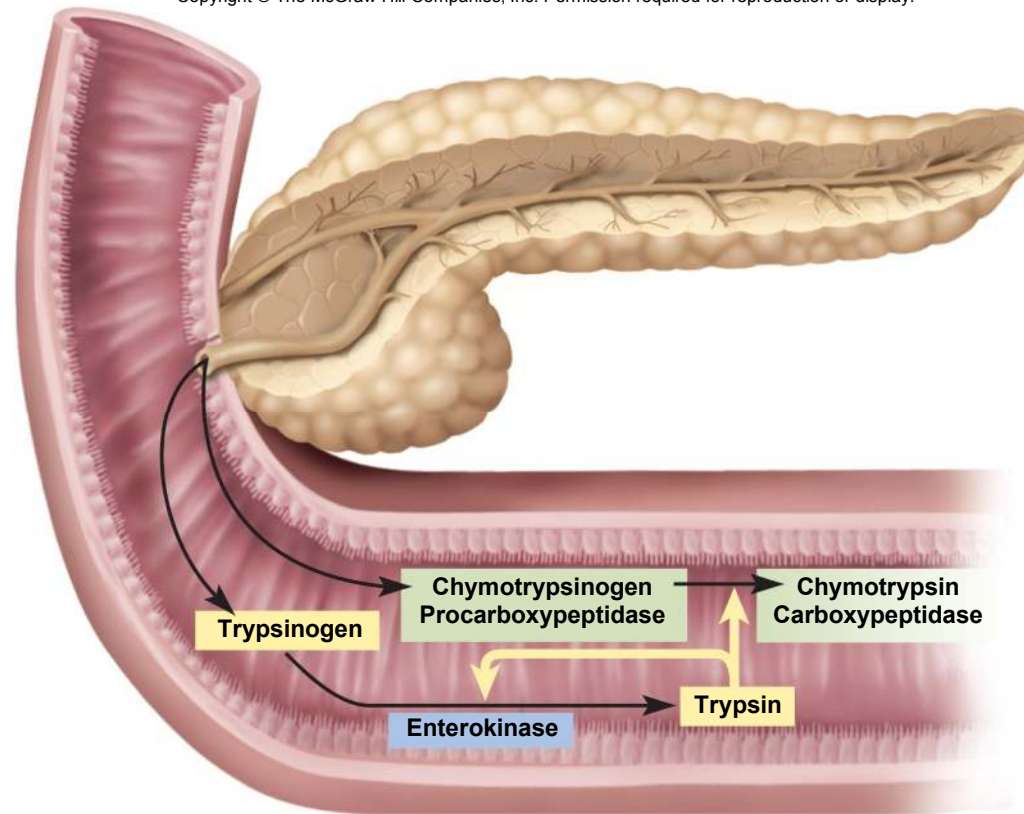


Figure 25.23

Regulation of Secretion

- ▶ Three stimuli are chiefly responsible for the release of pancreatic juice and bile
 - ▶ Acetylcholine (ACh): from vagus and enteric nerves
 - ▶ Stimulates acini to secrete their enzymes during the cephalic phase of gastric control even before food is swallowed
 - ▶ Enzymes remain in acini and ducts until chyme enters the duodenum

Regulation of Secretion

Cont.

- ▶ Cholecystikinin (CCK): secreted by mucosa of duodenum in response to arrival of fats in small intestine
 - ▶ Stimulates pancreatic acini to secrete enzymes
 - ▶ Strongly stimulates gallbladder
 - ▶ Induces contractions of the gallbladder and relaxation of hepatopancreatic sphincter causing discharge of bile into the duodenum
- ▶ Secretin: released from duodenum in response to acidic chyme arriving from the stomach
 - ▶ Stimulates ducts of both liver and pancreas to secrete more sodium bicarbonate
 - ▶ Raising pH to level pancreatic and intestinal digestive enzymes require