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Topic:

Structure of Mammalian Digestive Glands

by

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Structure of Mammalian Digestive Glands

- Digestive system of mammals consists of gastrointestinal tract or alimentary canal and accessory digestive glands, (Fig: I) which helps in process of digestion. In addition to this, it hepls in process of *osmoregulation , endocrine secretions, immune functions and the elimination of toxins.*

- The gastrointestinal tract of mammals is a continuous tube running from mouth to anus. The major organs of alimentary canal are : **mouth, buccal cavity, pharynx, esophagus, stomach (and rumen in ruminants), small intestine, large intestine, anus.**

- Digestive glands are located outside the digestive tract and secrete fluids into it. They consists of : **salivary glands, liver, gallbladder, and pancreas.** Besides these there are many other galnds located inside the alimentry canal: **mucous glands, Gastric glands, pyloric glands .**

- These secretory glands have two primary functions:
  i) **Secrete digestive enzymes, in** most areas of the alimentary tract, from the mouth to the distal end of the ileum, which help in chemical breakdown of food.
  ii) **Provide mucous** , from the mouth to the anus, for lubrication and protection of all parts of the alimentary tract.

- Most digestive secretions are formed only in **response to the presence of food** in the alimentary tract, and the **quantity** secreted in each segment of the tract is almost exactly the amount needed for proper digestion.
  *(**direct stimulation** of the surface of glandular cells) and epithelial stimulation activates **enteric nervous system** of the gut wall. The resulting nervous reflexes stimulate both the mucous cells and deeper glands to secrete their secretion)*

Structure of Mammalian Digestive Glands

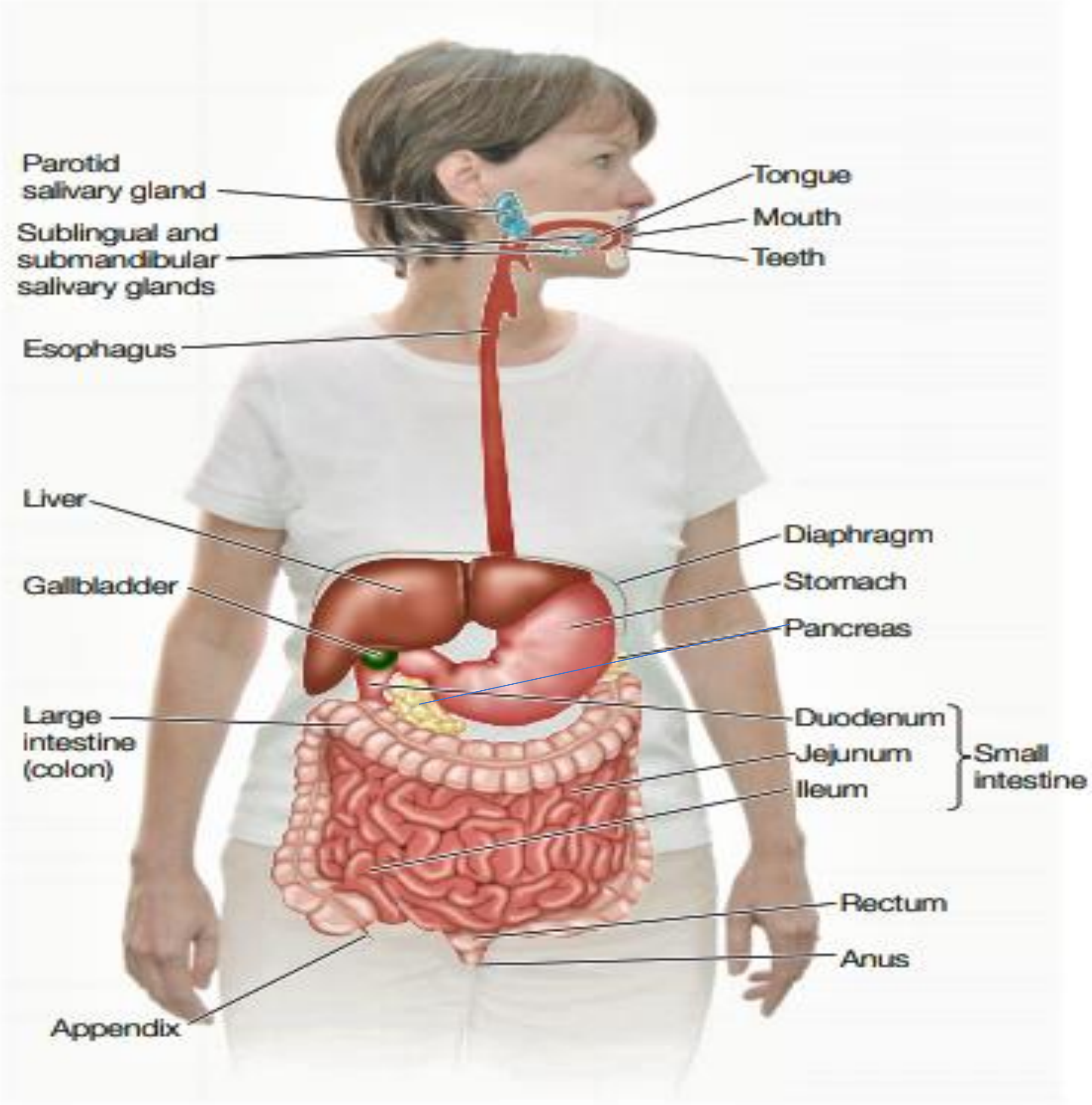


Fig. 1 showing digestive system and its associated digestive glands (in humans)

Structure of Mammalian Digestive Glands

A. Salivary glands

- Salivary glands are scattered throughout the oral cavity (Fig: 2 a & b). They are meant for the release of **saliva.**
- There are three pairs of large, multicellular salivary glands:

i) **The parotid,**

ii) **The submandibular, and**

iii) **The sublingual glands .**

- In addition to these large salivary glands, numerous small, coiled, tubular salivary glands are located deep to the epithelium of :
  - the tongue (lingual glands), - secrete lingual lipase
  - the palate (palatine glands),
  - the cheeks (buccal glands),-- secrete mucus, and
  - the lips (labial glands).
- All of the major large salivary glands are **compound acinar glands**, which are branching glands with clusters of acini resembling grapes. They produce **thin serous secretions** (watery secretion containing enzymes, antibodies, and inorganic ions, which are mainly involved in digestion and defense) **or thicker mucous secretions** (viscous secretion, containing mucin, which is mainly involved in lubrication) Thus, saliva is a combination of serous and mucous secretions from the various salivary glands.

Structure of Mammalian Digestive Glands

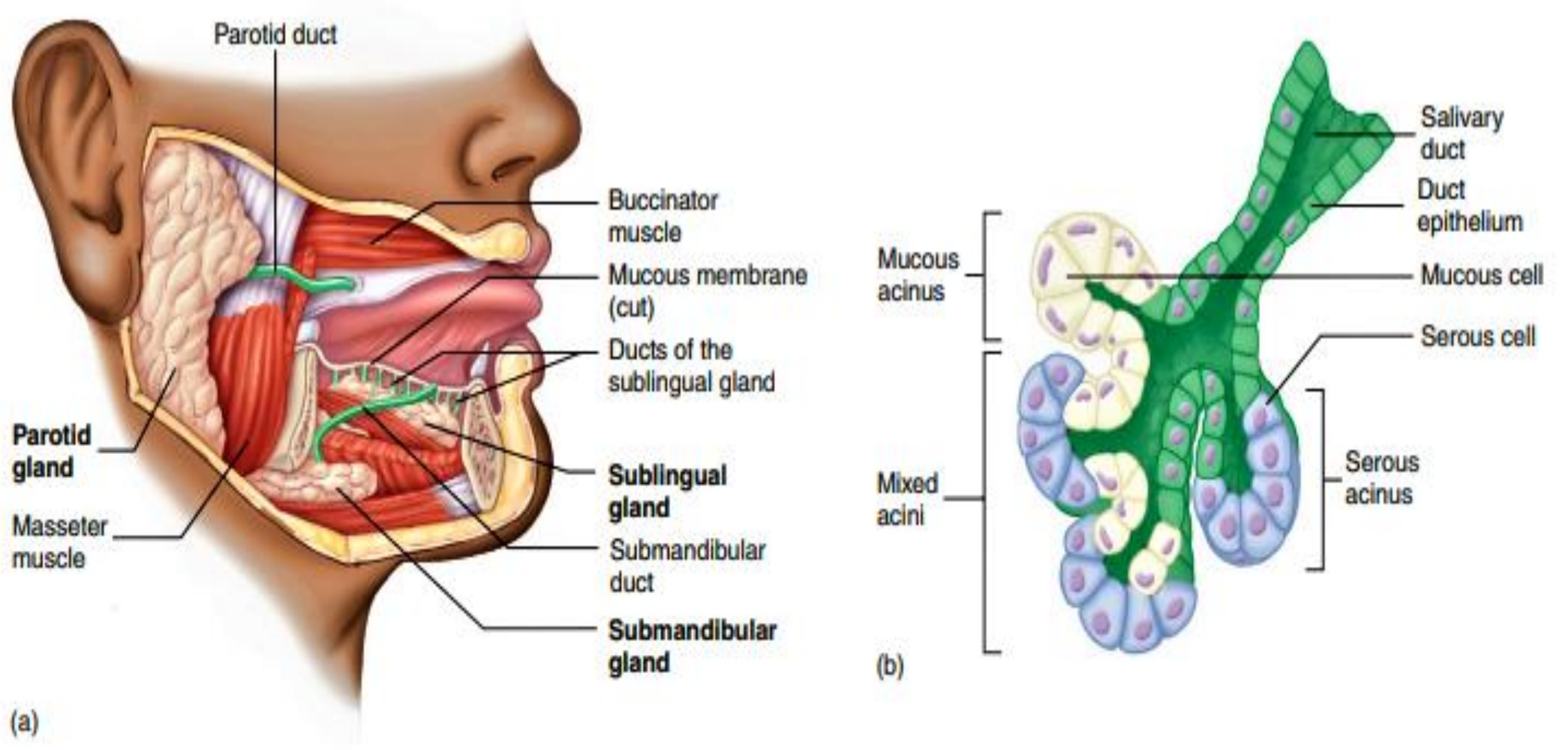


Fig. 2 a & b: Salivary glands

Structure of Mammalian Digestive Glands

i) The parotid glands

- The **largest** salivary glands,.
- The parotid glands(pă-rot′id; beside the ear), are located just anterior to the ear on each side of the head.
- They are ***serous glands,*** which produce mostly watery saliva.
- Each parotid duct (Stenson duct) exits the gland on its anterior margin, crosses the lateral surface of the masseter muscle, pierces the buccinator muscle, and enters the oral cavity adjacent to the **second upper molar** (Fig. 2 a).
- A viral infection can cause the parotid glands to become ***inflamed and swollen***, making the cheeks quite large. The most common type of viral infection results in **mumps.** The virus (*mumps orthorubulavirus*) causing mumps can also infect other tissues, including the testes, which can result in sterility in an adult male.

ii) The submandibular glands (below the mandible)

- Are mixed glands ***with more serous than mucous acini.***
- Each gland can be felt as a soft lump along the inferior border of the posterior half of the mandible.
- A submandibular duct (Whartons duct) exits each gland, passes anteriorly deep to the mucous membrane on the floor of the oral cavity, and opens into the oral cavity beside the frenulum of the tongue (Fig 2 a).

iii) The sublingual glands (below the tongue)

- The **smallest** of the three salivary glands.
- Are mixed glands containing ***some serous acini but consisting primarily of mucous acini.***
- They lie immediately below the mucous membrane in the floor of the oral cavity. These glands do not have single, well-defined ducts like those of the submandibular and parotid glands. Instead, each sublingual gland opens into the floor of the oral cavity through 10–12 small ducts (duct of Rivinus) (Fig. 2a).

Structure of Mammalian Digestive Glands

Saliva

- The salivary glands secrete a large amount of saliva at the rate of about **1–1.5 L/day Or 800 and 1500 milliliters /day.**

- Saliva contains two major types of protein secretion:

  (1) a serous secretion that contains **ptyalin (an α-amylase),** which is an enzyme for digesting starches, and

  (2) mucus secretion that contains **mucin** for lubricating and for surface protective purposes.

- Saliva has a pH between **6.0 and 7.0,** a favorable range for the *digestive action of ptyalin.*

- Mammalian saliva consists of about 99.5% H2O , 0.5% electrolytes and protein.

- Ruminants produce copious amounts of alkaline saliva. This saliva enables selective compartments of its stomach to house a population of microbes capable of digesting dietary cellulose. Salivary bicarbonates and phosphates buffer the acids produced during fermentation and maintain the pH of the ruminoreticulum within a narrow range. Urea is also recycled via the salivary glands back to the rumen microbes for protein synthesis. In nonruminant mammals, saliva is ultimately not as critical for digesting and absorbing foods, because enzymes produced by the pancreas and small intestine can digest food even in the absence of salivary and gastric secretion.

- Many carnivores, **such as dogs and cats, have no amylase** in their saliva; therefore, their natural diet contains very little starch.

Structure of Mammalian Digestive Glands

➢ **Saliva has multiple roles:**

i) **Moistening:** It helps keep the oral cavity moist , which is needed for *normal speech , lubrication of food particles , and act as solvent for molecules that stimulate taste buds .*

ii) **Digestion:** contain enzyme called **salivary amylase** (am′il-ās; starch-splitting enzyme) or **ptyalin** , which breaks the covalent bonds between glucose molecules in starch and other polysaccharides to produce the disaccharides maltose and isomaltose . *The release of maltose and isomaltose gives starches a sweet taste.* However, food spends very little time in the mouth, so only about **3–5% of the total carbohydrates are digested there**.

ii). **Defense:** against bacterial infections. —

i) Lysozyme- cause lysis of bacteria.
ii) Salivary agglutin- a glycoprotein that complexes with IgA antibodies and then binds to bacteria.
iii) Lactoferrin- which tightly binds to iron needed for bacterial multiplication.
iv) Rinsing away material that may serve as a food source for bacteria.

iv) **Neutralization** of acidic foods, as it is rich in bicarbonate buffers.

v) **Thermoregulation,** used as a means of temperature control in animals without sweat glands. e.g, Kangaroos actually spread saliva over their bodies, when outside temperatures approach lethal limits.

Structure of Mammalian Digestive Glands

Nervous regulation of salivary secretion

Salivary gland secretion is stimulated by both the parasympathetic and the sympathetic nervous systems, but the *parasympathetic system is the more important.* Salivary nuclei in the brainstem increase salivary secretions by *sending action potentials* through parasympathetic fibers of the **facial (VII)** and **glossopharyngeal (IX) cranial nerves** in response to a variety of stimuli, such as **tactile** stimulation in the oral cavity or certain tastes, especially **sour.** Higher centers of the brain also affect salivary gland activity. ***Odors that trigger thoughts of food or the sensation of hunger can increase saliva secretion.***

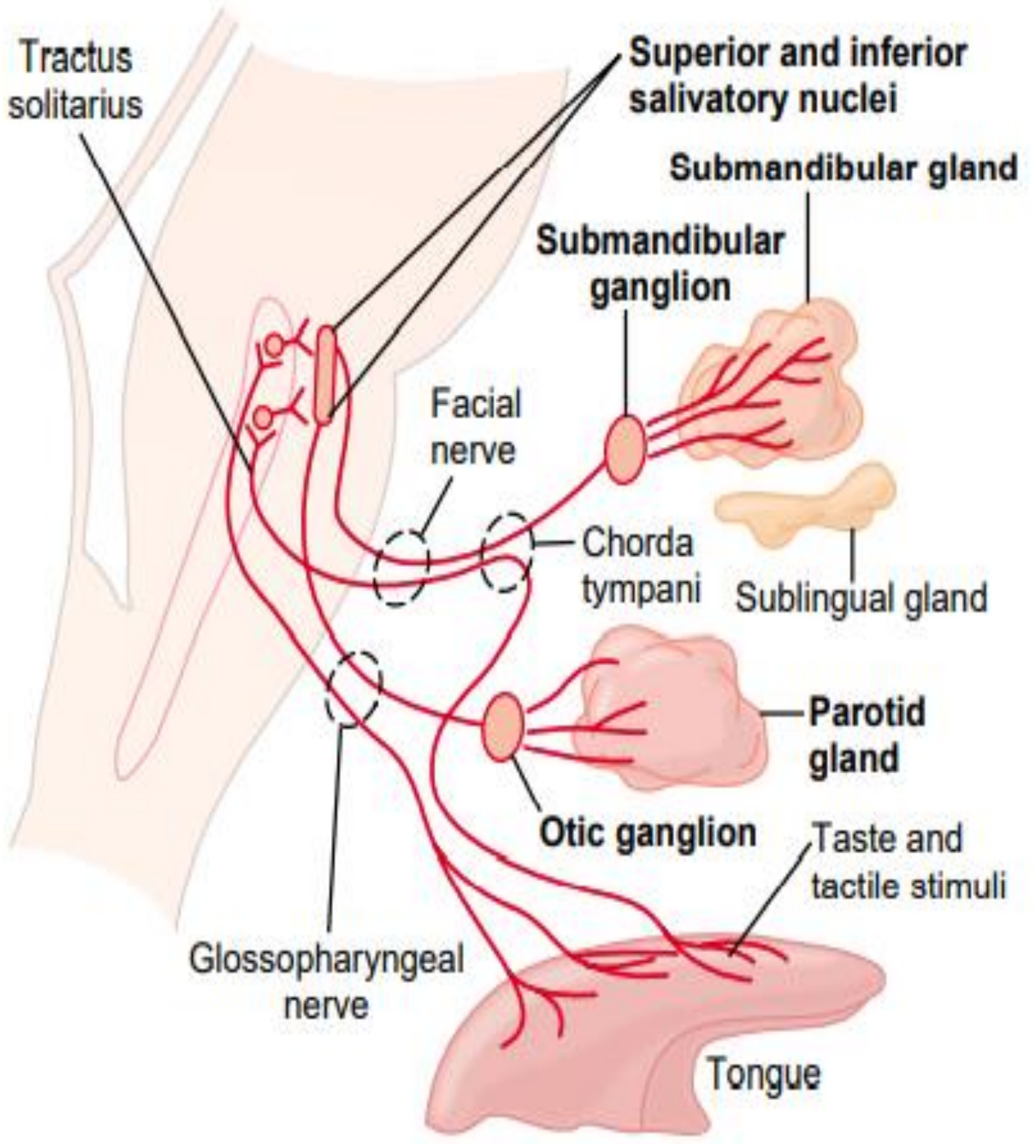


Fig. 3

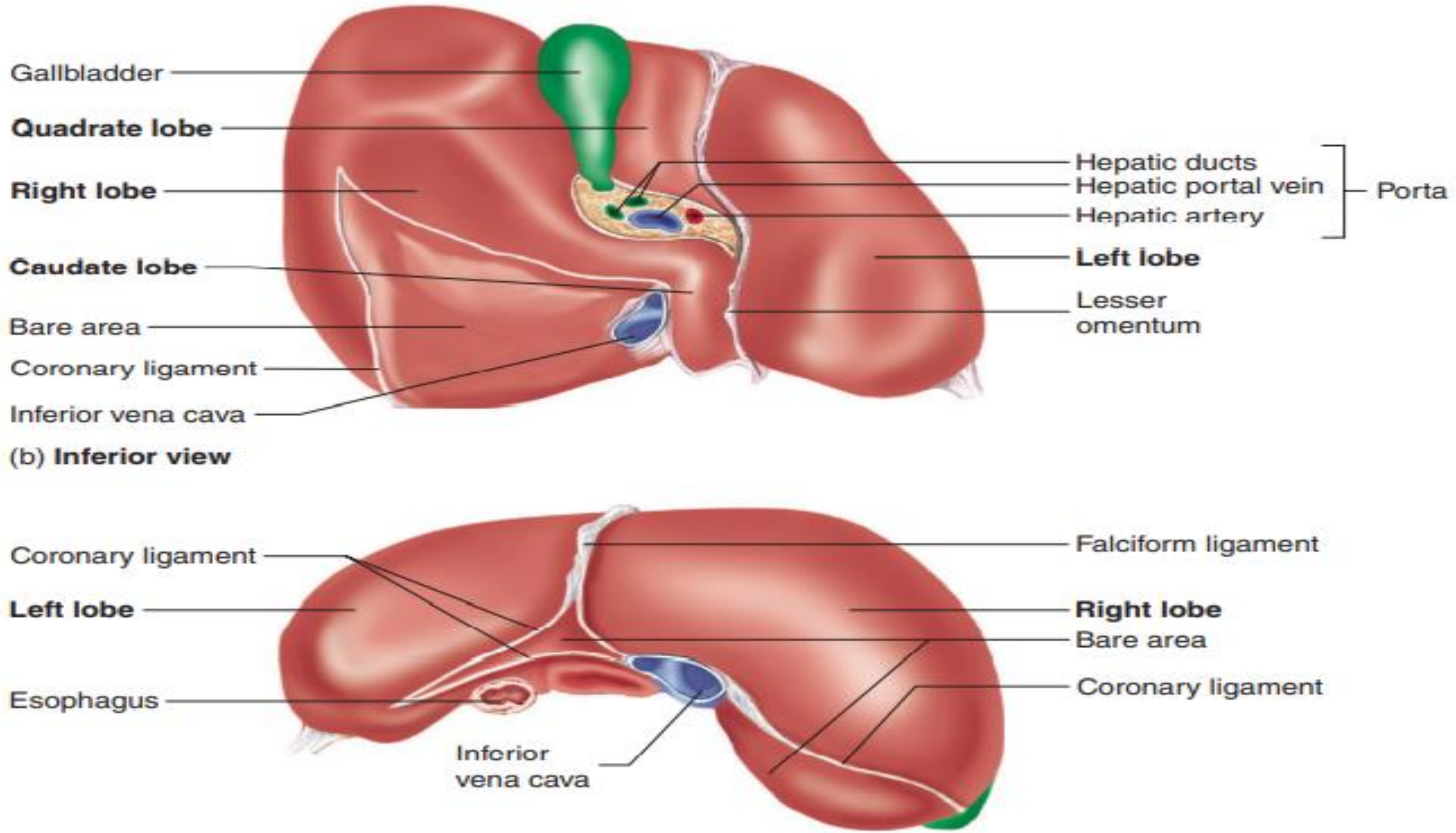
Structure of Mammalian Digestive Glands

B. Liver

Anatomy of the Liver

- The liver is the **largest internal gland** of the body, weighing about **1.36 kg (3 pounds)**.
- It is in the **right-**upper quadrant of the abdomen, tucked against the inferior surface of the diaphragm (Fig 4 a)
- The liver consists of two major lobes, **the right lobe and left lobe,** which are separated by a connective tissue septum, the **falciform ligament**. Two minor lobes, **the caudate lobe and the quadrate lobe**, can be seen from an inferior view, along with the porta.
- The **porta (gate)** is on the inferior surface of the liver, where the *various vessels, ducts, and nerves enter and exit the liver.* ***The hepatic Portal vein, the hepatic artery, and a small hepatic nerve plexus enter the liver through the porta*** (Fig 4 a)
- ***Lymphatic vessels and two hepatic ducts, one each from the right and left lobes, exit the liver at the porta.***
- The hepatic ducts transport **bile out of the liver.** (Fig 4 b).
- The right and left hepatic ducts unite to form a **single common hepatic duct** .
- The cystic duct from the gallbladder joins the common hepatic duct to form the **common bile duct,** which joins the pancreatic duct at the **hepatopancreatic duct.**
- The gallbladder is a small sac on the inferior surface of the liver that stores bile.
- Bile can flow from the gallbladder through the cystic duct into the common bile duct, or it can flow back up the cystic duct into the gallbladder

Structure of Mammalian Digestive Glands



(Fig. 4 a)

Structure of Mammalian Digestive Glands

Histology of the Liver (Fig. 5)

- A connective tissue capsule and visceral peritoneum cover the liver, except for the bare area, a small area on the diaphragmatic surface that lacks a visceral peritoneum and is surrounded by the **coronary ligament**.
- At the porta, the connective tissue capsule sends a branching network **of septa** (**walls**) into the substance of the liver to provide its main support. Vessels, nerves, and ducts follow the connective tissue branches throughout the liver.
- The connective tissue septa **divide the liver into hexagon-shaped lobules** with a portal triad at each corner .
- The triads are so named because three **vessels—the hepatic portal vein, hepatic artery, and hepatic duct**—are located in them.
- **Hepatic nerves and lymphatic vessels**, often too small to be seen easily in light micrographs, are also located in these areas.
- **A central vein** is in the center of each lobule. Central veins of the lobules unite to form **hepatic veins**, which exit the liver on its posterior and superior surfaces and empty into the inferior vena cava .
- **Hepatic cords** radiate out from the central vein of each **lobule** like the spokes of a wheel. The hepatic cords are composed of **hepatocytes,** the functional cells of the liver.
- The spaces between the hepatic cords are blood channels called hepatic sinusoids.
- The sinusoids are lined with a very thin, irregular squamous endothelium consisting of two cell populations:

  (1) extremely thin, **sparse endothelial cells and**

  (2) hepatic phagocytic cells, Kupffer cells.
- A cleftlike lumen, the **bile canaliculus** lies between the cells within each cord .

Structure of Mammalian Digestive Glands

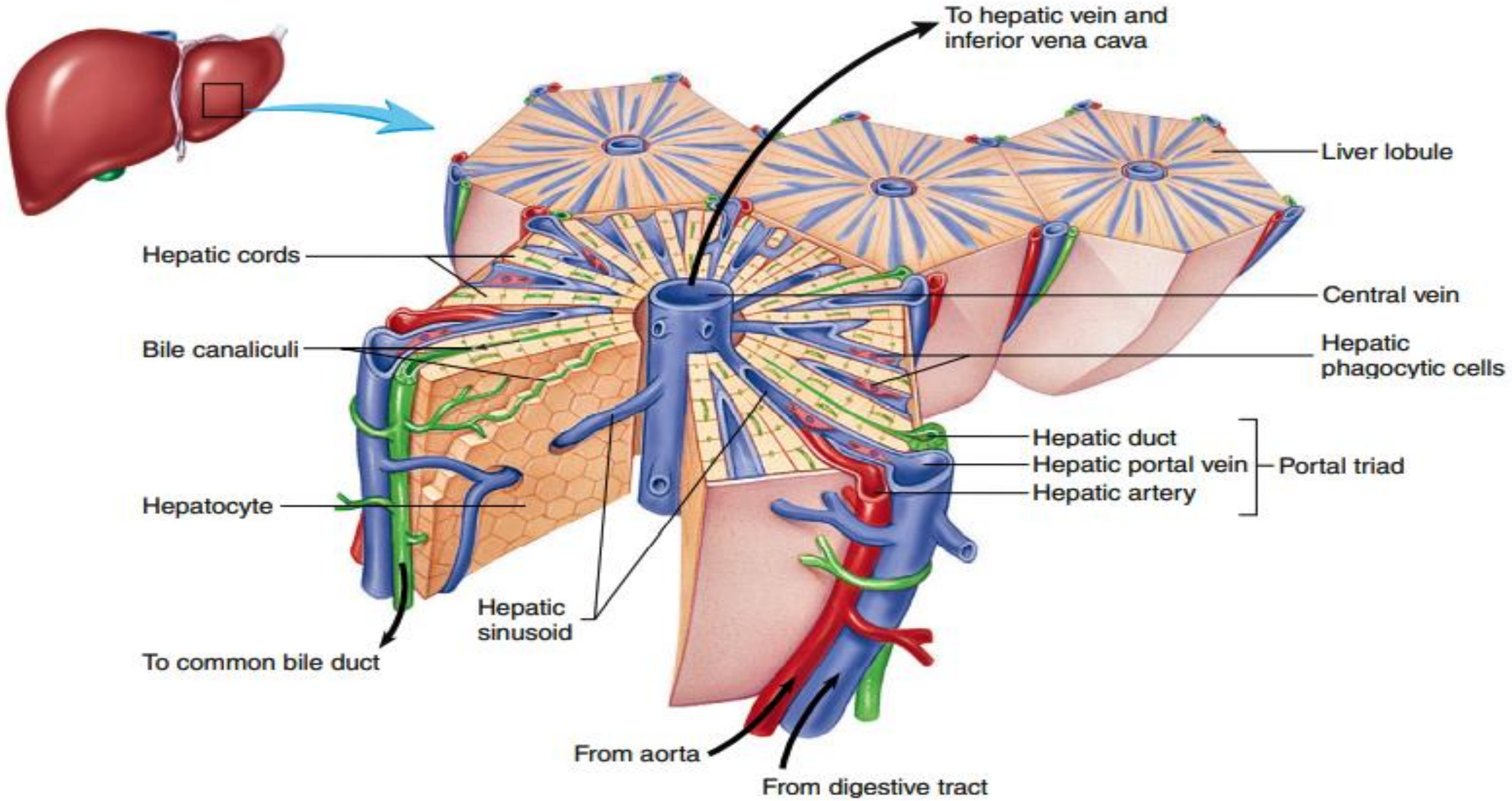


Fig. 5a: Histology of liver

Structure of Mammalian Digestive Glands

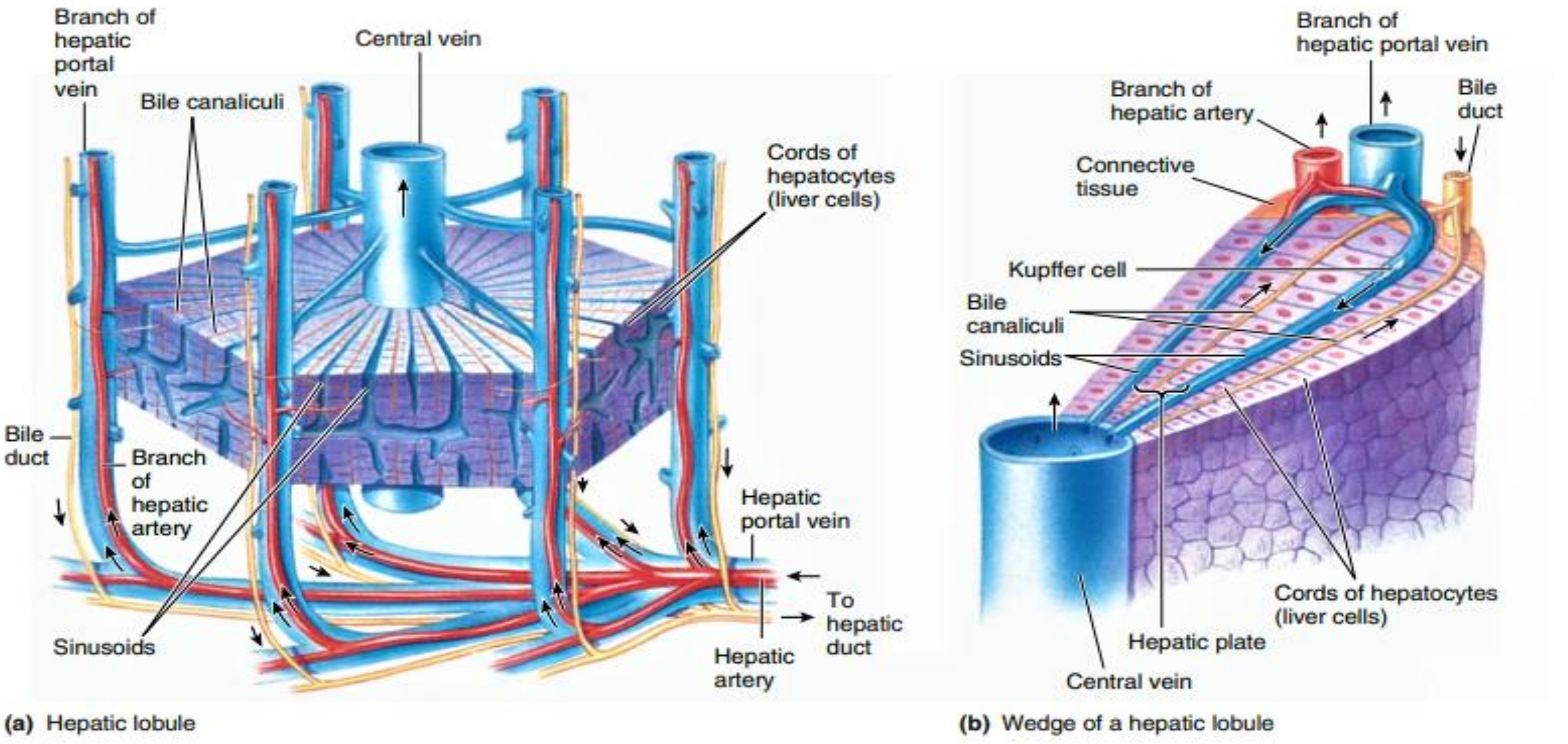


FIGURE 14-18 **Anatomy of the mammalian liver.**

Fig. 5b: Histology of liver

Structure of Mammalian Digestive Glands

- Hepatocytes have six major functions:
  (1) **bile production,**
  (2) **storage,**
  (3) **interconversion of nutrients,**
  (4) **detoxification,**
  (5) **phagocytosis, and**
  (6) **synthesis of blood components.**
- Nutrient rich, deoxygenated blood from the viscera enters the **hepatic sinusoid**s from branches of the **hepatic portal vein** and mixes with nutrient depleted, oxygenated blood from the hepatic arteries .
- From the blood, the **hepatocytes can take up the oxygen and nutrients, which are stored, detoxified, used for energy, or used to synthesize new molecules.**
- Molecules produced by or modified in the hepatocytes are released into **the hepatic sinusoids or into the bile canaliculi.**
- Mixed blood in the hepatic sinusoids flows to the **central vein,** where it exits the lobule and then exits the liver through the **hepatic veins.**
- Bile, produced by the hepatocytes and consisting primarily of metabolic by-products, flows through the bile canaliculi toward the hepatic triad and exits the liver through the **hepatic ducts.**
- Blood, therefore, flows from the triad toward the **center of each lobule**, whereas bile flows away from the center of the lobule **toward the triad.**
- In the fetus, special blood vessels bypass the liver sinusoids. The remnants of fetal blood vessels can be seen in the adult as the round ligament (**ligamentum teres) and the ligamentum venosum .**

Structure of Mammalian Digestive Glands

❖ Functions of the Liver

The liver performs important digestive and excretory functions, stores and processes nutrients, detoxifies harmful chemicals, and synthesizes new molecules.

I. Bile Production

- The liver produces and secretes about **600–1000 mL** of bile each day .
- Bile contains no digestive enzymes, but it plays a role in digestion because it **neutralizes and dilutes stomach acid and emulsifies lipids.**
- The pH of chyme as it leaves the stomach is too low for the normal function of pancreatic enzymes. Bile helps neutralize the acidic chyme and bring the pH up to a level at which pancreatic enzymes can function.
- Bile salts **emulsify lipids**.
- Bile also contains excretory products, such as bile pigments; one bile pigment is **bilirubin,** which results from the breakdown of hemoglobin.
- Bile also contains cholesterol, lipids, lipid-soluble hormones, and lecithin.
- **Neural and hormonal stimuli regulate** the secretion and release of bile (Bile secretion by the liver is increased by parasympathetic stimulation through the vagus nerve.
- **Secretin,** which is released from the duodenum, also stimulates bile secretion, primarily by increasing the water and bicarbonate ion content of bile.
- **Cholecystokinin** stimulates gallbladder contractions to release bile into the duodenum.
- Bile salts also increase bile secretion through a positive-feedback system. Over 90% of bile salts are reabsorbed in the ileum and carried in the blood by the hepatic portal circulation.This recycling process reduces the loss of bile salts in the feces.
- Bile secretion into the duodenum continues until the duodenum empties.

Structure of Mammalian Digestive Glands

2. Storage

- Hepatocytes can remove sugar from the blood and store it in the form of **glycogen.**
- They can also **store lipids, vitamins (A, B12, D, E, and K), copper, and iron**. This storage function is usually short-term, and the amount of stored material in the hepatocytes—hence their size—fluctuates during the day.
- Hepatocytes help maintain **blood sugar levels within very narrow limits**. If a large amount of sugar enters the general circulation after a meal, the blood osmolality will increase, resulting in hyperglycemia. Under normal conditions, this is prevented because the blood from the small intestine passes through the hepatic portal vein to the liver, where hepatocytes remove glucose and other substances from the blood, store them, and then secrete them back into the circulation when needed.

3. Nutrient Interconversion

- The interconversion of nutrients is another important function of the liver. Ingested nutrients are not always present in the proportion needed by the tissues. In this case, the liver can convert some nutrients into others. For example, if a person is on a diet that is excessively **high in protein**, an oversupply of amino acids and an undersupply of lipids and carbohydrates may be delivered to the liver. The hepatocytes break down the amino acids and cycle many of them through metabolic pathways, so that they can be used to produce **adenosine triphosphate, lipids, and glucose .**
- Hepatocytes also **transform substances that cannot be used by most cells into more readily usable substances**. For example, they combine ingested dietary **fats with choline and phosphorus** in the liver to produce **phospholipids,** which are essential components of plasma membranes. In addition, vitamin D is hydroxylated in the liver hepatocytes. The **hydroxylated form of vitamin D, which is the major circulating form of vitamin D,** is transported through the circulation to the kidneys, where it is again hydroxylated. The **double-hydroxylated vitamin D is the active form of the vitamin,** which functions in Calcium maintenance

Structure of Mammalian Digestive Glands

4. Detoxification

- Many ingested substances are harmful to body cells.
- In addition, the body itself produces many by-products of metabolism that, if accumulated, are toxic.
- The liver forms a **major line of defense by** altering the structure of many of these harmful substances to make them less toxic or to make their elimination easier. **Ammonia, for** example, a by-product of amino acid metabolism, is toxic and not readily removed from the circulation by the kidneys. Hepatocytes remove ammonia from the circulation and convert it to **urea,** which is less toxic than ammonia. Urea is then secreted into the circulation and eliminated by the kidneys in the urine.
- The liver hepatocytes also remove other substances from the circulation and **excrete them into the bile**

5. Phagocytosis

- Hepatic phagocytic cells (**Kupffer cells**), which lie along the sinusoid walls of the liver, phagocytize "*worn-out" and dying red and white blood cells, some bacteria, and other debris that enters the liver through the circulation.*

6. Synthesis

- The liver can produce its own new compounds, including blood proteins such as ***albumins, fibrinogen, globulins, heparin, and clotting factors,*** which are released into the circulation.

Structure of Mammalian Digestive Glands

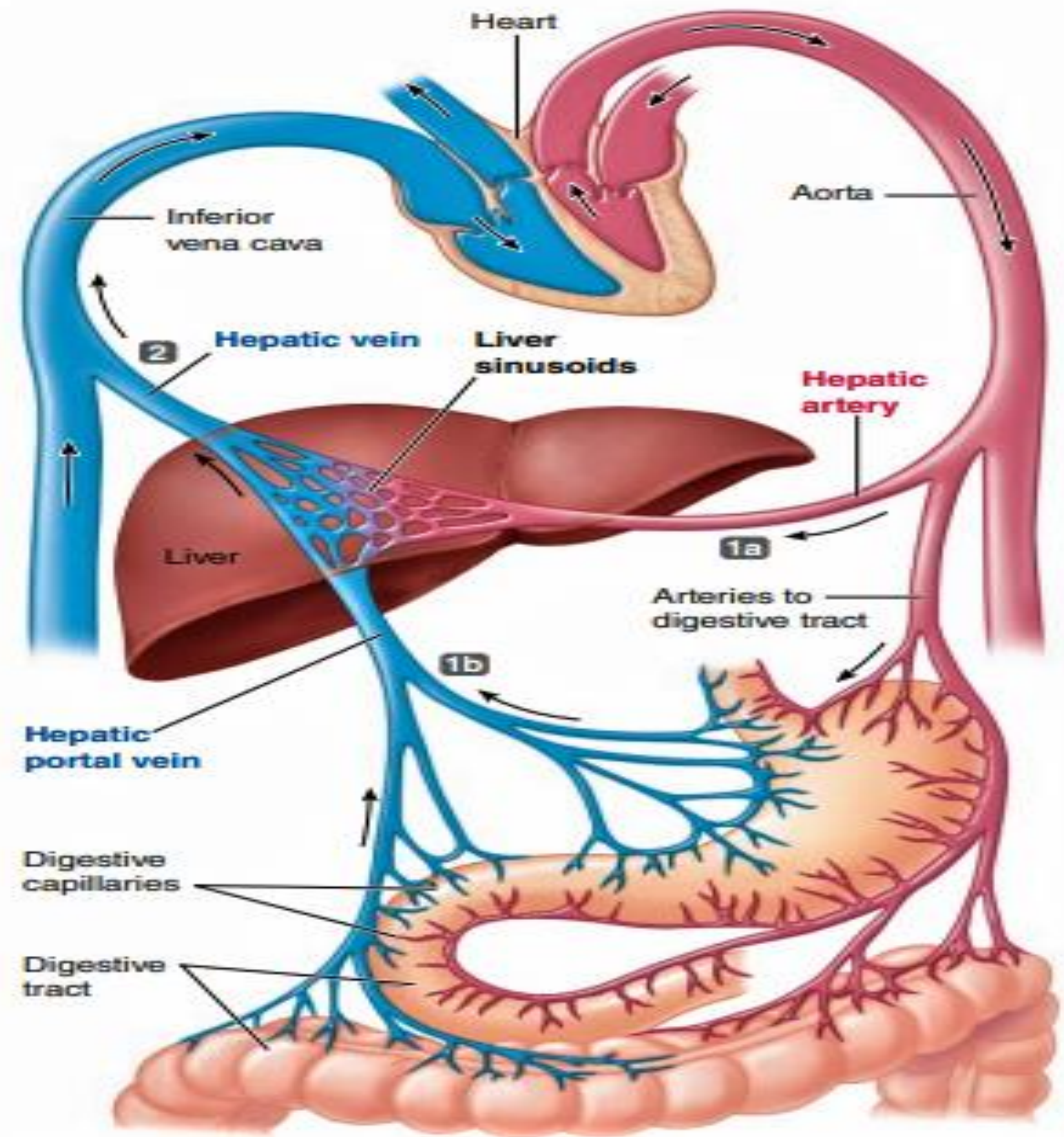
Hepatic portal system

The liver receives blood from two sources:

1a Arterial blood, which provides the liver's O_2 supply and carries bloodborne metabolites for hepatic processing, is delivered by the **hepatic artery**.

1b Venous blood draining the digestive tract is carried by the **hepatic portal vein** to the liver for processing and storage of newly absorbed nutrients.

2 Blood leaves the liver via the **hepatic vein**.



Structure of Mammalian Digestive Glands

C. Gallbladder

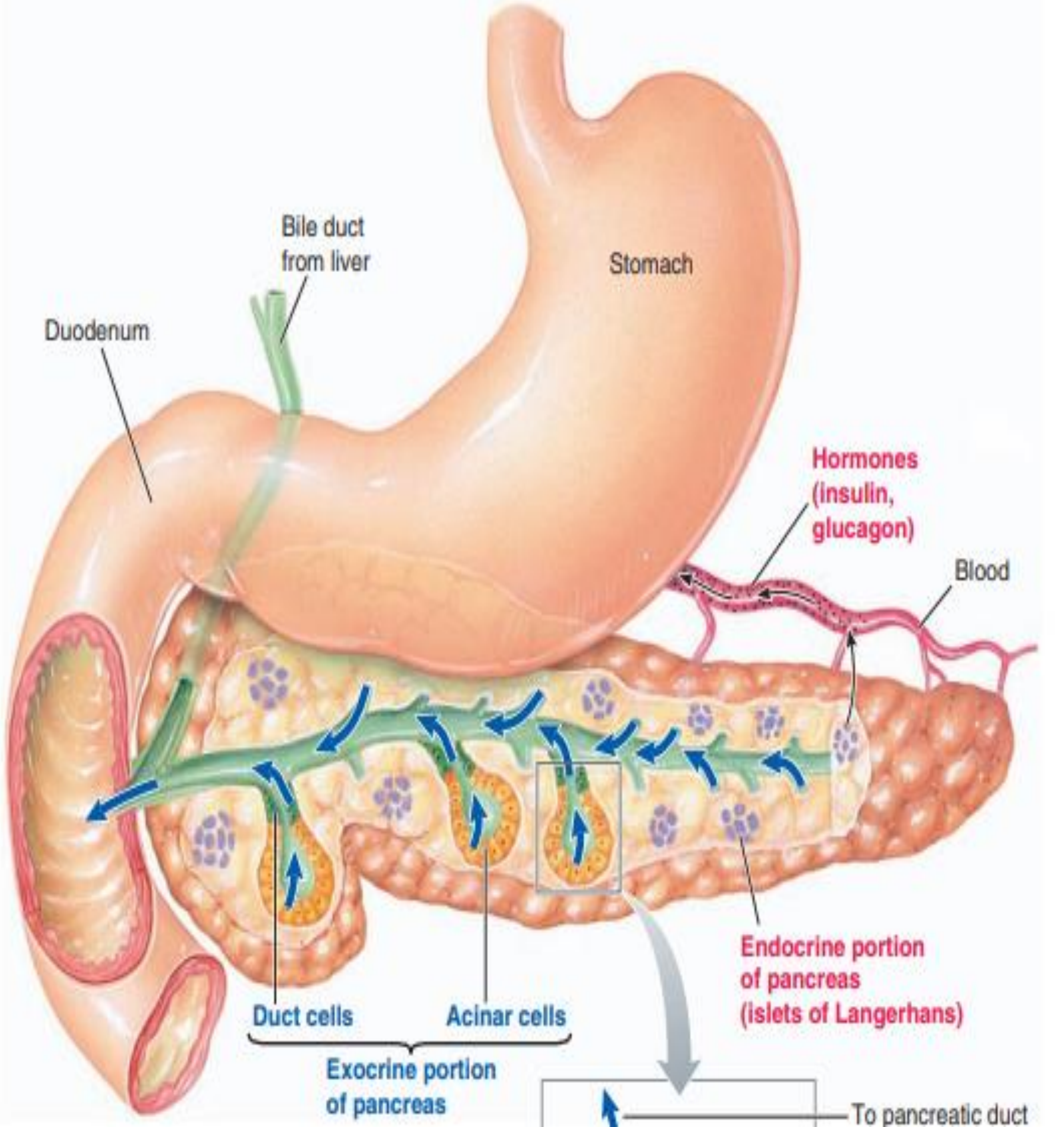
- The gallbladder is **a saclike** structure on the inferior surface of the liver.
- It is about **8 cm long and 4 cm wide**
- Three tunics form the gallbladder wall:
  - (1) an inner **mucosa** folded into rugae that allow the gallbladder to expand;
  - (2) a **muscularis**, which is a layer of smooth muscle that allows the gallbladder to contract; and
  - (3) an outer covering of **serosa.**
- The **cystic duct** connects the gallbladder to the common bile duct.
- The liver continually secretes bile, which flows to the gallbladder, where **40–70 mL of bile can be stored**.
- While the bile is in the gallbladder, water and electrolytes are absorbed, and bile salts and pigments become as **much as 5–10 times more concentrated** than they were when secreted by the liver.
- Shortly after a meal, the gallbladder **contracts in response to stimulation by cholecystokinin** and, to a lesser degree, in response **to vagal stimulation**, thereby dumping large amounts of concentrated bile into the small intestine.
- **Cholesterol,** secreted by the liver, may precipitate in the gallbladder to produce **gallstones.** Cholesterol is not soluble in water and is ordinarily kept in solution by bile salts. Gallstones can form when the bile contains excess cholesterol due to a high-cholesterol diet or due to cholesterol in the gallbladder. Occasionally, a gallstone passes out of the gallbladder and enters the ***cystic duct, blocking the release of bile***. This condition interferes with normal digestion, and often the gallstone must be surgically removed. If the gallstone moves far enough down the duct, it can ***also block the pancreatic duct***, resulting in **pancreatitis.**

Structure of Mammalian Digestive Glands

D. Pancreas

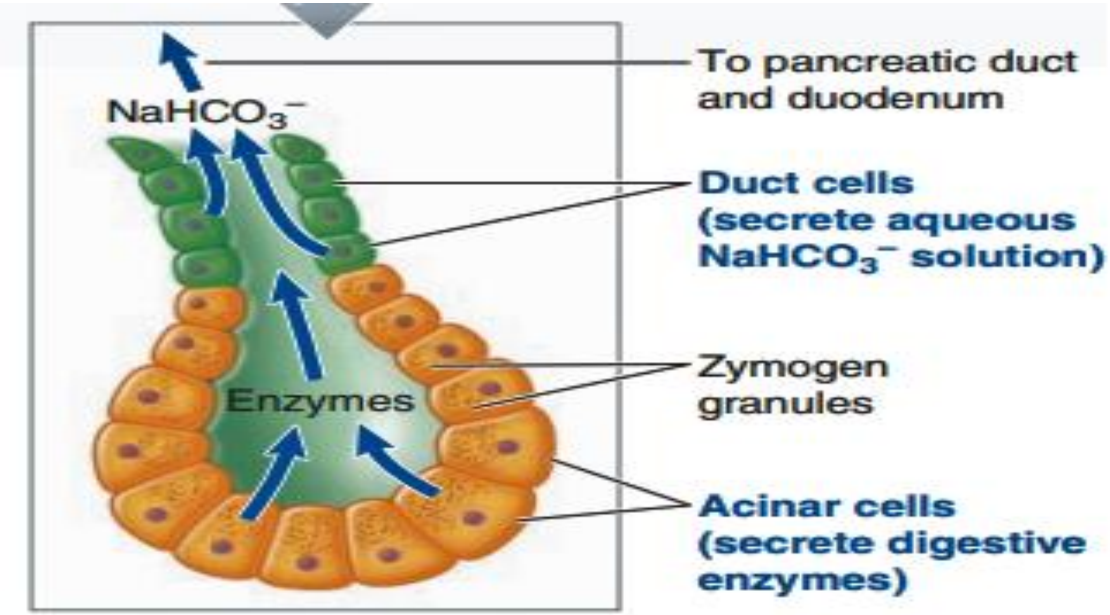
Anatomy of the Pancreas

- The pancreas is a complex organ composed of both **endocrine and exocrine** tissues that perform several functions.
- The pancreas consists of **a head**, located within the curvature of the duodenum; **a body, and a tail**, which extends to the spleen.
- The endocrine part of the pancreas consists of **pancreatic islets, or islets of Langerhans** . The islet cells produce **insulin and glucagon,** which are very important in controlling the blood levels of nutrients, such as ***glucose and amino acids***, and **somatostatin,** which regulates *insulin and glucagon secretion and may inhibit growth hormone secretion.*



Structure of Mammalian Digestive Glands

- The exocrine part of the pancreas is a compound **acinar gland** . The acini produce digestive enzymes. Clusters of acini form *lobules that are separated by thin septa*. Lobules are connected by small intercalated ducts *to intra-lobular ducts*, which leave the lobules to join *interlobular ducts* between the lobules. *The interlobular ducts attach to the main pancreatic duct*, The ducts are lined with **simple cuboidal epithelium**, and the epithelial cells of the **acini are pyramid-shaped.**



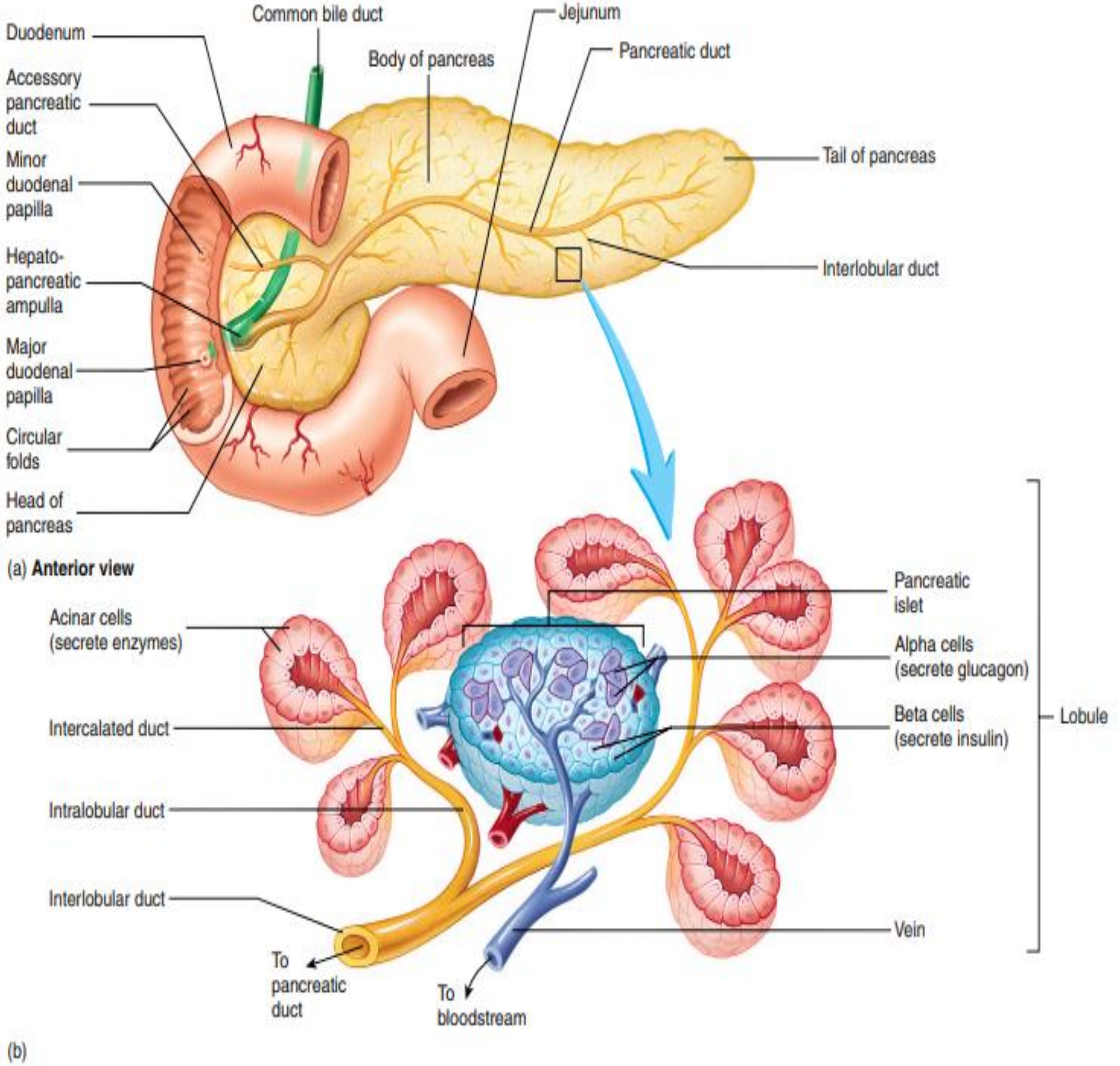
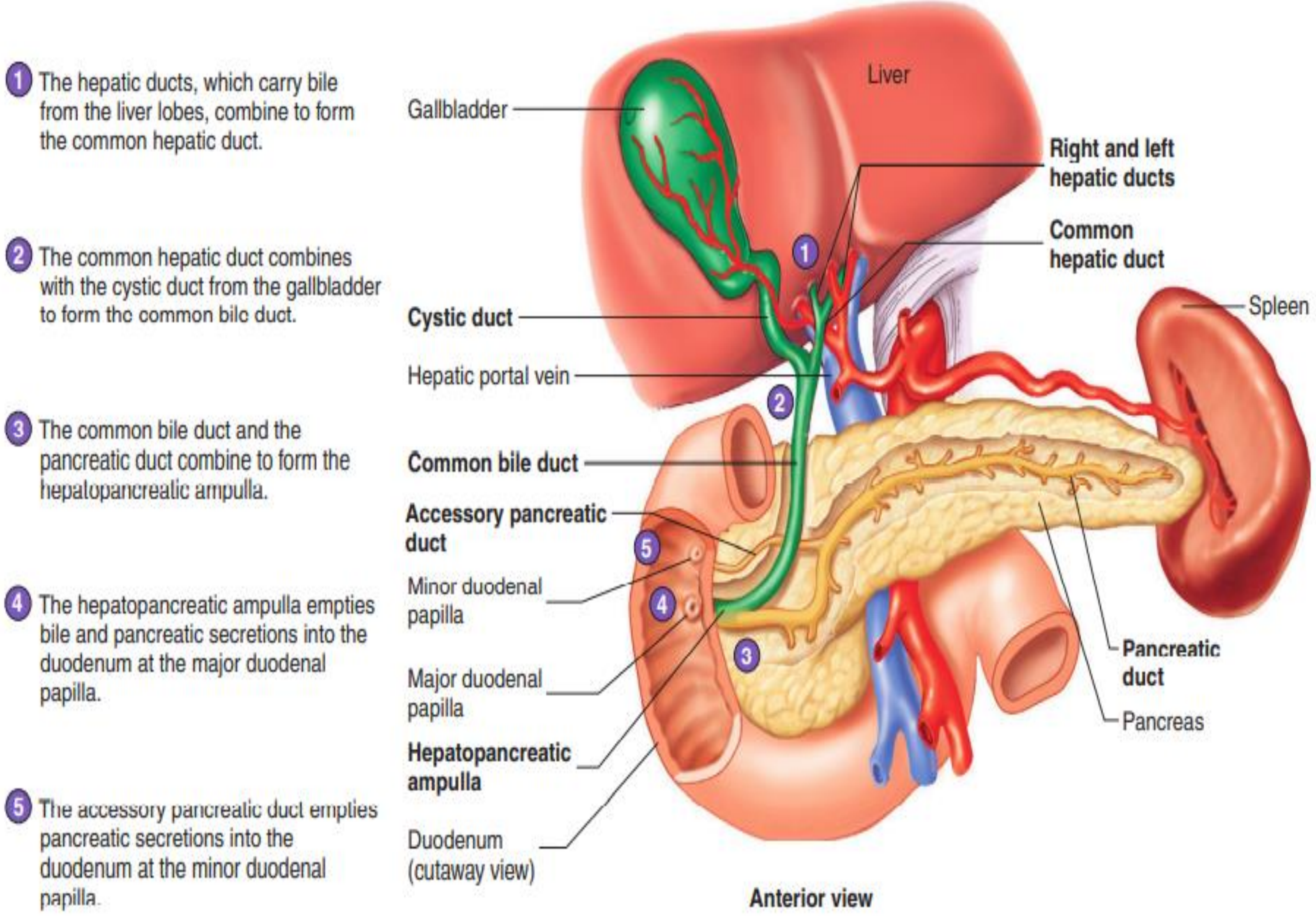


FIGURE 24.22 AP|R Anatomy and Histology of the Duodenum and Pancreas

Structure of Mammalian Digestive Glands

- The pancreatic duct (**Duct of Wirsung**) joins the *common bile duct* at the **hepatopancreatic ampulla, or Vater's ampulla .** The hepatopancreatic ampulla empties into the duodenum at the **major duodenal papilla.** A smooth muscle sphincter, the **hepatopancreatic ampullar sphincter, or sphincter of Oddi,** regulates the opening of the ampulla.
- In most people, an accessory pancreatic duct (**Duct of Santorini**) opens at the **minor duodenal papilla.**
- A smooth muscle sphincter surrounds the pancreatic duct where it enters the hepatopancreatic ampulla.



PROCESS FIGURE 24.18 Flow of Bile and Pancreatic Secretions Through the Duct System of the Liver, Gallbladder, and Pancreas

Structure of Mammalian Digestive Glands

Pancreatic Secretions

- The exocrine secretions of the pancreas, called **pancreatic juice**, have an *aqueous component and an enzymatic component*..

i) **The aqueous component :** is produced principally **by columnar epithelial cells** that line the smaller ducts of the pancreas.

-It contains **Na+ and K+** in about the same concentration found in extracellular fluid.

-Bicarbonate ions (HCO_3^-) - major aqueous component,

1. They neutralize the *acidic chyme* that enters the small intestine from the stomach, by **increasing the pH,** this stops pepsin digestion in duodenum
2. Provides the proper environment for the *function of pancreatic enzymes.*

ii). **Enzymatic component:** is produced by the acinar cells of the pancreas. The enzymes are important in digesting all major classes of foods.

1. Proteins: To digest proteins, **proteolytic pancreatic enzymes**, are secreted in inactive forms, The major proteolytic enzymes **are trypsin, chymotrypsin, and carboxypeptidase.** They are secreted in their **inactive forms as trypsinogen, chymotrypsinogen, and procarboxypeptidase** and are activated by the removal of certain peptides from the larger precursor proteins. If these were produced in their active forms, they would digest the tissues producing them. The proteolytic **enzyme enterokinase** , which is attached to the brush border of the small intestine, **activates trypsinogen. Trypsin then activates more trypsinogen, as well as chymotrypsinogen and procarboxypeptidase.**
2. Carbohydrates: **pancreatic amylase,** which continues the polysaccharide digestion initiated in the oral cavity.
3. lipids,: **pancreatic lipase,** a lipid-digesting enzymewhich breaks down lipids into monoglycerides and free fatty acids
4. **Deoxyribonucleases and ribonucleases,** degrade DNA and RNA to their component nucleotides respectively.

Structure of Mammalian Digestive Glands

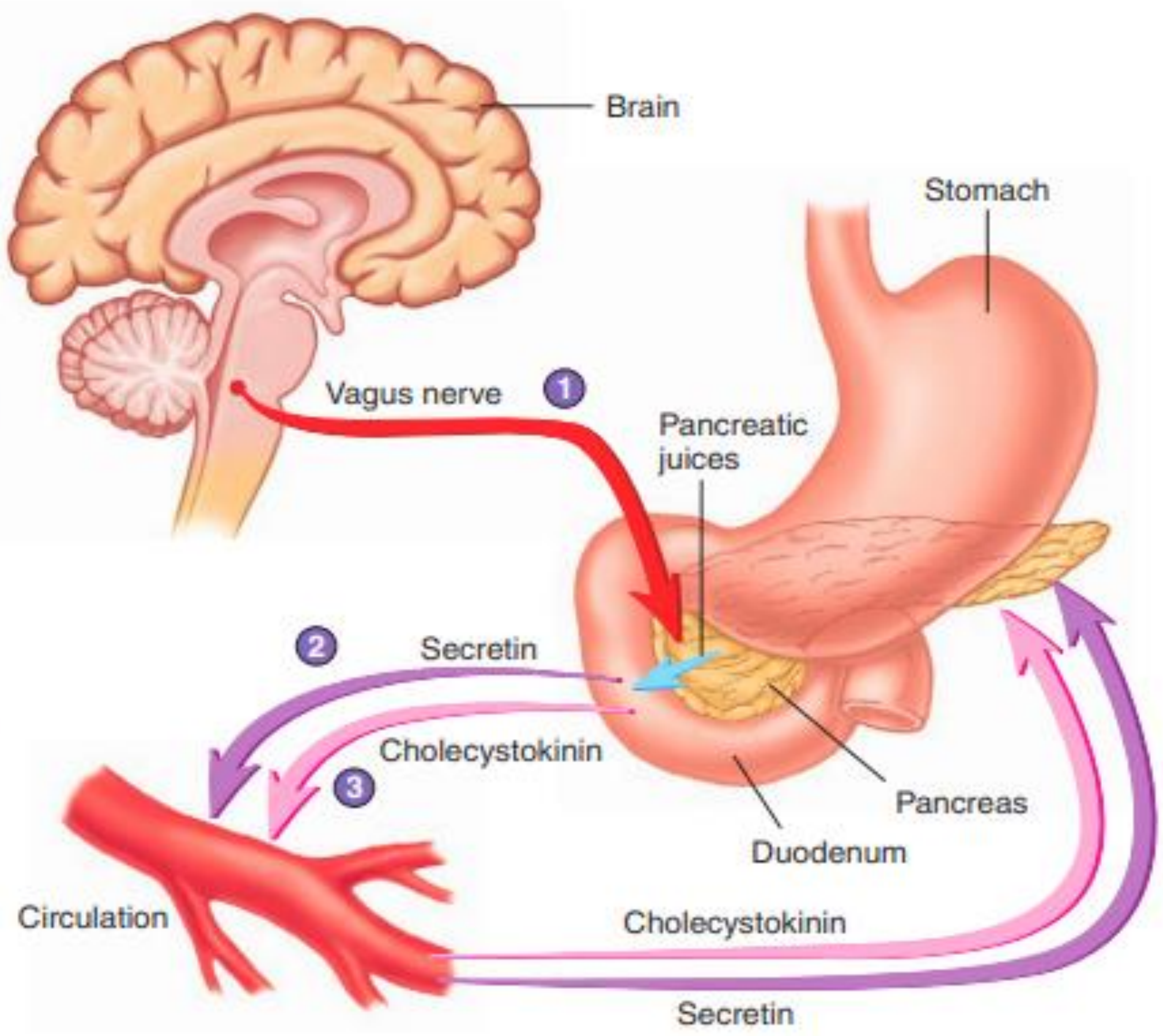
Regulation of Pancreatic Secretion

- Both **hormonal and neural mechanisms** control the exocrine secretions of the pancreas.
- An acidic chyme in the duodenum stimulates the release of **Secretin.** Secretin stimulates the **secretion of a watery, bicarbonate ion–rich solution** from the pancreas into the duodenum. Bicarbonate **ions increase the pH** of chyme in the duodenum, so that the duodenum is not damaged by acidic pH. In addition, pancreatic and brush border enzymes do not function at a low pH. Therefore Increase is also required for the activation of pancreatic and intestinal enzymes.
- Presence of fatty acids and other lipids in the duodenum. Stimulates **Cholecystokinin** which cause cntraction of gallbladder to *release* ***bile*** , and the ***secretion of pancreatic juice rich in digestive enzymes.***
- Parasympathetic stimulation through the *vagus (X)* ***nerves also stimulates the secretion of pancreatic juices*** rich in pancreatic enzymes, and *sympathetic impulses inhibit secretion.*

- **Pancreatitis** is an inflammation of the pancreas involving the release of pancreatic enzymes within the pancreas itself, which *digest pancreatic tissue*. Pancreatitis can result from ***alcoholism, the use of certain drugs, pancreatic duct blockage, cystic fibrosis, viral infection, or pancreatic cancer.*** Symptoms can range from *mild abdominal pain to systemic shock and coma*

Structure of Mammalian Digestive Glands

1. Parasympathetic stimulation from the vagus nerve (*red arrow*) causes the pancreas to release a secretion rich in digestive enzymes.
2. Secretin (*purple arrows*), released from the duodenum, stimulates the pancreas to release a watery secretion, rich in bicarbonate ions.
3. Cholecystokinin (*pink arrows*), released from the duodenum, causes the pancreas to release a secretion rich in digestive enzymes.



PROCESS FIGURE 24.24 Control of Pancreatic Secretion

Fig. Regulation of pancreatic secretion

Structure of Mammalian Digestive Glands

Gastric glands

❖Stomach mucosa contains following types of cells and glands, which release their secretions through tubelike gastric pits.

i) Mucus-secreting cells : that line the entire surface of the stomach

ii) tubular glands: 2 types

a) oxyntic glands (also called gastric glands) - The oxyntic (acid-forming) glands are located on the inside surfaces of the **body and fundus** of the stomach, constituting the proximal 80 per cent of the stomach. It is composed of three types of cells:

(1) mucous neck cells,
(2) peptic (or chief) cells,
(3) Parietal or oxyntic cells

b) pyloric glands- The pyloric glands are located in the antral portion of the stomach, the distal 20 per cent of the stomach. The pyloric glands secrete mainly **mucus for protection** of the pyloric mucosa from the stomach acid. They also secrete the **hormone gastrin**.

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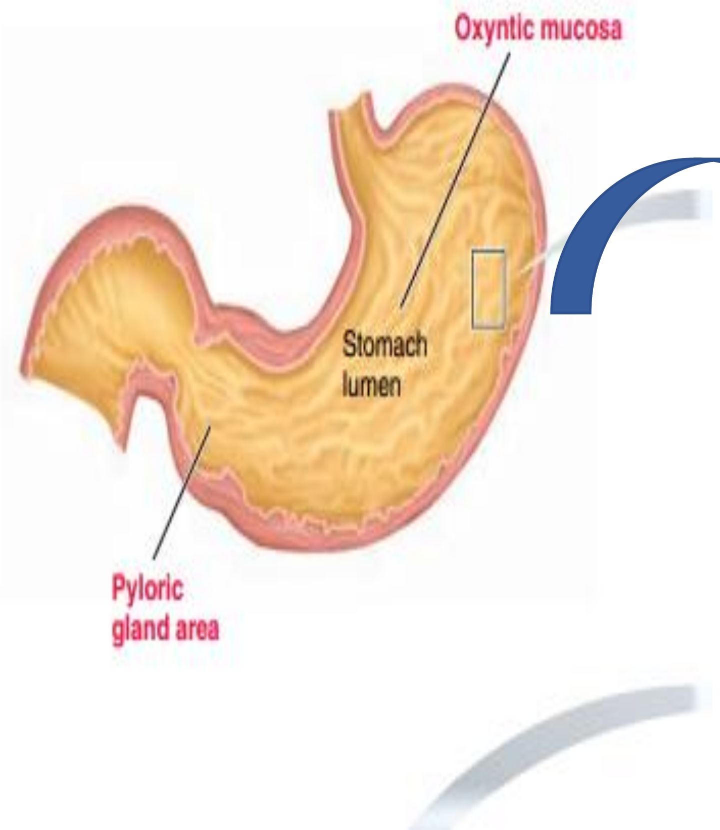
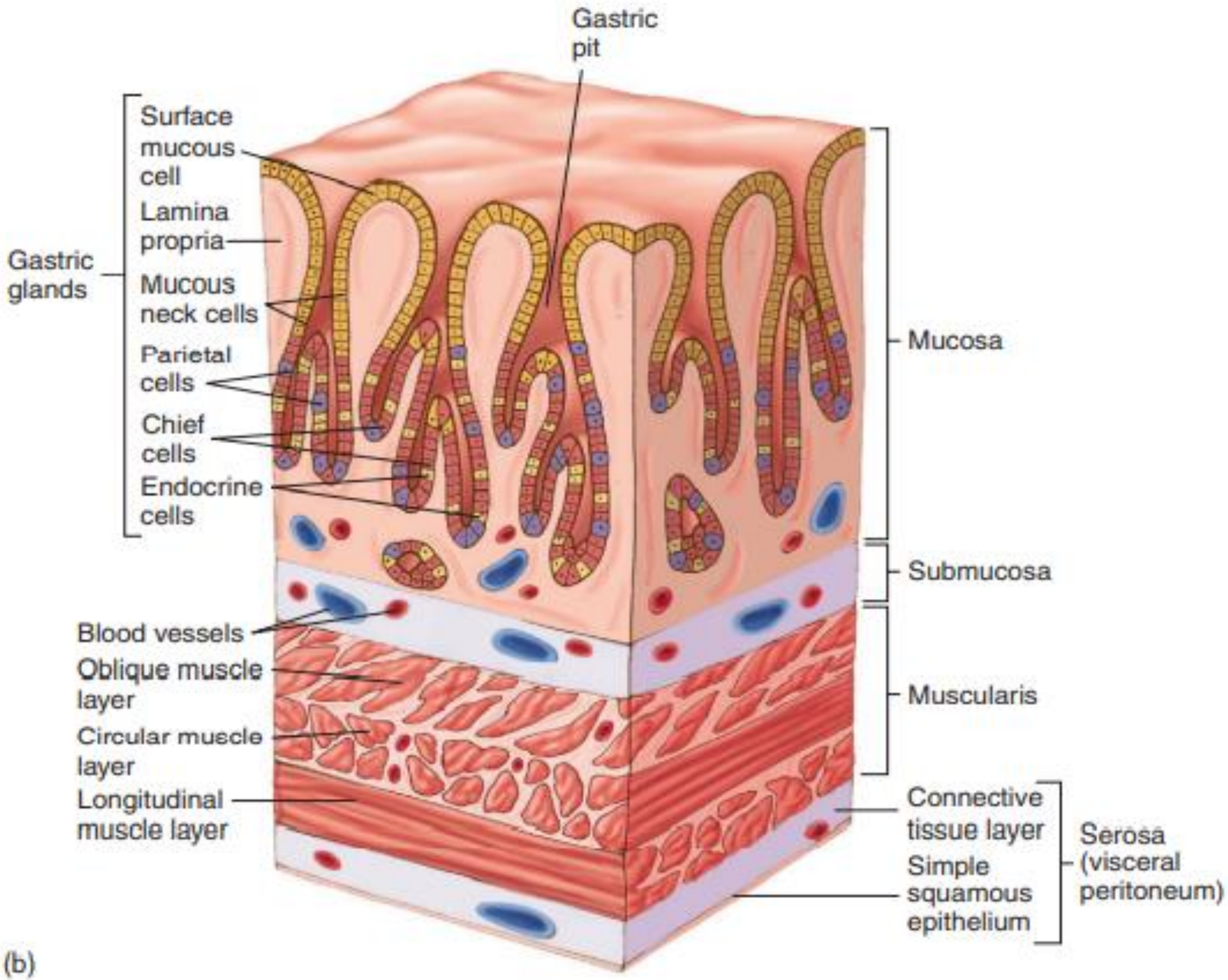
Structure of Mammalian Digestive Glands





(b)

Structure of Mammalian Digestive Glands

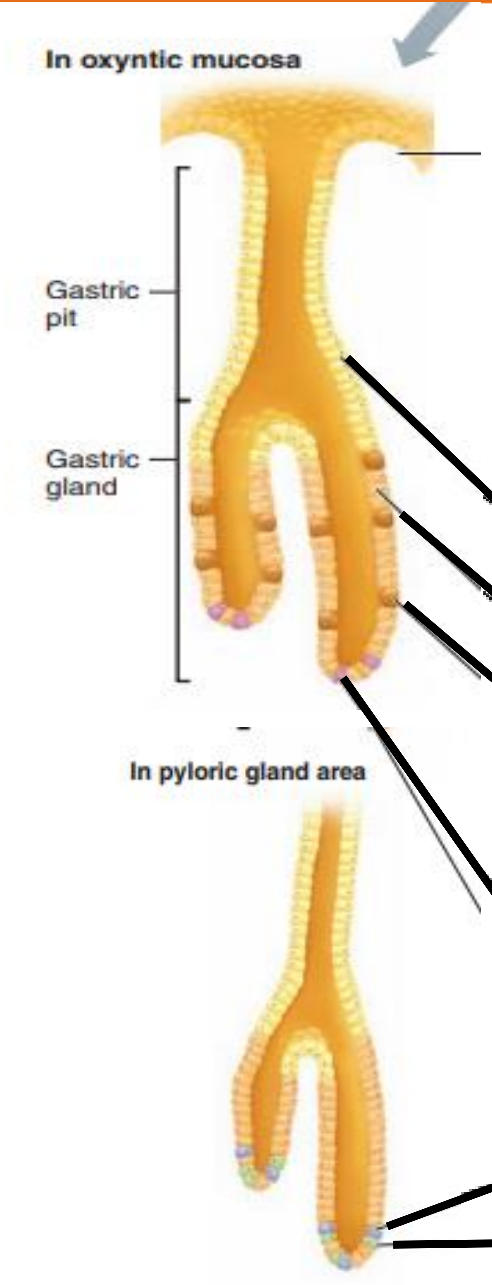


TABLE 14-2 The Stomach Mucosa and the Gastric Glands

Type of Secretory Cell	Product Secreted	Stimuli for Secretion	Function(s) of Secretory Product
Exocrine Cells			
Mucous cells	Alkaline mucus	Mechanical stimulation by contents	Protects mucosa against mechanical, pepsin, and acid injury
Chief cells	Pepsinogen	ACh, gastrin	When activated, begins protein digestion
Parietal cells	Hydrochloric acid	ACh, gastrin, histamine	Activates pepsinogen, breaks down connective tissue, denatures proteins, kills microorganisms
	Intrinsic factor		Facilitates absorption of vitamin B_{12}
Endocrine/Paracrine Cells			
Enterochromaffin-like (ECL) cells	Histamine	ACh, gastrin	Stimulates parietal cells
G cells	Gastrin	Protein products, ACh	Stimulates parietal, chief, and ECL cells
D cells	Somatostatin	Acid	Inhibits parietal, G, and ECL cells

Structure of Mammalian Digestive Glands

Gastric mucus is protective

The surface of the gastric mucosa is covered by a layer of mucus, which serves as a protective barrier against several forms of potential injury to the gastric mucosa:

- By virtue of its **lubricating** properties, mucus protects the gastric mucosa against mechanical injury.
- Mucus helps protect the stomach wall from **selfdigestion** because pepsin is inhibited when it comes in contact with the mucus coating the stomach lining. (However, mucus does not affect pepsin activity in the lumen, where digestion of dietary protein proceeds without interference.)
- Being alkaline, mucus helps protect against acid injury by **neutralizing HCl** in the vicinity of the gastric lining, but it does not interfere with the function of HCl in the lumen. Whereas the pH in the lumen may be as low as 2, the pH in the mucus layer adjacent to the mucosal cell surface is about 7.

Structure of Mammalian Digestive Glands

TABLE 24.2 Functions of Major Digestive Secretions

Fluid or Enzyme	Function
Oral Cavity Secretions	
Serous saliva (mostly water, bicarbonate ions)	Moistens food and mucous membrane; neutralizes bacterial acids; flushes bacteria from oral cavity; has weak antibacterial activity
Salivary amylase	Digests carbohydrates
Mucus	Lubricates food; protects digestive tract from digestion by enzymes
Lingual lipase	Digests a minor amount of lipids
Esophagus Secretions	
Mucus	Lubricates esophagus; protects lining of esophagus from abrasion and allows food to move more smoothly through esophagus
Gastric Secretions	
Hydrochloric acid	Antibacterial; decreases stomach pH to activate pepsinogen to pepsin
Pepsin*	Digests protein into smaller peptide chains; activates pepsinogen
Mucus	Protects stomach lining from digestion
Intrinsic factor	Binds to vitamin B_{12} and aids in its absorption
Gastric lipase	Digests a minor amount of lipids
Liver Secretions	
Bile Bile salts Bile pigments (bilirubin) Cholesterol Mucus Lecithin	Bile salts emulsify lipids, making them available to lipases, and help make end products soluble and available for absorption by the intestinal mucosa; many of the other bile contents are waste products transported to the intestines for disposal

Structure of Mammalian Digestive Glands

TABLE 24.2 Functions of Major Digestive Secretions

Fluid or Enzyme	Function
Pancreas Secretions	
Trypsin*	Digests proteins (cleaves at arginine or lysine amino acids); activates trypsinogen and other digestive enzymes
Chymotrypsin*	Digests proteins (cleaves at hydrophobic amino acids)
Carboxypeptidase*	Digests proteins (removes amino acids from the carboxyl end of proteins)
Pancreatic amylase	Digests carbohydrates (hydrolyzes starches and glycogen to form maltose and isomaltose)
Pancreatic lipase	Digests lipids (breaks down triglycerides into monoglycerides and free fatty acids)
Ribonuclease	Digests ribonucleic acid (hydrolyzes phosphodiester bonds)
Deoxyribonuclease	Digests deoxyribonucleic acid (hydrolyzes phosphodiester bonds)
Bicarbonate ions	Neutralize acid from stomach; provide appropriate pH for pancreatic enzymes
Small Intestine Secretions	
Mucus	Protects duodenum from stomach acid, gastric enzymes, and intestinal enzymes; provides adhesion for fecal matter; protects intestinal wall from bacterial action and acid produced in the feces
Peptidases†	Split amino acids from polypeptides
Enterokinase†	Activates trypsin from trypsinogen
Sucrase†	Splits sucrose into glucose and fructose
Maltase†	Splits maltose into two glucose molecules
Isomaltase†	Splits isomaltose into two glucose molecules
Lactase†	Splits lactose into glucose and galactose

*These enzymes are secreted as inactive forms and then activated.
†These enzymes remain in the microvilli.

Structure of Mammalian Digestive Glands

TABLE 24.3 Functions of the Gastrointestinal Hormones

Site of Production	Method of Stimulation	Secretory Effects	Motility Effects
Gastrin			
Stomach	Distension; partially digested proteins, autonomic stimulation, ingestion of alcohol or caffeine	Increases gastric secretion	Causes a minor increase in gastric motility
Secretin			
Duodenum	Acidity of chyme	Decreases gastric secretion; stimulates pancreatic and bile secretions high in bicarbonate ions	Decreases gastric motility
Cholecystokinin			
Duodenum	Fatty acids and peptides	Slightly decreases gastric secretion; stimulates pancreatic secretions high in digestive enzymes; causes contraction of the gallbladder and relaxation of the hepatopancreatic ampullar sphincter	Strongly decreases gastric motility

Structure of Mammalian Digestive Glands

	Daily Volume (ml)	pH
Saliva	1000	6.0–7.0
Gastric secretion	1500	1.0–3.5
Pancreatic secretion	1000	8.0–8.3
Bile	1000	7.8
Small intestine secretion	1800	7.5–8.0
Brunner's gland secretion	200	8.0–8.9
Large intestinal secretion	200	7.5–8.0
Total	6700	

Daily secretion of gastrointestinal juices

Structure of Mammalian Digestive Glands

Stay Blessed