

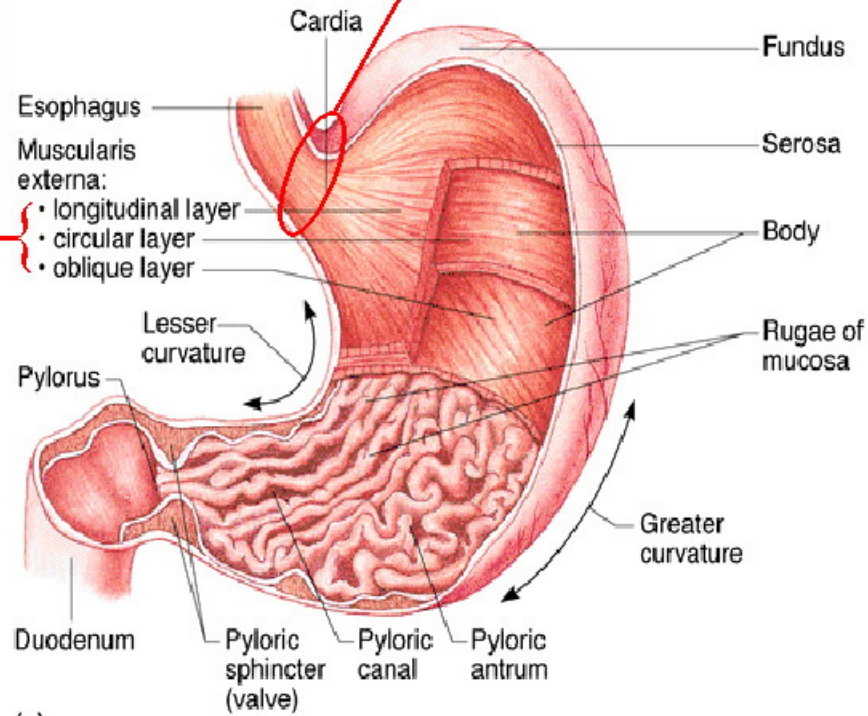
# Stomach

The stomach is divided into four areas: Cardia, fundus, body, and pylorus.

- **Cardia**- surrounds the superior opening of the stomach near the esophagus.
- **Fundus**- the balloon-like portion above and to the left of the cardia which acts as a temporary storage area.
- **Body**- the large central portion of the stomach.
- **Pylorus**- the narrow inferior region that leads to the duodenum. The **pyloric sphincter** is a muscular valve that controls the flow of food from the stomach to the duodenum and prevents the regurgitation of food from the duodenum to the stomach.

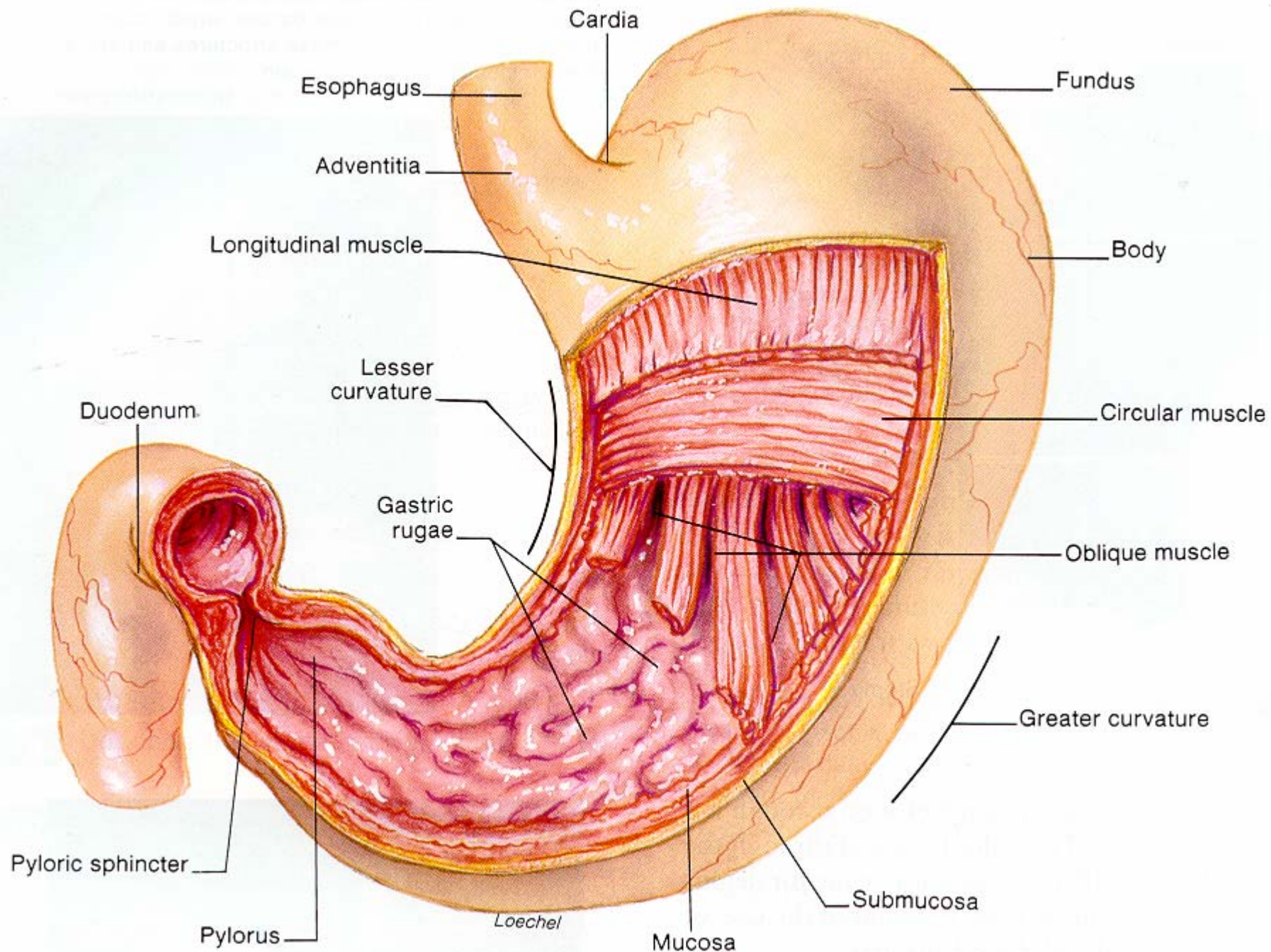
The three-layered muscularis causes compression and churning of contents.

The gastroesophageal region has a functional but not a structural sphincter

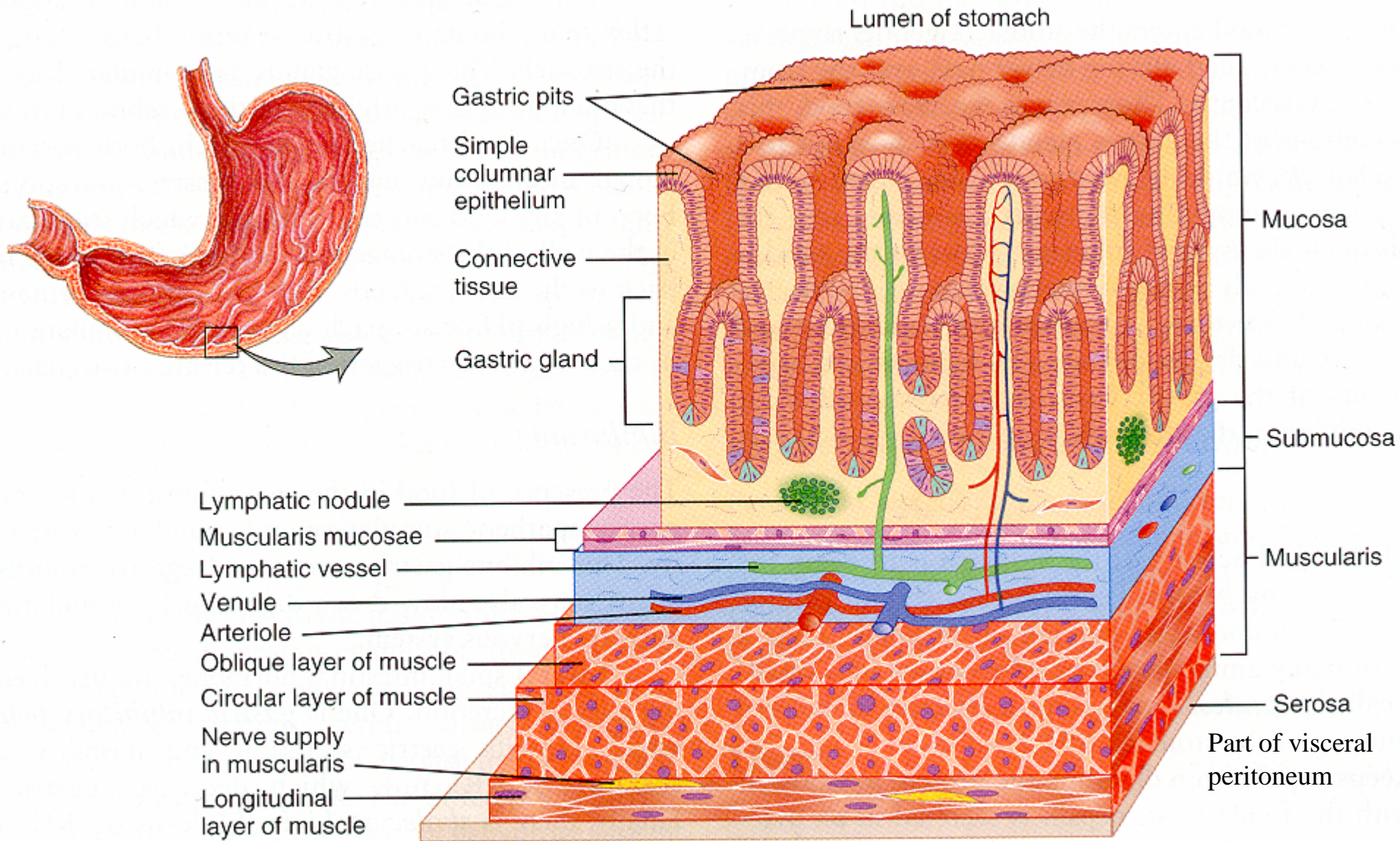


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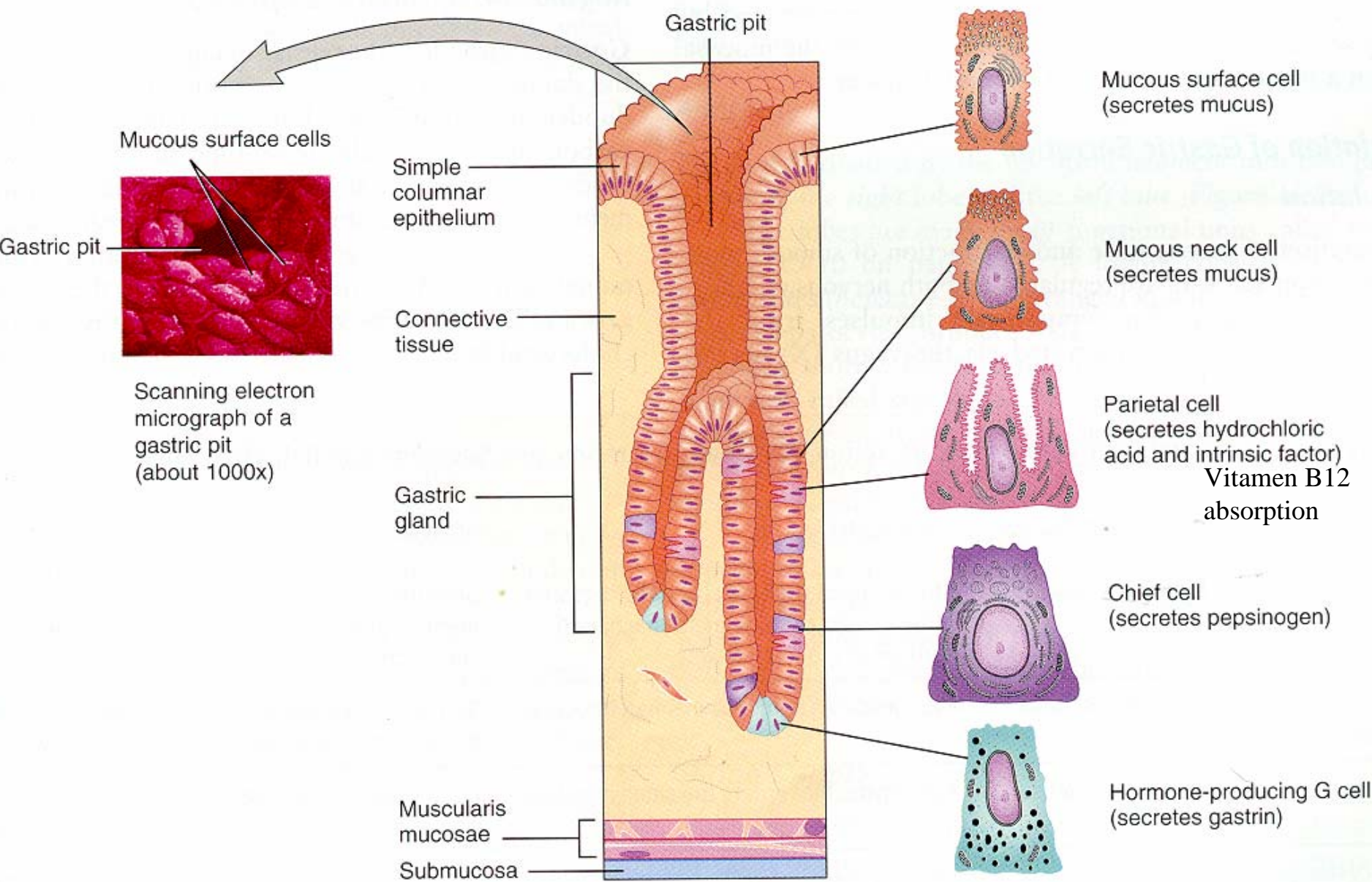
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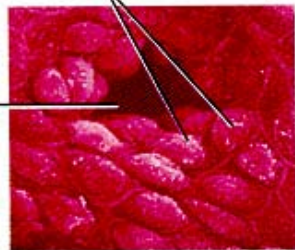








Mucous surface cells



Scanning electron micrograph of a gastric pit (about 1000x)

Gastric pit

Simple columnar epithelium

Connective tissue

Gastric gland

Muscularis mucosae

Submucosa

Mucous surface cell (secretes mucus)

Mucous neck cell (secretes mucus)

Parietal cell (secretes hydrochloric acid and intrinsic factor) Vitamin B12 absorption

Chief cell (secretes pepsinogen)

Hormone-producing G cell (secretes gastrin)

**Chart 12.2** Composition of gastric juice

<b>Component</b>	<b>Source</b>	<b>Function</b>
Pepsinogen	Chief cells of the gastric glands	Inactive form of pepsin
Pepsin	Formed from pepsinogen in the presence of hydrochloric acid	Protein-splitting enzyme capable of digesting nearly all types of protein
Hydrochloric acid	Parietal cells of the gastric glands	Changes pepsinogen into pepsin; provides an acid environment needed for the action of pepsin
Mucus	Goblet cells and mucous glands	Provides a viscous, alkaline protective layer on the stomach wall
Intrinsic factor	Parietal cells of the gastric glands	Aids in the absorption of vitamin B <sub>12</sub>



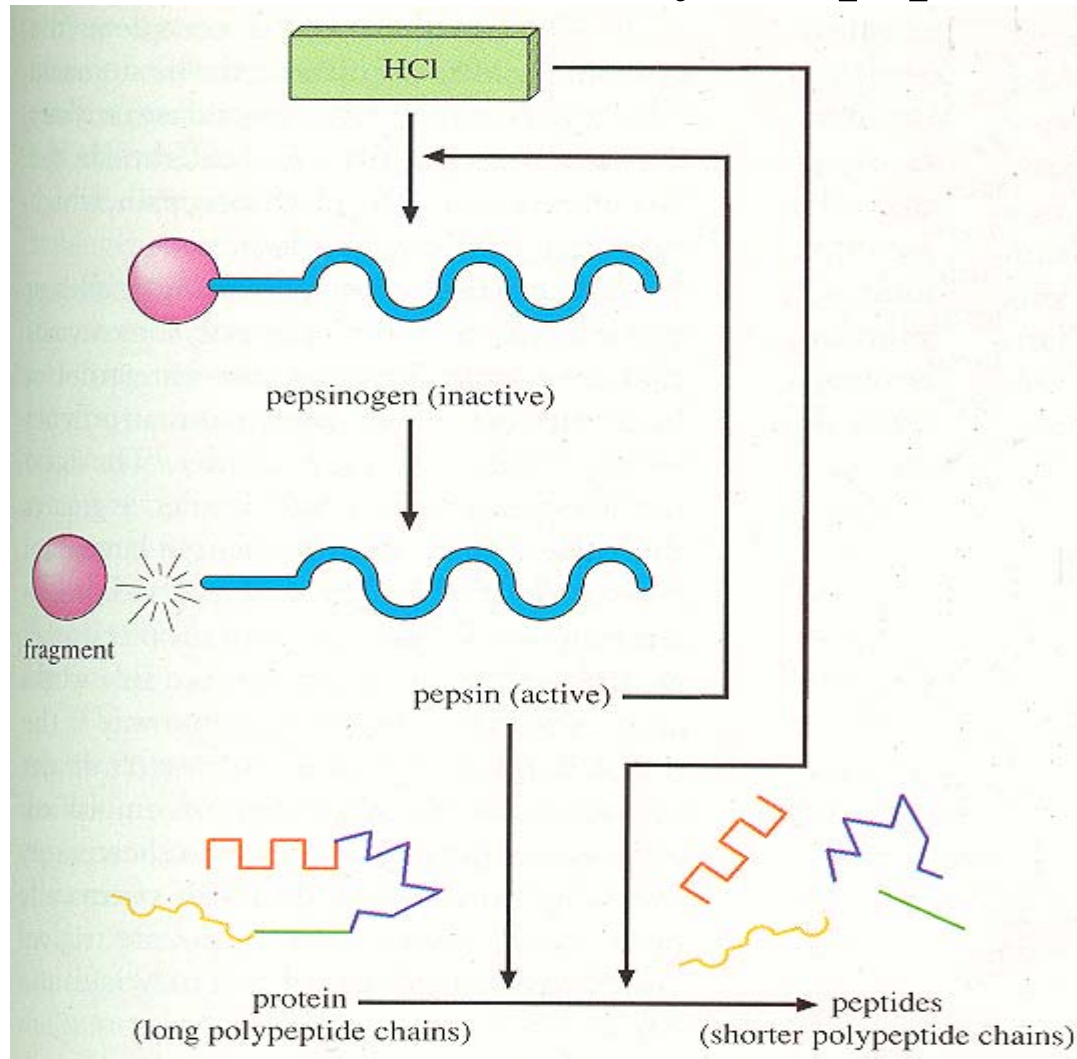
# Digestion in the Stomach

Can be divided into two phases: mechanical and chemical.

- Mechanical- the muscular churning of the food contents that mixes it with the gastric juices and forms the liquid mass called chyme. The muscular movement also propels the chyme toward the duodenum, where the pyloric sphincter opens to allow small portions to enter.

# Digestion in the Stomach

- Chemical- The digestion of protein begins here with the secretion of the enzyme, pepsin.





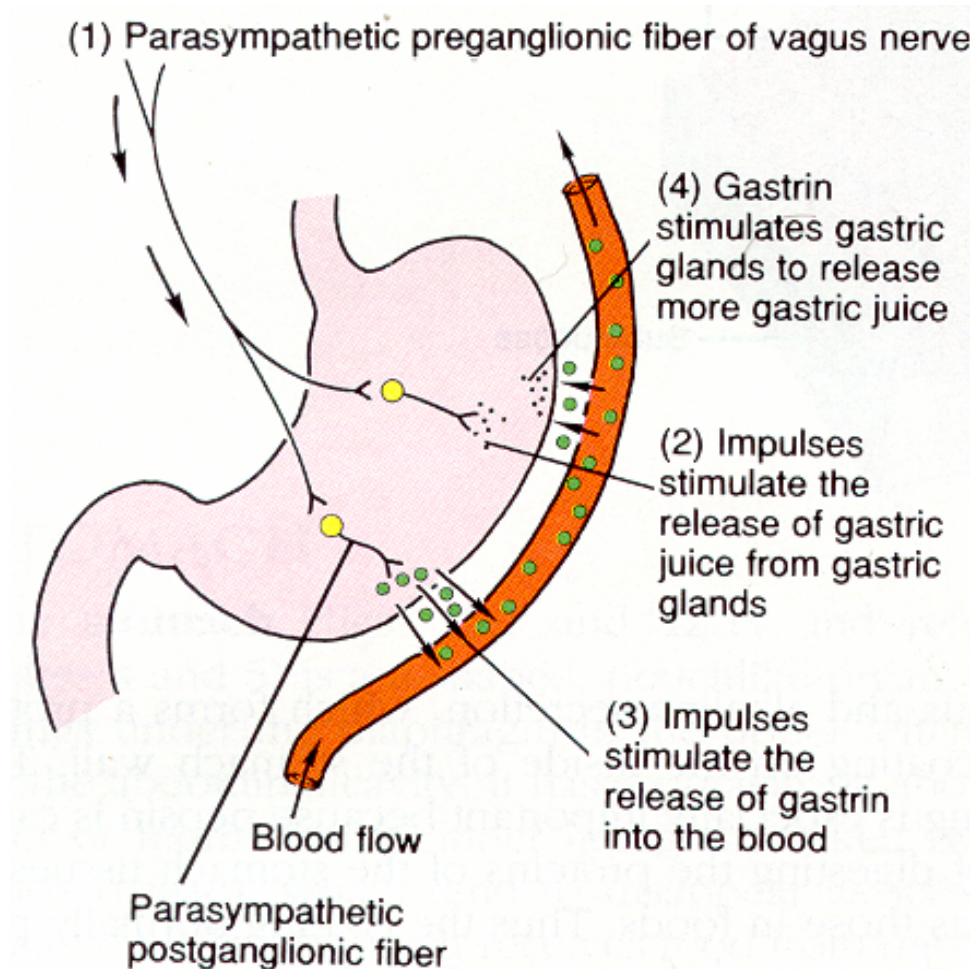
# Regulation of Gastric Secretions

## Stimulation

- Parasympathetic impulses from the medulla via the **vagus nerve**
  - promote peristalsis
  - stimulate gastric glands to secrete
- Sight, smell, taste, and thought
  - stimulate gastric secretions by activating parasympathetic nerves originating in the cerebral cortex.
- Stretching of the stomach by food stimulates receptors in the wall of the stomach that send impulses to the medulla and back to the stomach.

# Regulation of Gastric Secretions

- Partially digested protein, caffeine, and a high pH of the chyme stimulates the release of **gastrin** (a hormone that stimulates the secretion of gastric juices, increases parastalsis, and relaxes the pyloric sphincter).





# Regulation of Gastric Secretions

Inhibition is controlled by sympathetic neural impulses and intestinal hormones

- Control of sympathetic system
  - the presence of food in the small intestine causes the inhibition of the parasympathetic system and the stimulation of the sympathetic system.
  - Negative emotions also stimulates the sympathetic system.

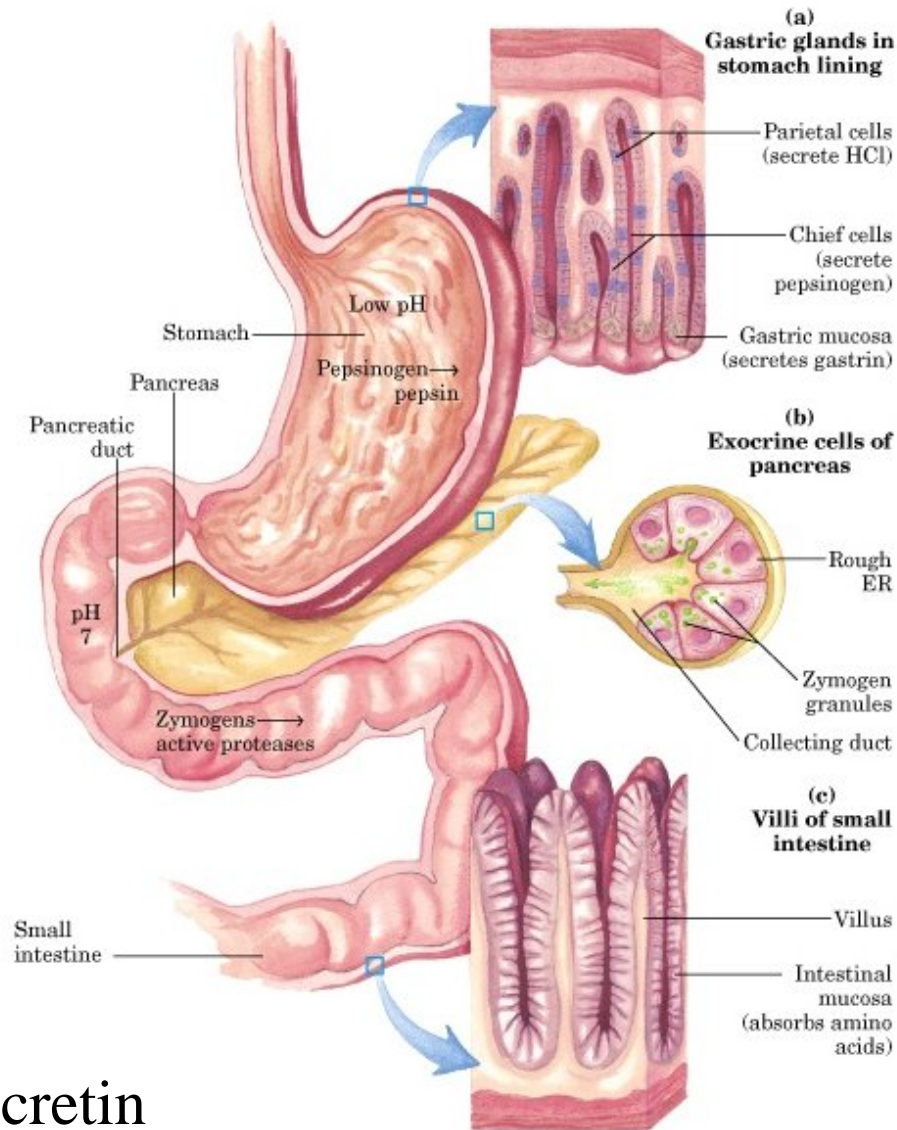
# Regulation of Gastric Secretions

- Intestinal hormones that regulate gastric secretions
  - **gastric inhibitory peptide (GIP)**- secretion of GIP from the intestinal mucosa is stimulated by fatty acids and glucose in the small intestine. It inhibits gastric secretion and slows down gastric emptying. It also stimulates the release of insulin by the pancreas.

# Regulation of Gastric Secretions

- **Secretin**- secretion is stimulated by acid chyme that enters the small intestine. It inhibits secretion of gastric juice and stimulates secretion of pancreatic juices that are rich in bicarbonate ions.

# Protein digestion



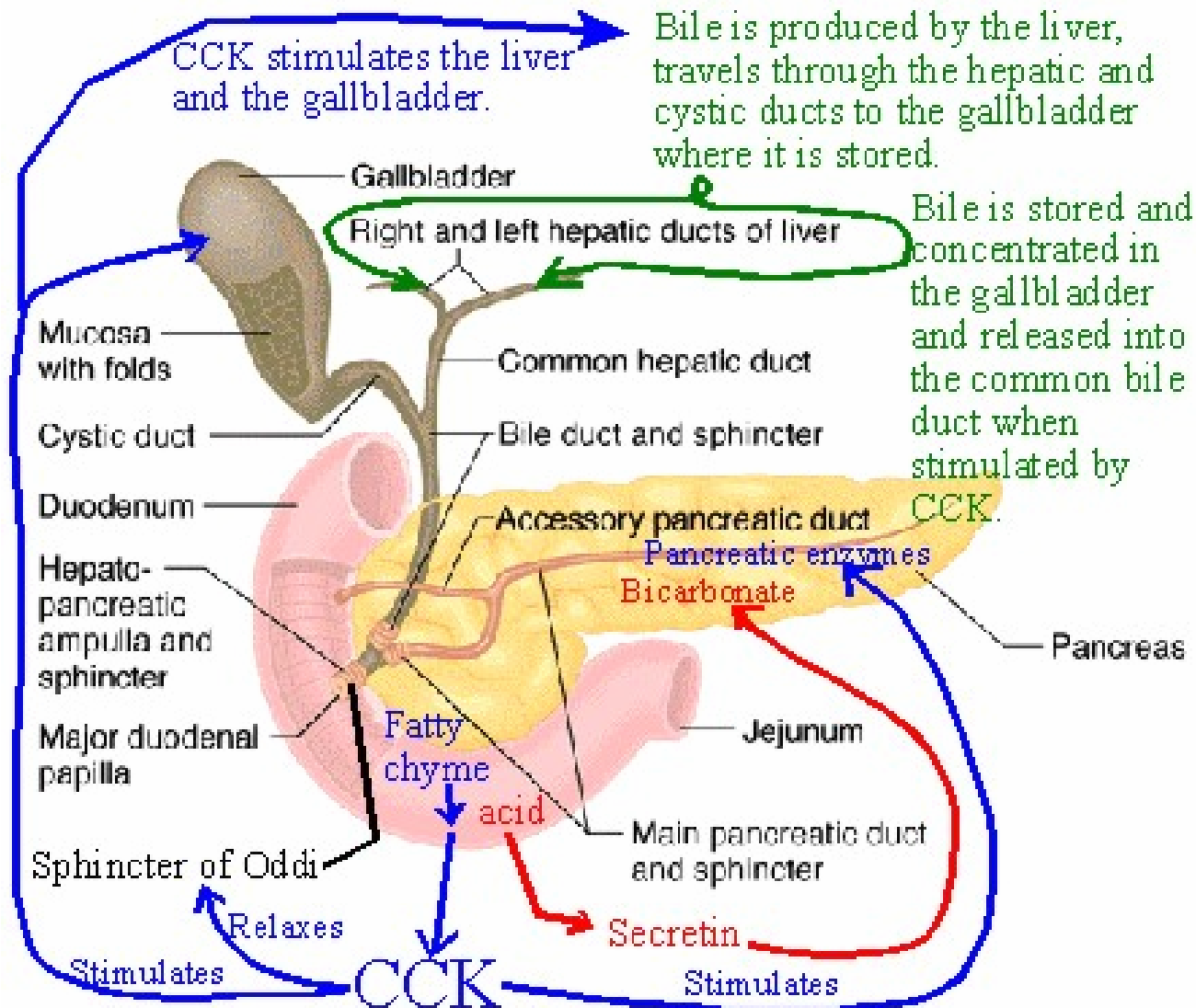
Function of secretin



# Regulation of Gastric Secretions

- **Cholecystokinin**- secretion is stimulated by partially digested proteins (amino acids) and triglycerides (fatty acids). It inhibits gastric emptying, stimulates the secretion of pancreatic juice rich in digestive enzymes, causes the ejection of bile from the gallbladder, and induces a feeling of satiety (feeling of satisfaction or fullness).

# Hepato-pancreatic Junction



# Regulation of Gastric Emptying

- The regulation of the passage of food from the stomach to the small intestine is so that the small intestine have time for complete digestion of the food before it is moved further along the GI tract and more food is allowed to enter.
- This is regulated by both nerves and hormones
- Gastric emptying is the fastest with carbohydrates, then proteins, and the slowest with fats



# Vomiting

- The forcible expulsion of the contents of the upper GI tract (stomach and duodenum) through the mouth by the squeezing of the stomach between the diaphragm and the abdominal muscle.
- Vomiting can have many stimulants
  - dizziness, drugs, unpleasant sights, etc.
- Prolonged vomiting can cause imbalance in fluid , electrolyte, and acid/base.

# Stomach Growling

- **migrating motor complex- is a distinct pattern of electromechanical activity observed in gastrointestinal smooth muscle during the periods between meals.**
- **It is thought to serve a "housekeeping" role and sweep residual undigested material through the digestive tube.**

# Absorption

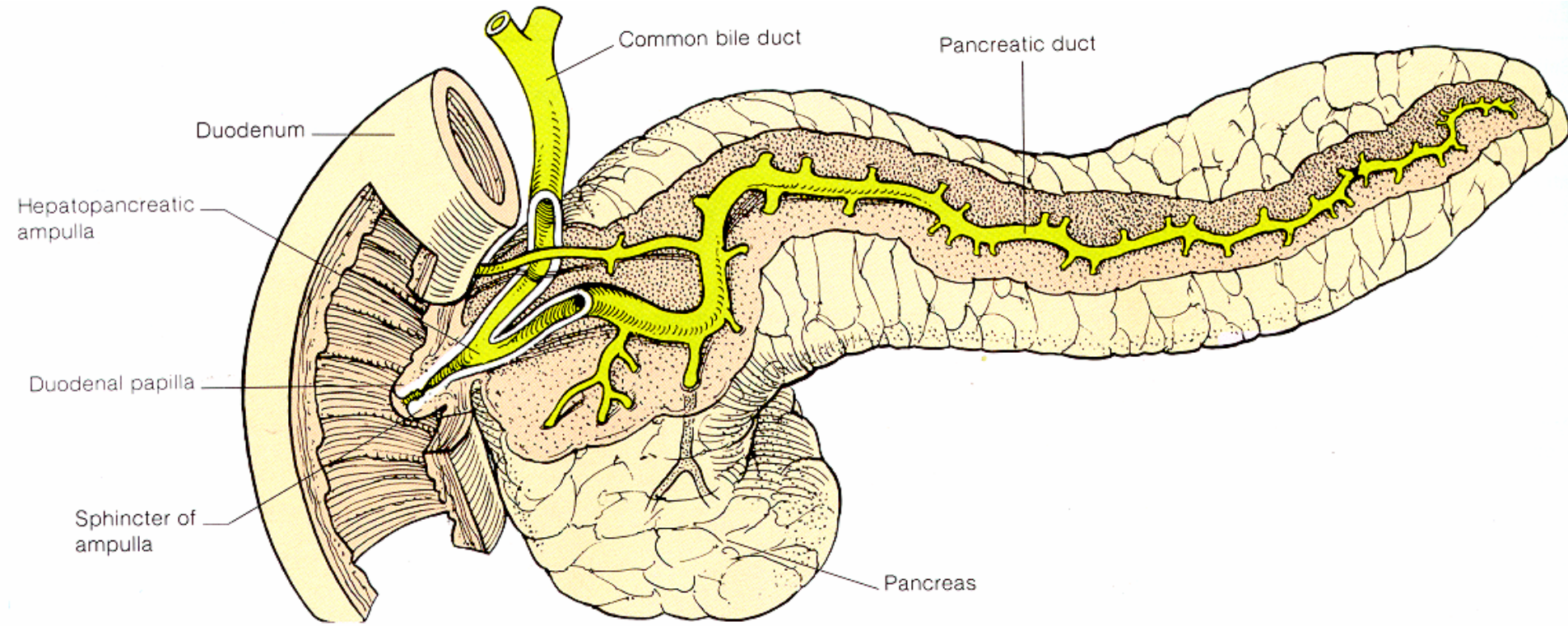
The process of moving digested material across the mucosa into the blood stream.

- Very little absorption occurs in the stomach.
  - The stomach does absorb some water, electrolytes, certain drugs (especially aspirin), and alcohol.
    - The absorption of alcohol is faster in females than males because the female has less of **alcohol dehydrogenase**, the enzyme that breaks down alcohol to a less harmful substance.
- Most digestion occurs in the small intestine where it is aided by the three accessory structures: the pancreas, liver, and gallbladder. Therefore it is in the small intestine that most of all of absorption occurs.



# Pancreas

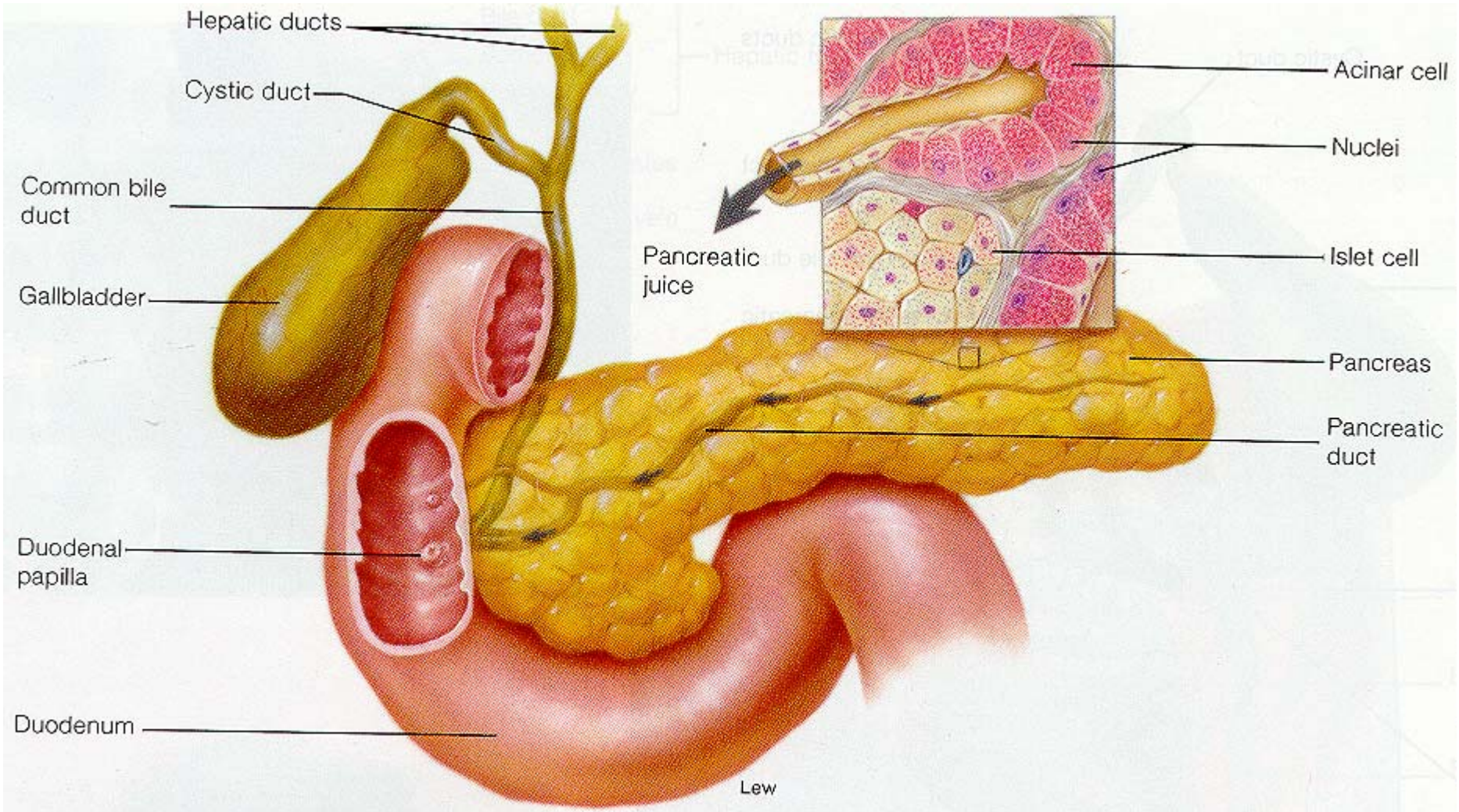
- The accessory digestive organ that lies behind the stomach and secretes contents into the duodenum through the **pancreatic duct**, which unites with the **common bile duct** from the liver and gallbladder to form a single duct that empties into the duodenum.



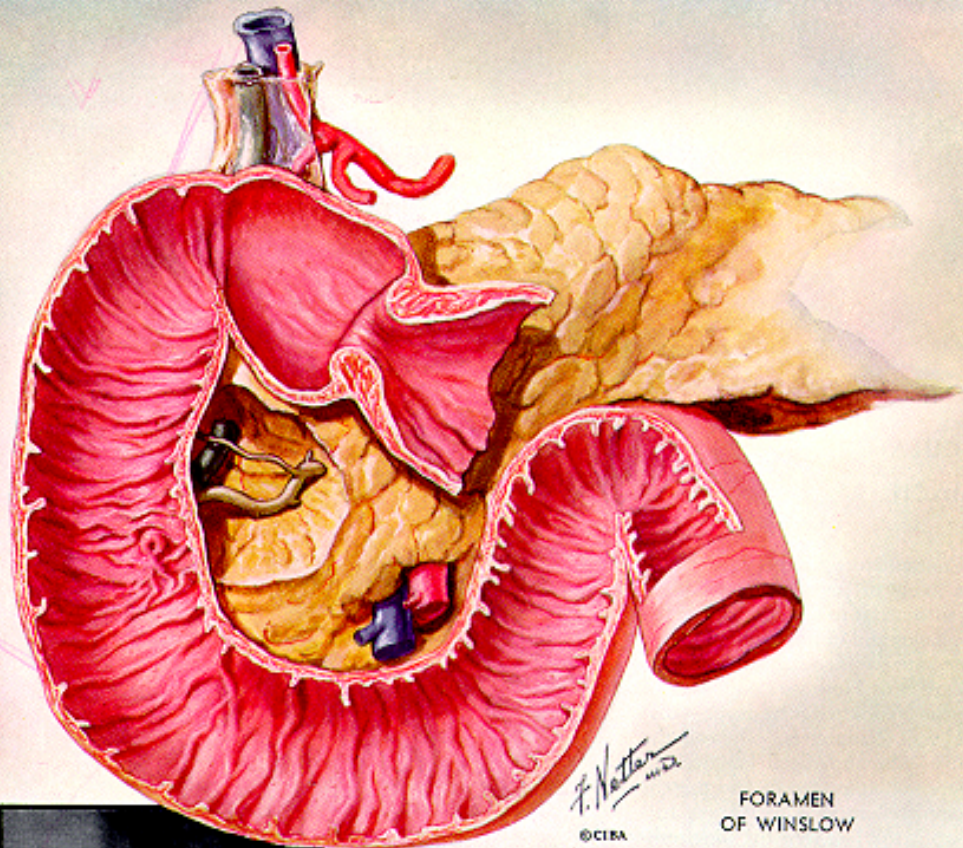
# Pancreas

- The pancreas is made up of two types of cells
  - **pancreatic islet cells** (islets of langerhans)- constitute the endocrine portion of the gland that secretes insulin and glucagon.
  - The cell of the **pancreatic acini**- glands that secrete digestive enzymes (pancreatic juices). These cells comprise most of the pancreas.

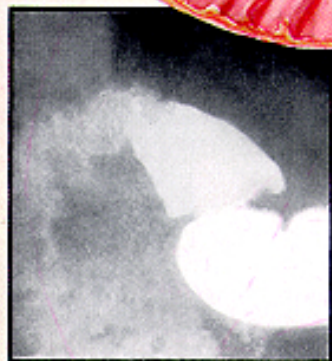




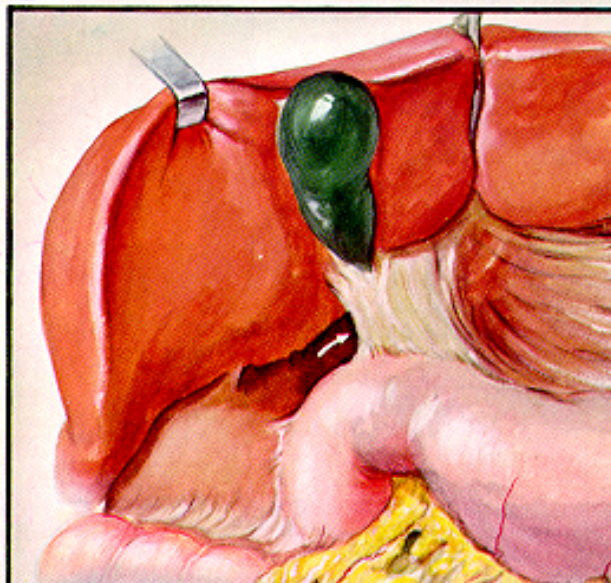




FORAMEN  
OF WINSLOW



NORMAL  
DUODENAL BULB



# Pancreatic Juice

- A clear colorless liquid that consist of mostly water, some salts, sodium bicarbonate, and enzymes.
- The sodium bicarbonate gives the juice a slightly alkaline pH that stops the action of pepsin from the stomach and creates the proper environment for the enzymes in the intestine.

# Pancreatic Juice

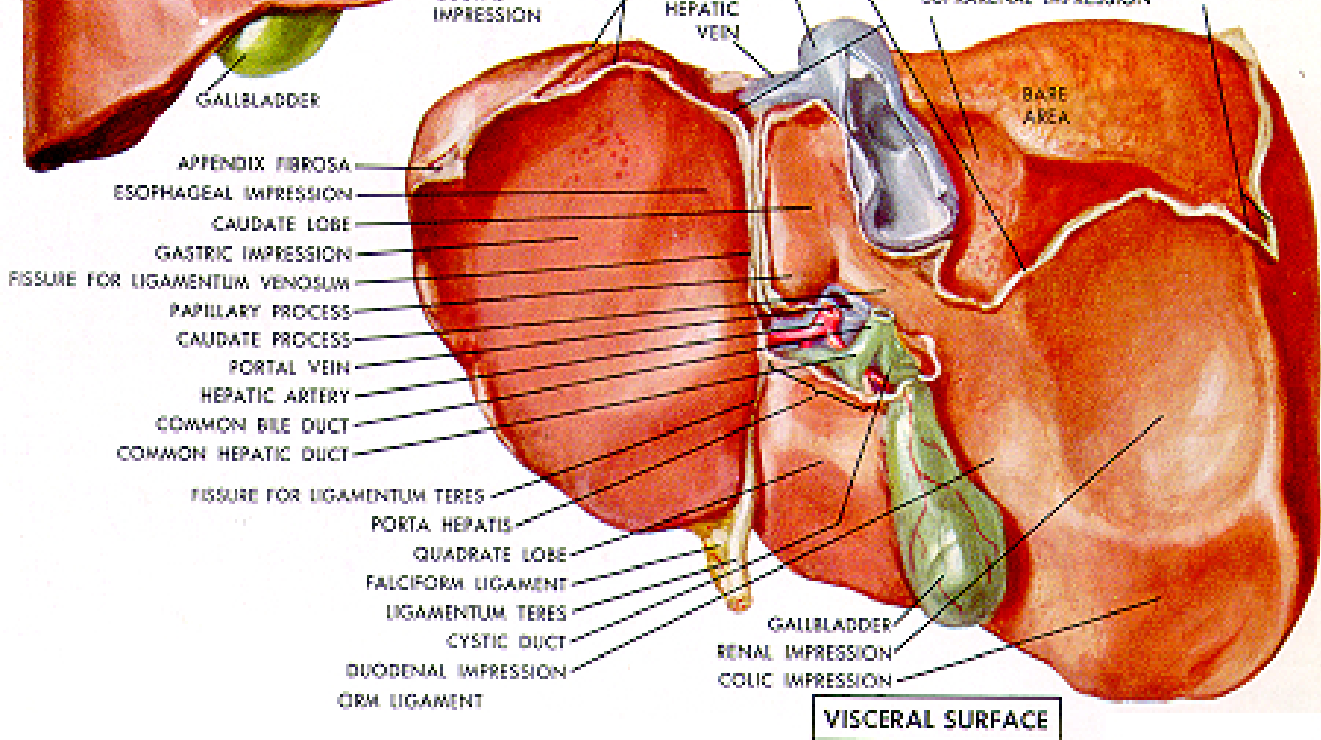
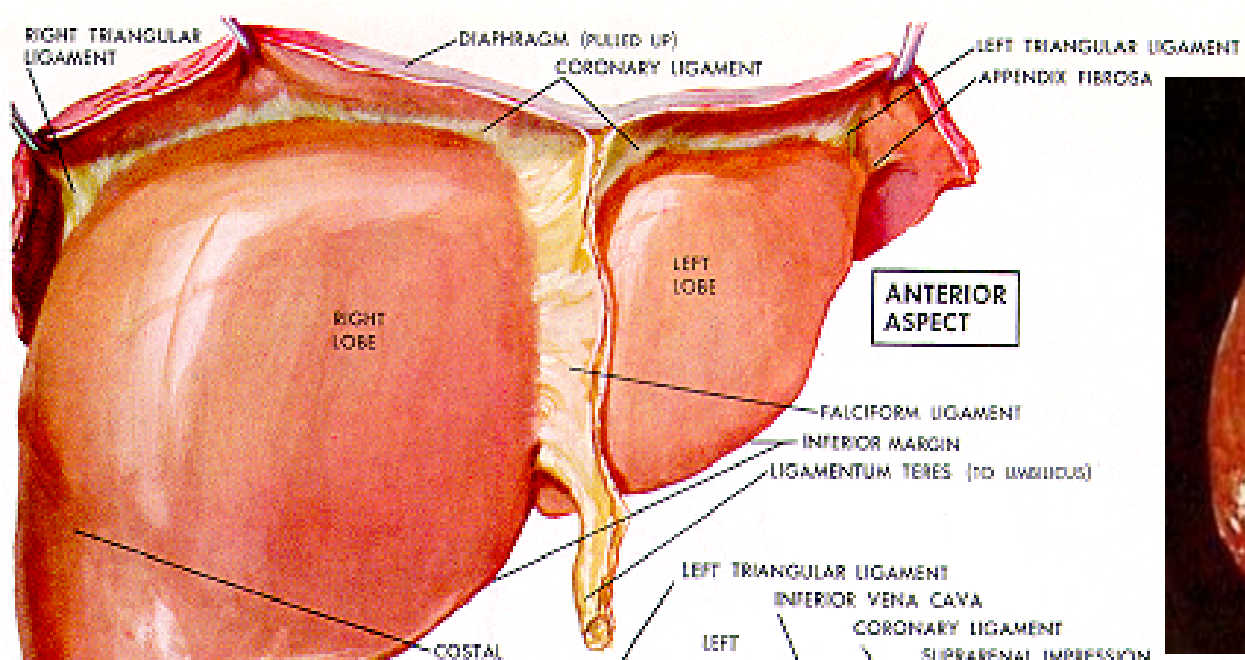
## Pancreatic Enzymes

- **Pancreatic amylase**- carbohydrate digestion.
- **Trypsin, chymotrypsin, and carboxypeptidase**- protein digestion.
- **Pancreatic lipase**- triglyceride digestion.
- **Ribonuclease and Deoxyribonuclease**- nucleic acid digestion.

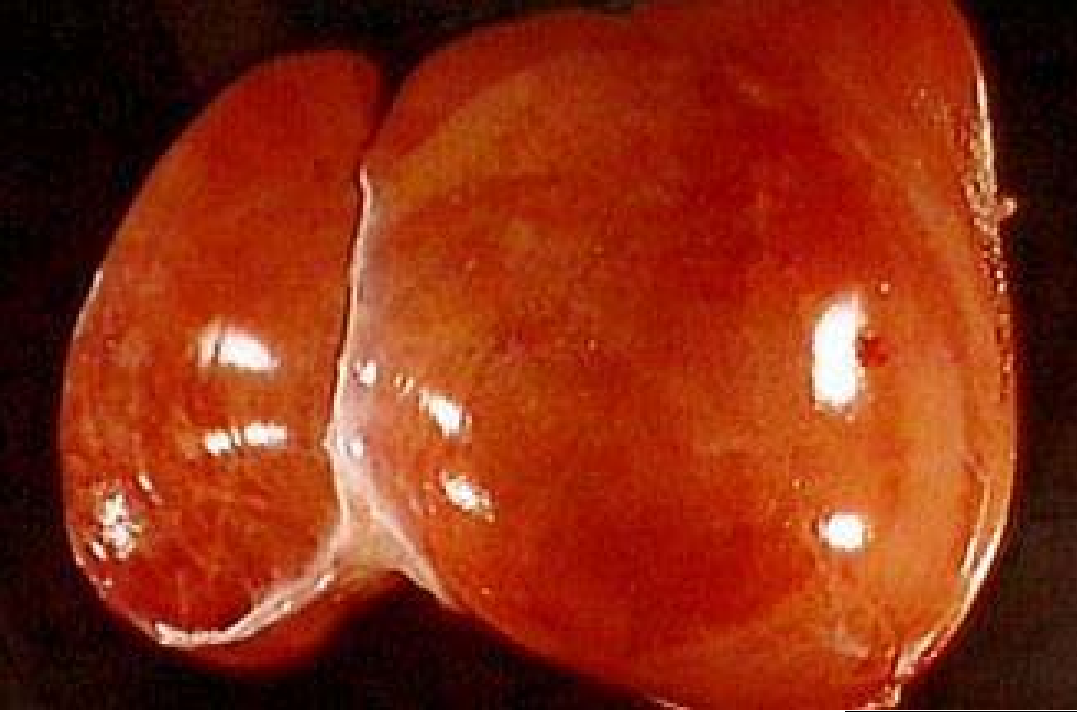
The secretion of the pancreatic juices is controlled by nervous and hormonal mechanisms (vagus nerve, cholecystokinin, secretin)

# Liver

- The heaviest gland in the body, weighting about 3 lbs in the average adult.
- It is located under the diaphragm, mostly on the right side of the abdominal cavity.
- It is covered by a connective tissue capsule and the visceral peritoneum.



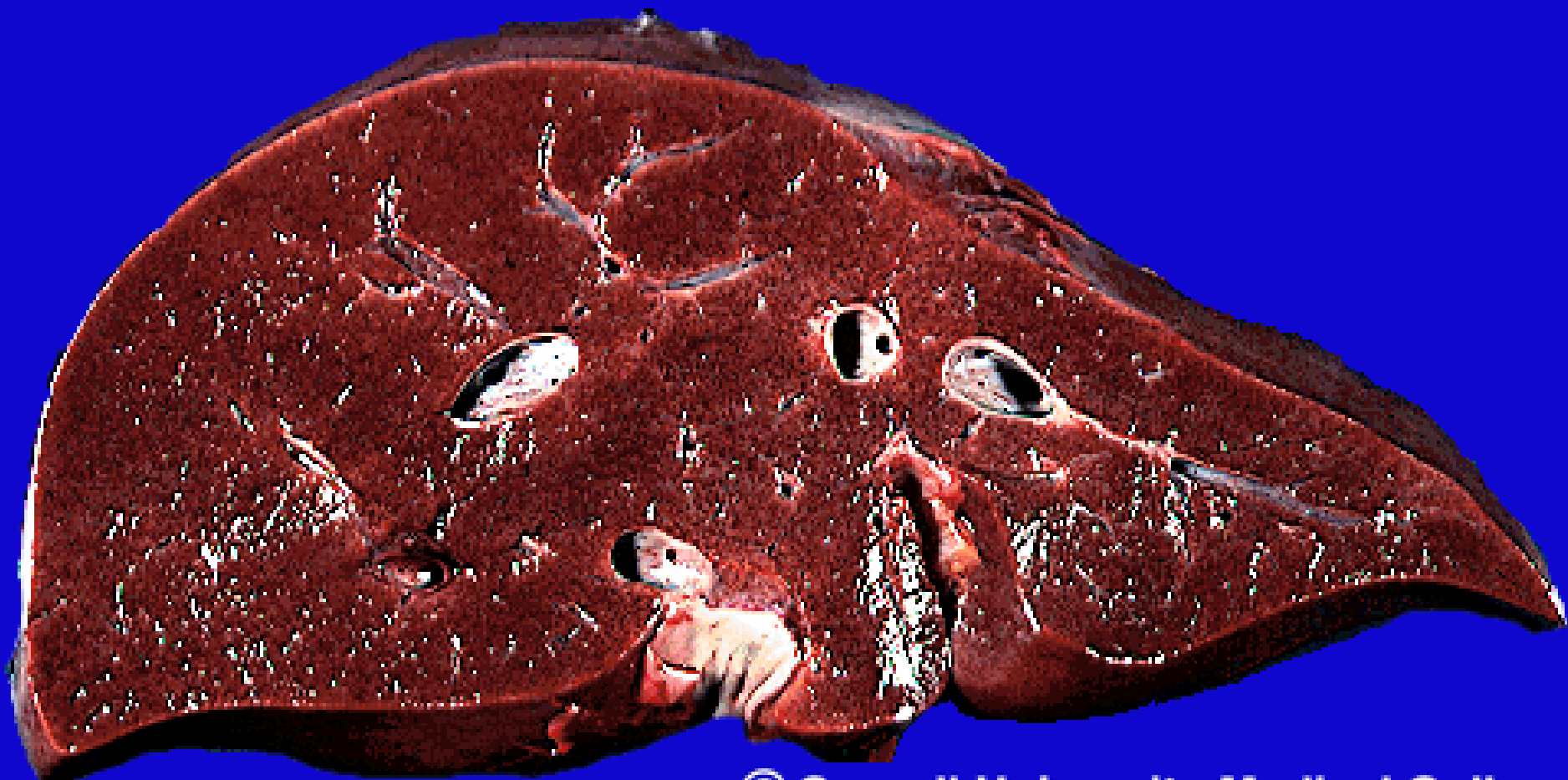




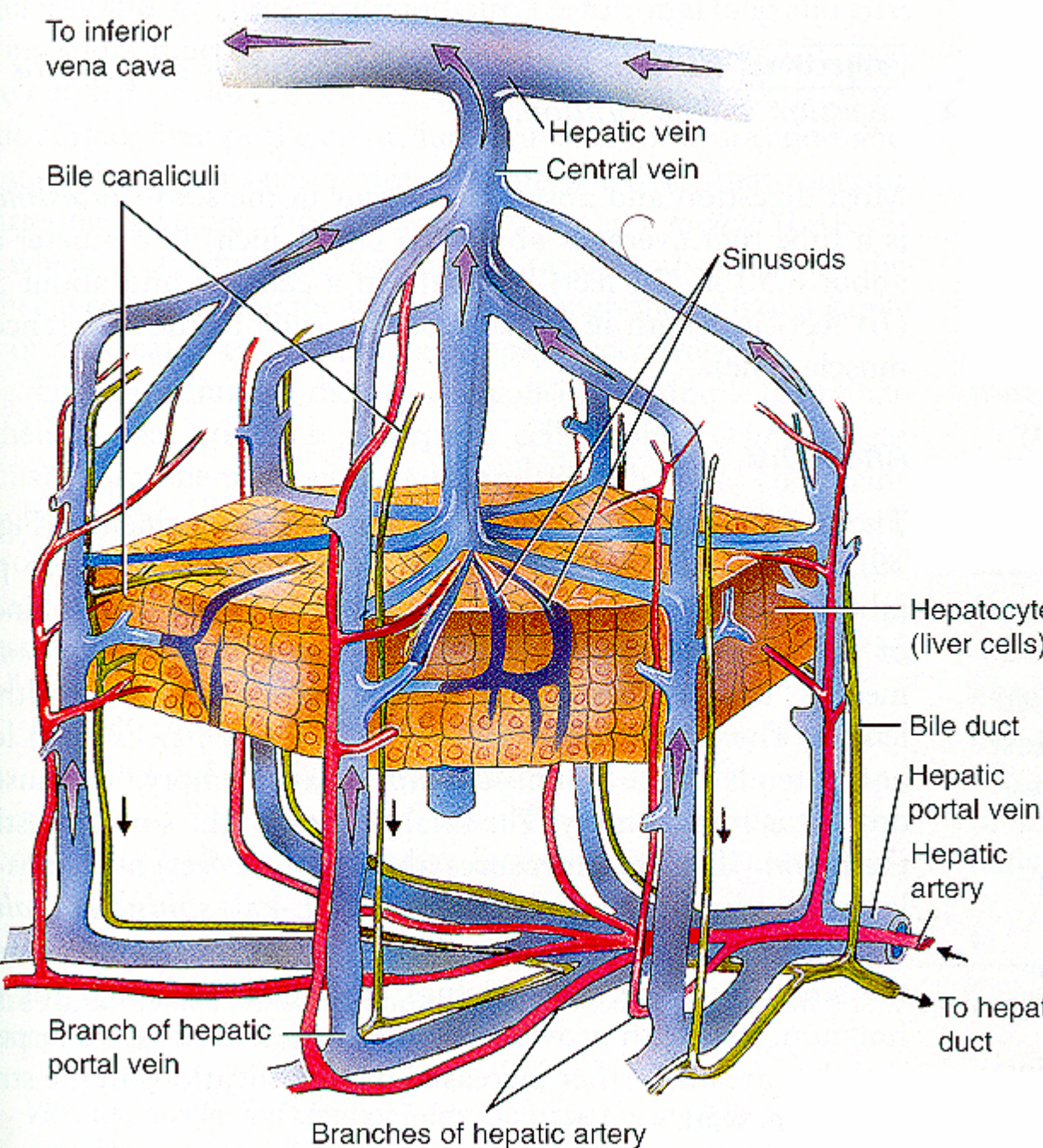
Liver Cirrhosis







© Cornell University Medical College



**Lobules**-functional units of the liver consisting of hepatocytes arranged radially around a central vein

**sinusoids**- channels that separate groups of hepatocytes. Blood from the portal vein brings nutrients to the hepatocytes via the sinusoids.

**Stellate reticuloendothelial cells (Kupffer cells)**- partly line the sinusoids that function to destroy worn-out white and red cells, bacteria, and toxic substances.

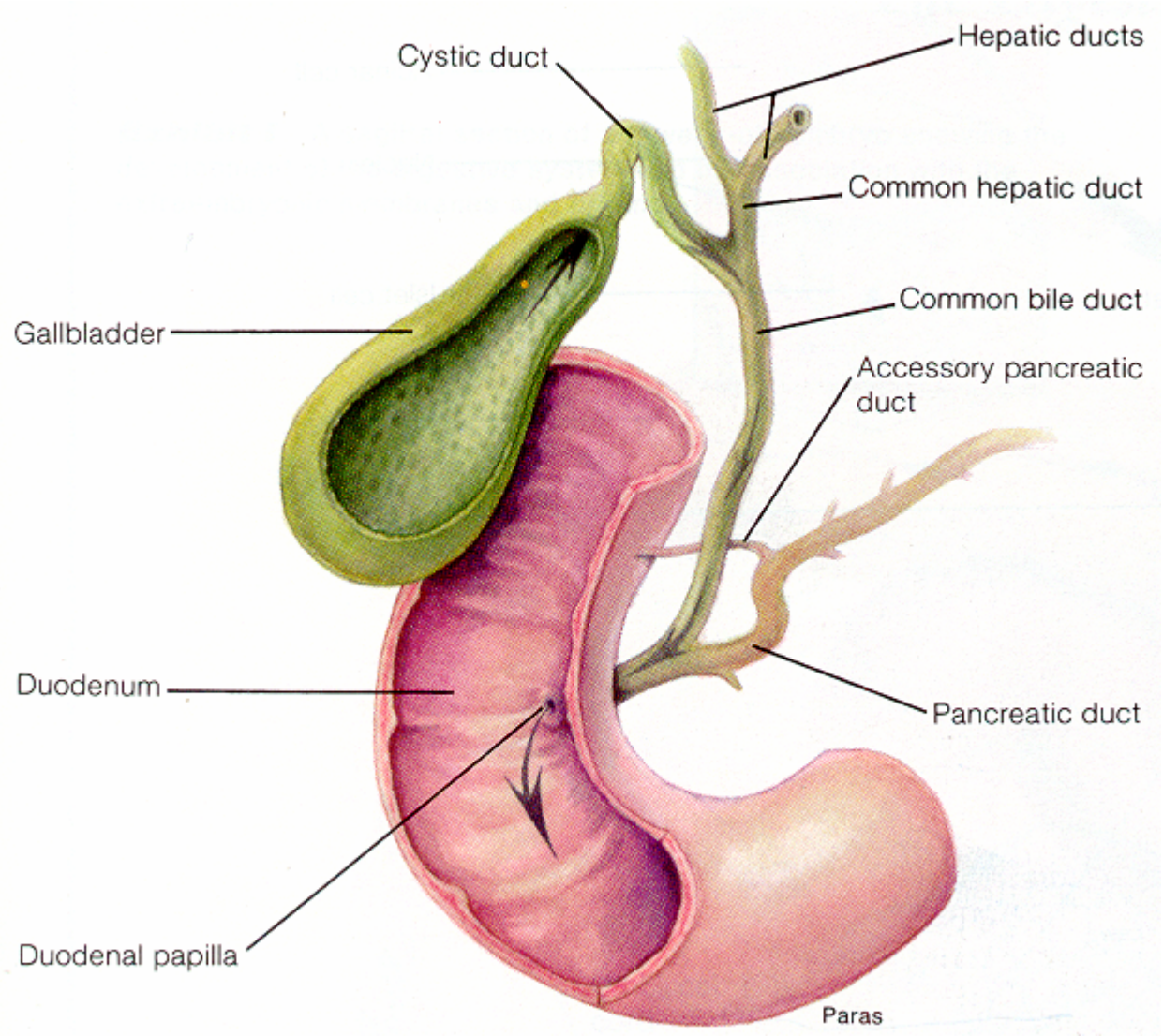
**Bile canaliculi**- small channels that course between the hepatocytes that relay bile to the right and left hepatic ducts.

**Common hepatic duct**- formed when the right and left hepatic ducts unite to a single tube to leave the liver.

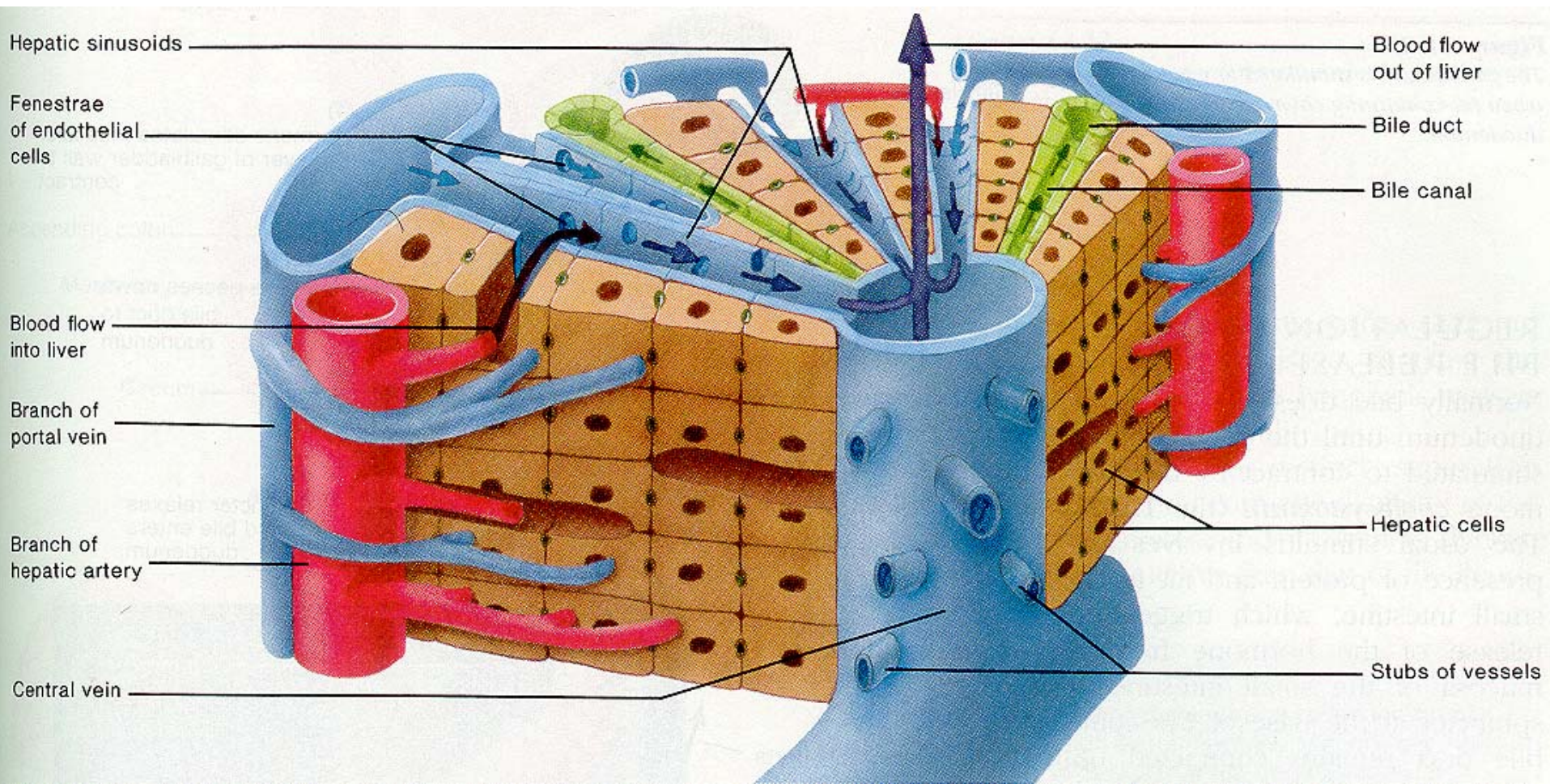
**Cystic duct**- duct that leads from the gallbladder.

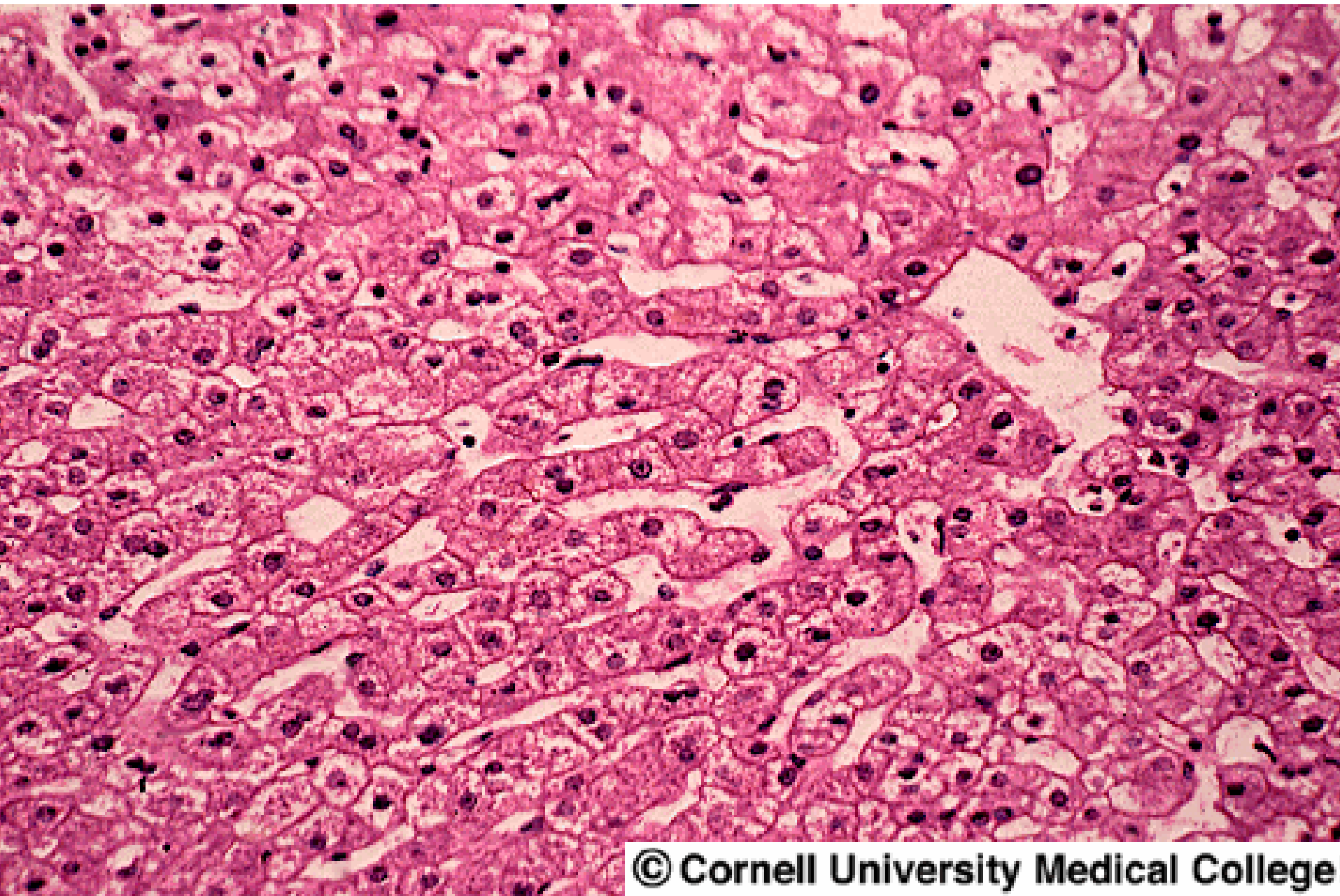
**Common bile duct**- formed from the uniting of the cystic duct and the common bile duct.











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# Blood Supply

The liver receives blood from two sources

- Hepatic artery- provides oxygenated blood.
- Hepatic portal vein- receives deoxygenated blood containing newly absorbed nutrients.

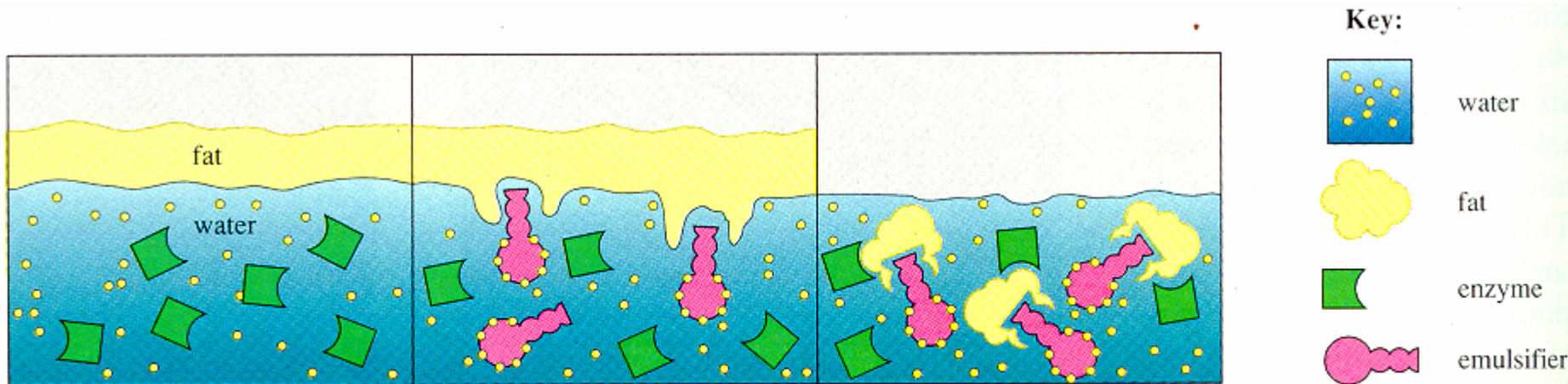


# Bile

- A yellow, brownish, or olive-green liquid secreted by the hepatocytes.
- It has a pH of 7.6-8.6
- It consist of mostly water and bile salts, cholesterol, phospholipids (lecithin), bile pigments and several ions.
- It is stored in the gallbladder.

# Bile

- It is an excretory product with a digestive function.
  - bile salts aid in the digestion of fats
- Bile salts aid in **emulsification** of fats (the conversion of fat globules into a suspension of fat droplets), allowing enzymes greater surface area from which they can chemically digest fat.



# Bile

- The principal bile pigment is bilirubin (a breakdown product of red blood cells.
  - is broken down in the intestine to stercobilin which gives feces its color.

# Regulation of Bile Secretion

- Bile secretion is determined by both nervous and hormonal factors.
- Parasympathetic stimulation via the vagus nerve increases the production of bile.
- Secretin stimulates the production of bile.
- Cholecystikin causes ejection of bile from the gallbladder.

# Functions of the Liver

- carbohydrate metabolism- The liver is very important in maintaining normal blood glucose.
  - can convert glucose to glycogen when glucose blood concentrations are high (hyperglycemia)
  - converts glycogen to glucose in hypoglycemic states.
- Lipid metabolism- stores some triglycerides and breaks down fatty acids.

# Functions of the Liver

- Protein metabolism-
  - synthesizes most plasma proteins, such as globulin, albumin, prothrombin, and fibrinogen.
  - converts one amino acid to another
  - convert amino acids for energy use or for storage in the form of fat or carbohydrates.
  - makes urea from protein breakdown products (ammonia,  $\text{NH}_3$ )



- Chronic liver disease usually results from years of inflammation, which ultimately leads to fibrosis and decline in function. Histologically, this is referred to as Cirrhosis.
- Common causes
  - chronic alcohol use
  - viral hepatitis (B or C)
  - hemochromatosis
- After many years (generally greater than 20) of chronic insult, the liver may become unable to perform some or all of its normal functions.

# Most Common Findings of Cirrhosis

- **Hyperbilirubinemia:** The diseased liver may be unable to conjugate or secrete bilirubin appropriately. This can lead to
  - Icterus - Yellow discoloration of the sclera.
  - Jaundice - Yellow discoloration of the skin.
  - Bilirubinuria - Golden-brown coloration of the urine.

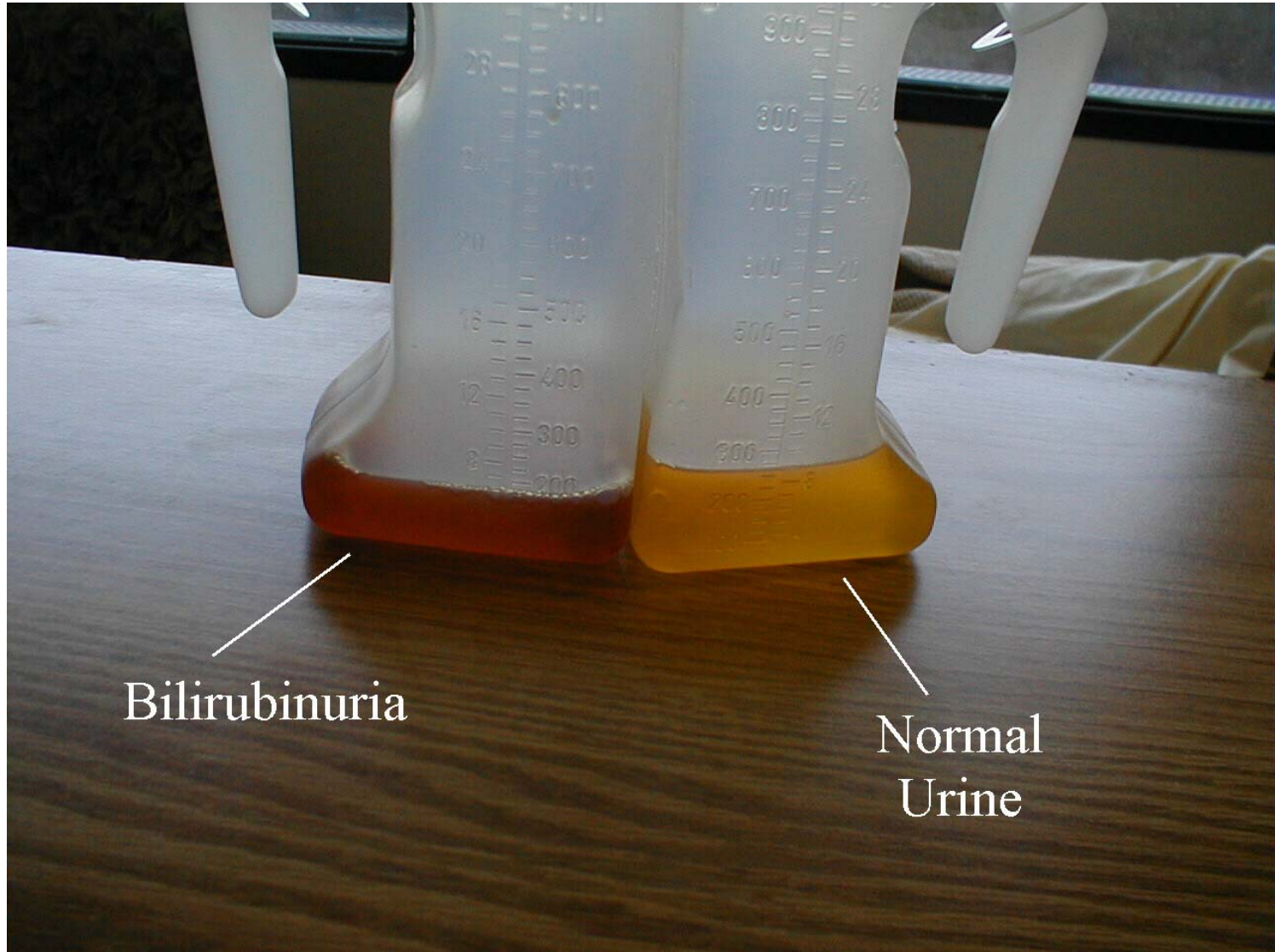
# Icterus



# Jaundice



# Bilirubinuria



# Most Common Findings of Cirrhosis

- Ascites (accumulation of fluid in the peritoneal cavity) due to portal vein hypertension which results from increased resistance to blood flow through an inflamed and fibrotic liver.
- Lower Extremity Edema due to impaired synthesis of the protein albumin leading to lower intravascular oncotic pressure and resultant leakage of fluid into soft tissues. This is particularly evident in the lower extremities.



# Ascites



# Lower Extremity Edema



# Most Common Findings of Cirrhosis

- Increased Systemic Estrogen Levels: The liver may become unable to process particular hormones, leading to their peripheral conversion into estrogen. High levels promote:
  - Breast development (gynecomastia).
  - Spider Angiomata - dilated arterioles most often visible on the skin of the upper chest.
  - Testicular atrophy.



# Gynecomastia



# Spider Angioma

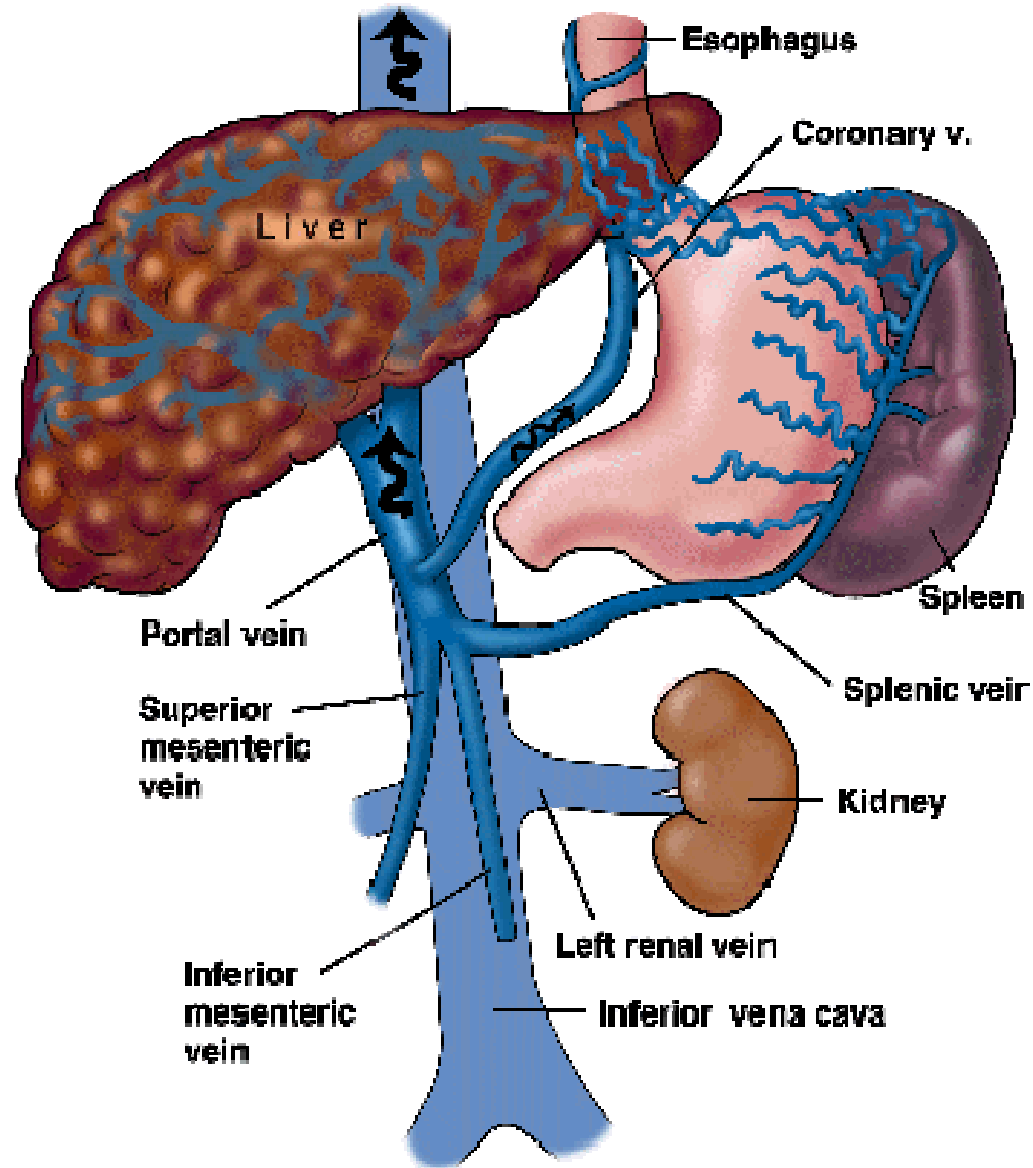


# Most Common Findings of Cirrhosis

- **Varices:** In the setting of portal hypertension, blood "finds" alternative pathways back to the heart that do not pass through the liver.
- The most common is via the splenic and short gastric veins, which pass through the esophageal venous plexus enroute to the SVC. This causes **esophageal varices** which can bleed profoundly, though these are not apparent on physical examination. A much less common path utilizes the recanalized umbilical vein, which directs blood through dilated superficial veins in the abdominal wall. These are visible on inspection of the abdomen and are known as **Caput Medusae**.

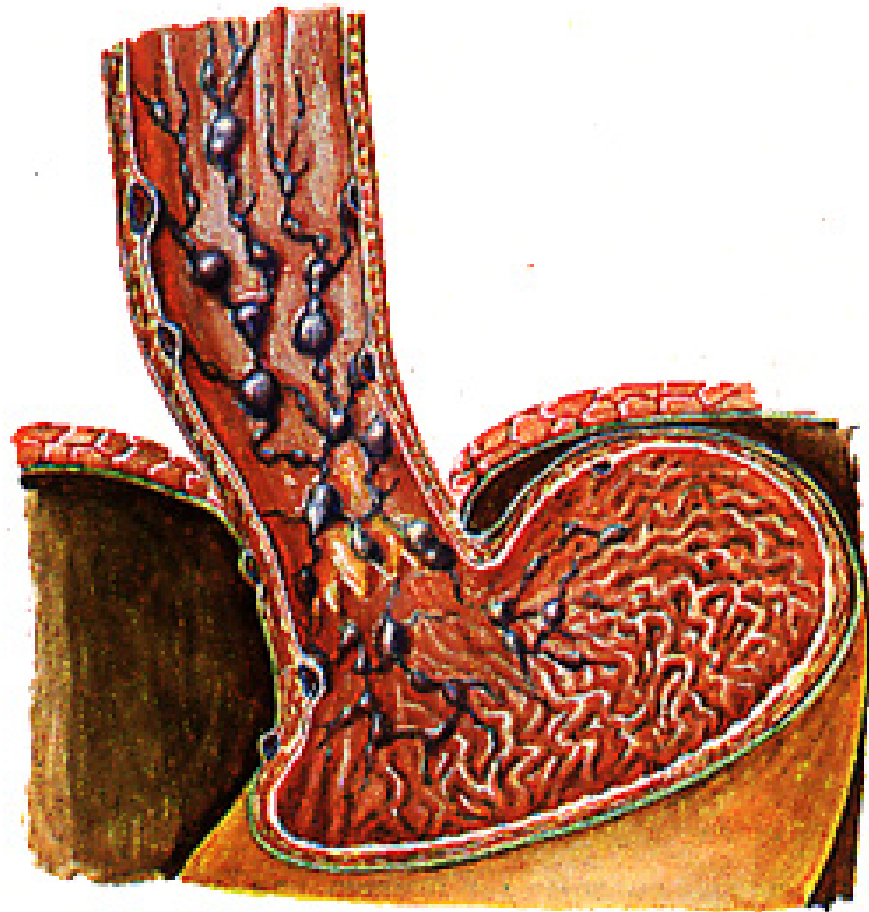


# Alternate Venous Path



# Caput Medusae







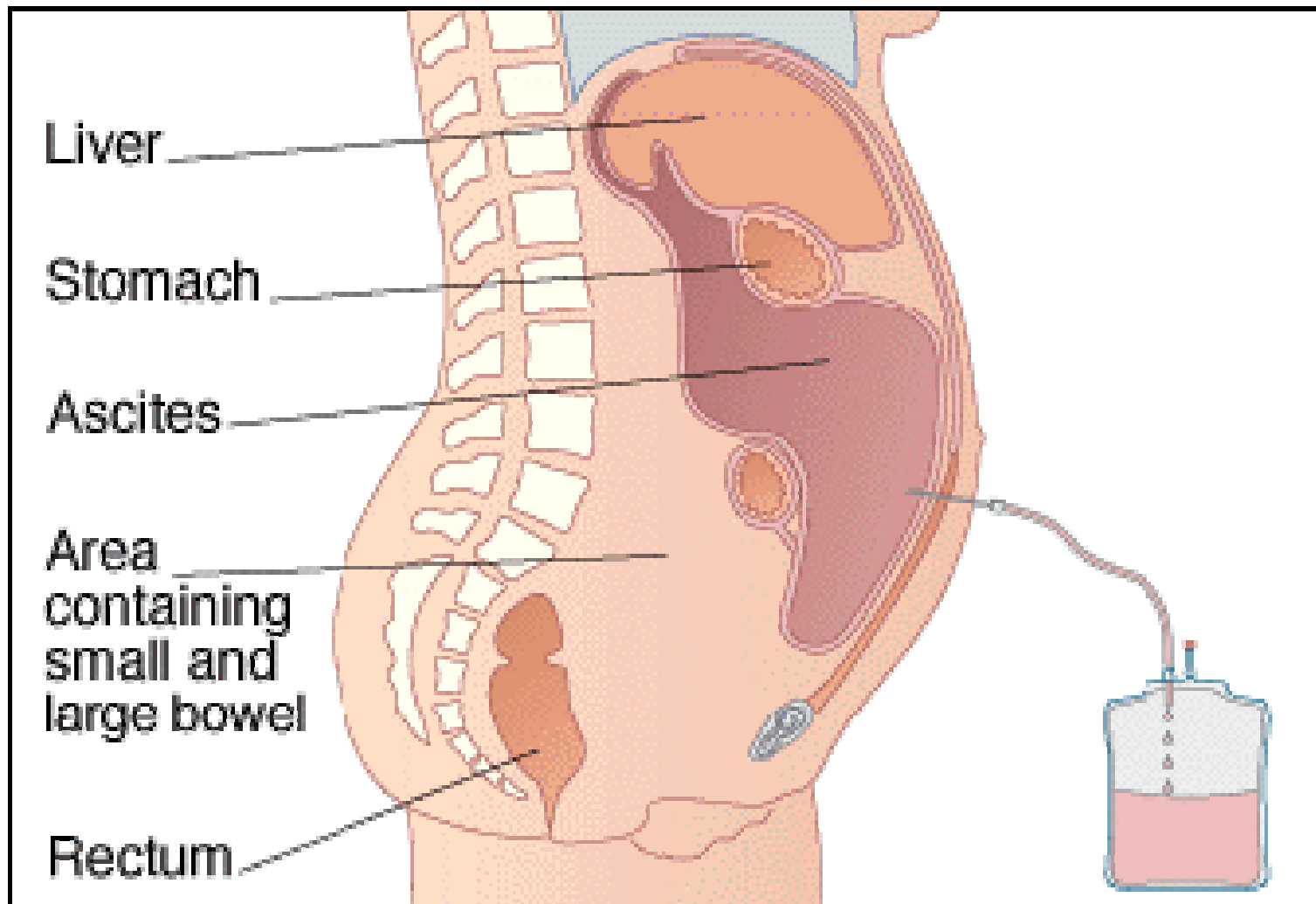


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# Functions of the Liver

- Removal of drugs and hormones-
  - can detoxify drugs (alcohol)
  - excrete drugs into the bile, such as penicillin, erythromycin, etc.
  - can alter and excrete hormones, such as thyroid hormone, steroids (estrogen and aldosterone)
- Excrete bile- most of which is bilirubin (red cell breakdown product)
- Synthesis of bile salts- used in the small intestine for fat emulsification.

# functions of the Liver

- Storage-
  - stores vitamins
    - A, B<sub>12</sub>, D, E, and K
  - minerals- iron and copper
- Phagocytosis- the Kupffer's cells (stellate reticuloendothelial cells) phagocytize worn-out red and white cells and some bacteria.
- Activation of vitamen D- the skin, kidney, and liver participate in the activation of vitamin D.

# Gallbladder

- A pear shaped sac located in a depression under the liver.
- Smooth muscle contraction in the walls, following hormonal stimulation, cause the ejection of bile into the cystic duct.

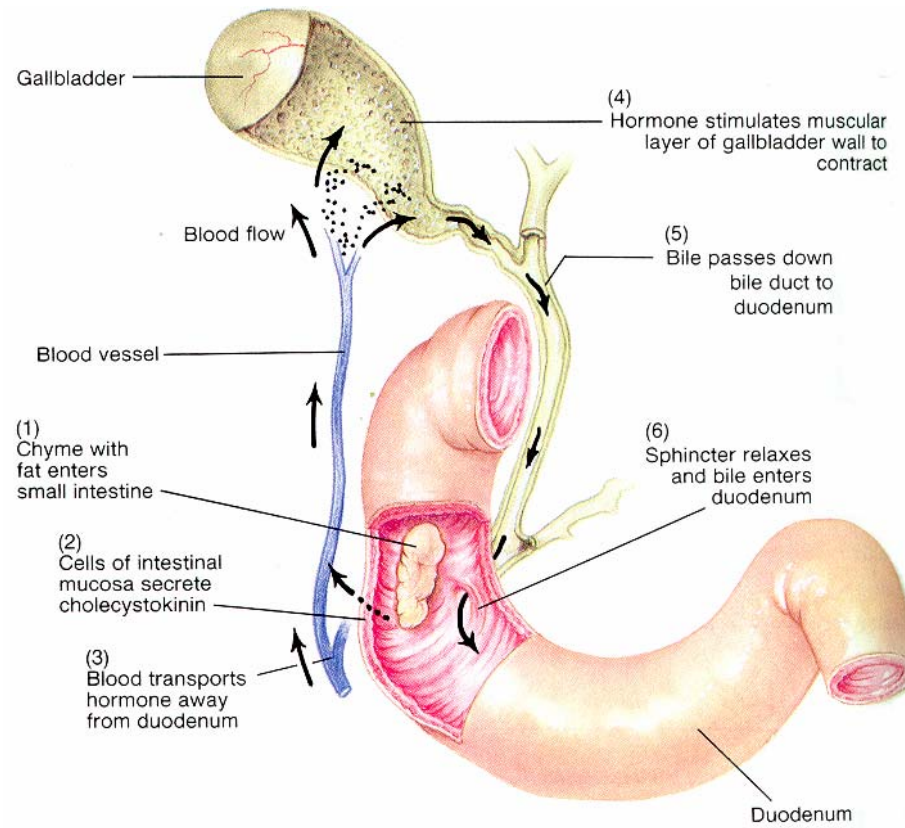
## Functions

- Concentrates and stores bile
- Storage is facilitated by the closure of the common bile duct resulting in bile back up to the cystic duct to the gallbladder for storage.

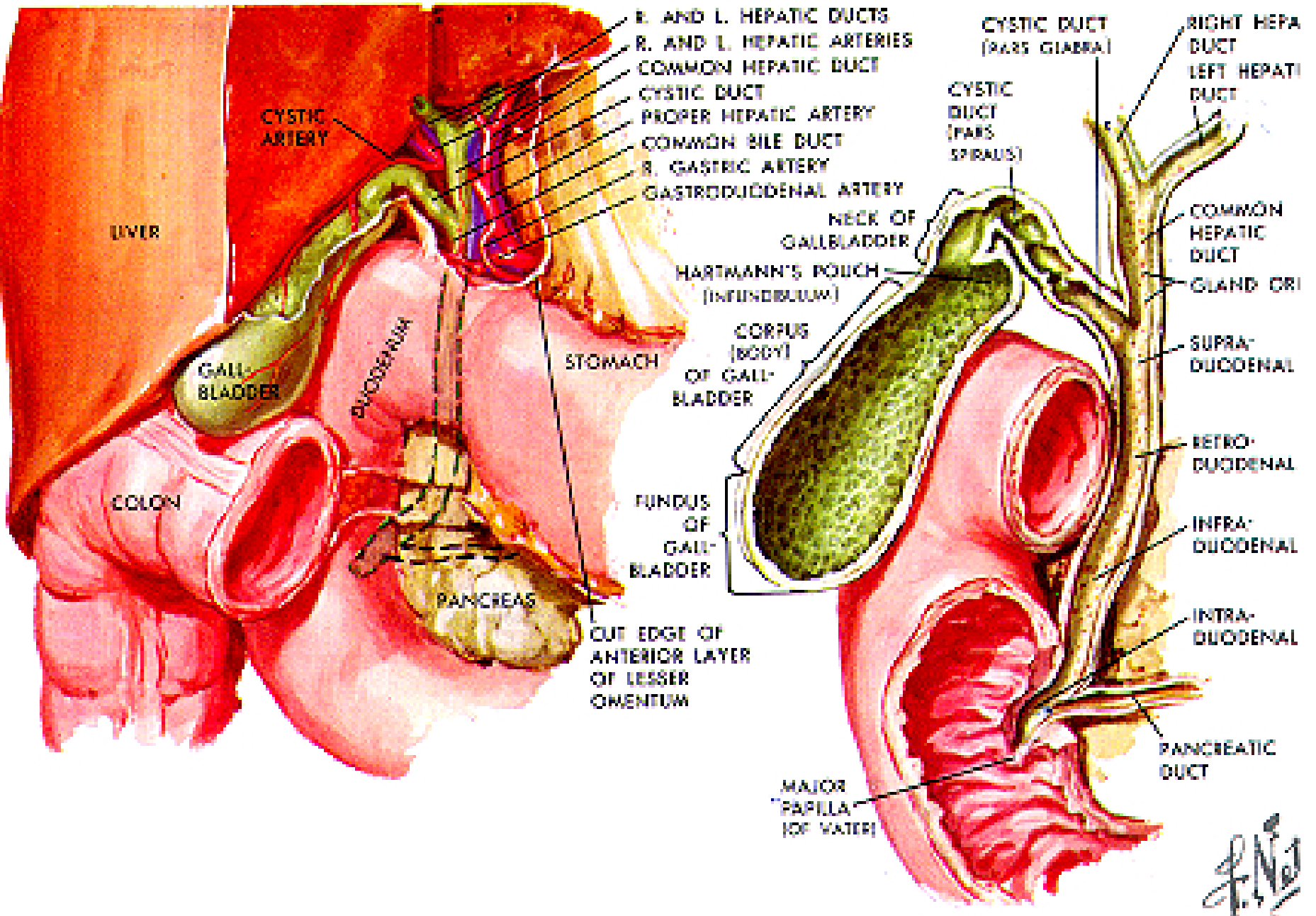
# Gallbladder

## Emptying of the Gallbladder

- When triglycerides enter the small intestine, cholecystikinin is released to stimulate contractions of the gallbladder, which releases bile into the common bile duct and on into the small intestine.







R. AND L. HEPATIC DUCTS  
 R. AND L. HEPATIC ARTERIES  
 COMMON HEPATIC DUCT  
 CYSTIC DUCT  
 PROPER HEPATIC ARTERY  
 COMMON BILE DUCT  
 R. GASTRIC ARTERY  
 GASTRODUODENAL ARTERY

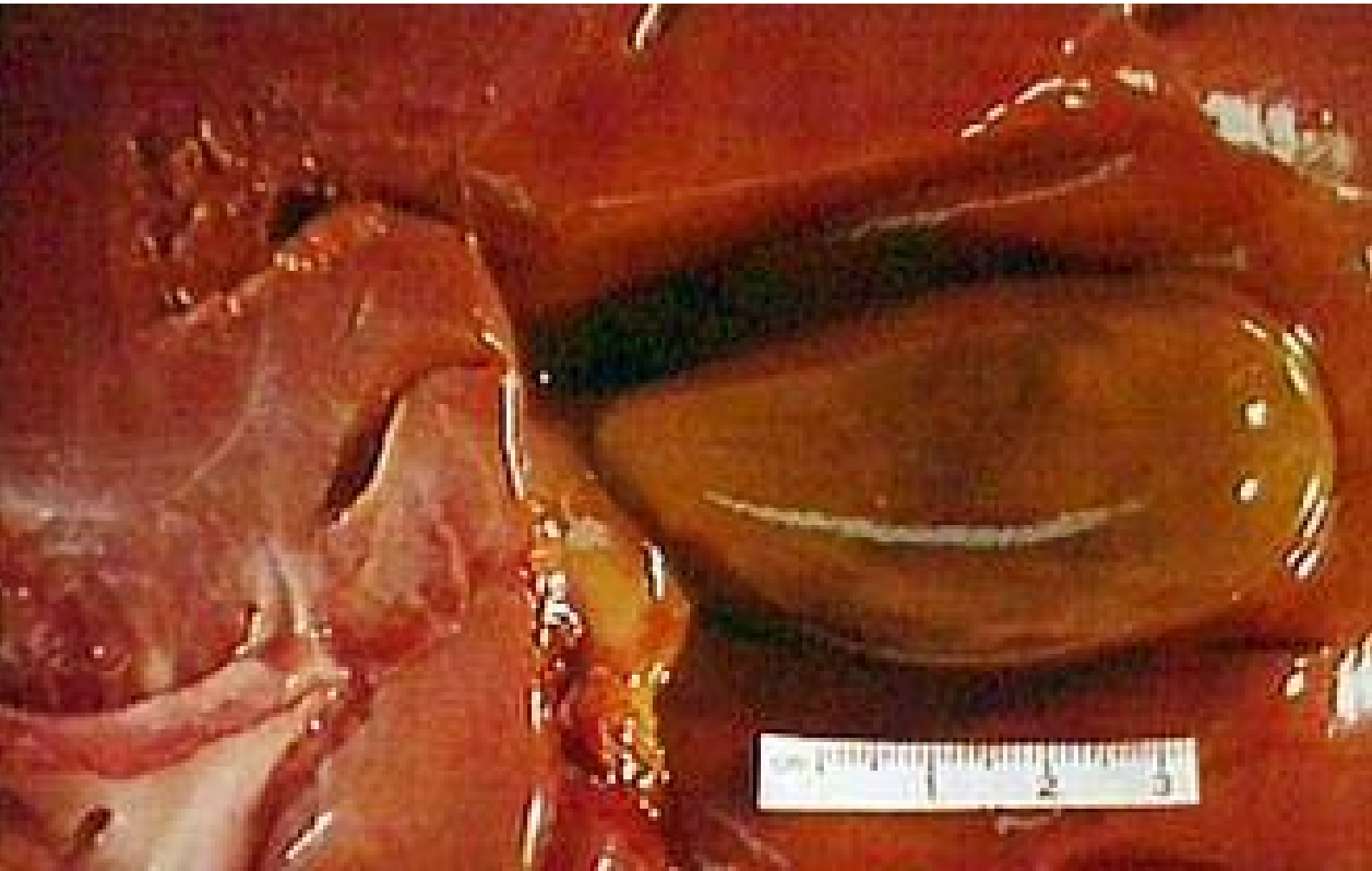
CYSTIC DUCT (PARS GLABRA)  
 CYSTIC DUCT (PARS SPHINCTERATA)  
 RIGHT HEPATIC DUCT  
 LEFT HEPATIC DUCT

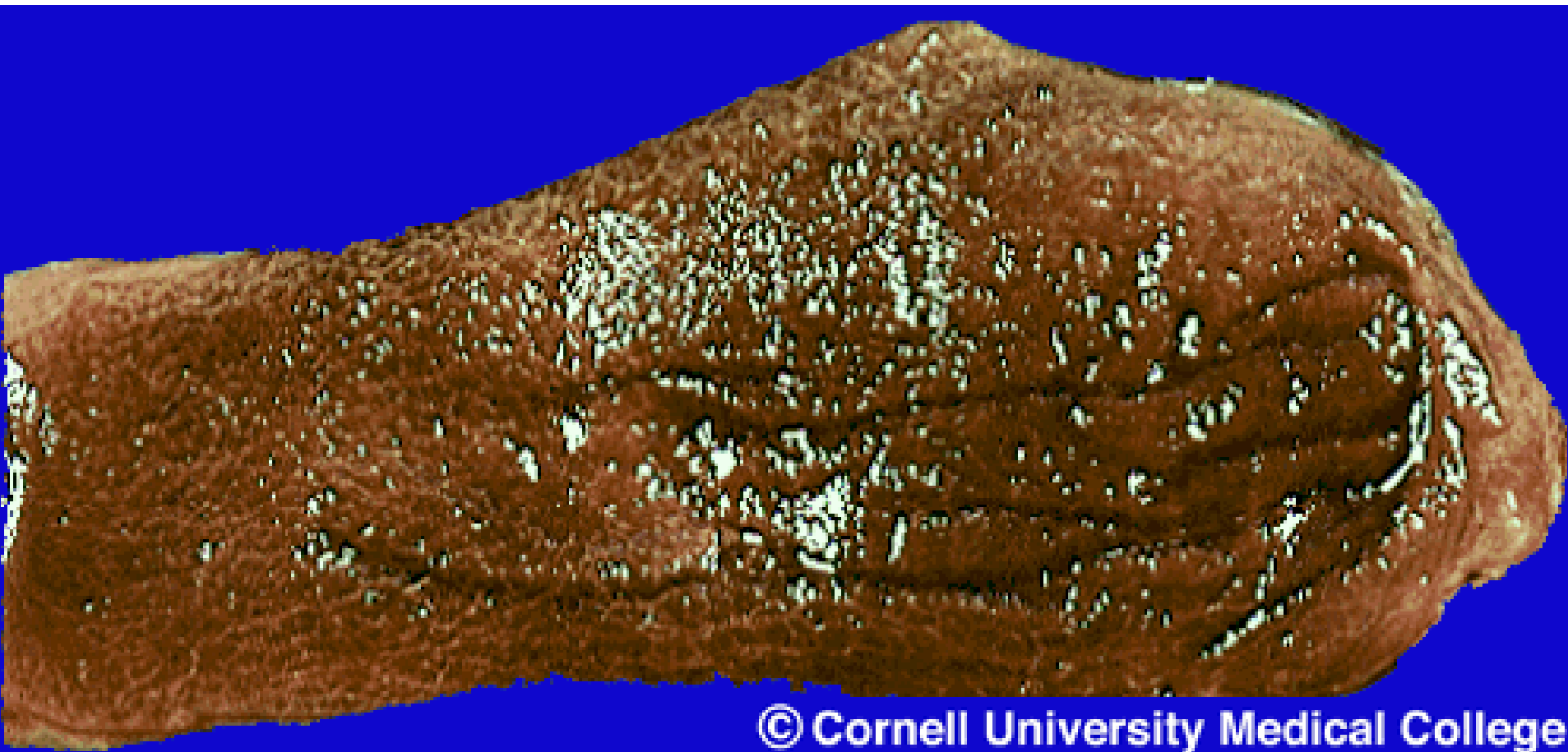
NECK OF GALLBLADDER  
 HARTMANN'S POUCH (INFUNDIBULUM)  
 CORPUS (BODY) OF GALL-BLADDER  
 FUNDUS OF GALL-BLADDER

COMMON HEPATIC DUCT  
 GLAND ORI  
 SUPRA-DUODENAL  
 RETRO-DUODENAL  
 INFRA-DUODENAL  
 INTRA-DUODENAL  
 PANCREATIC DUCT

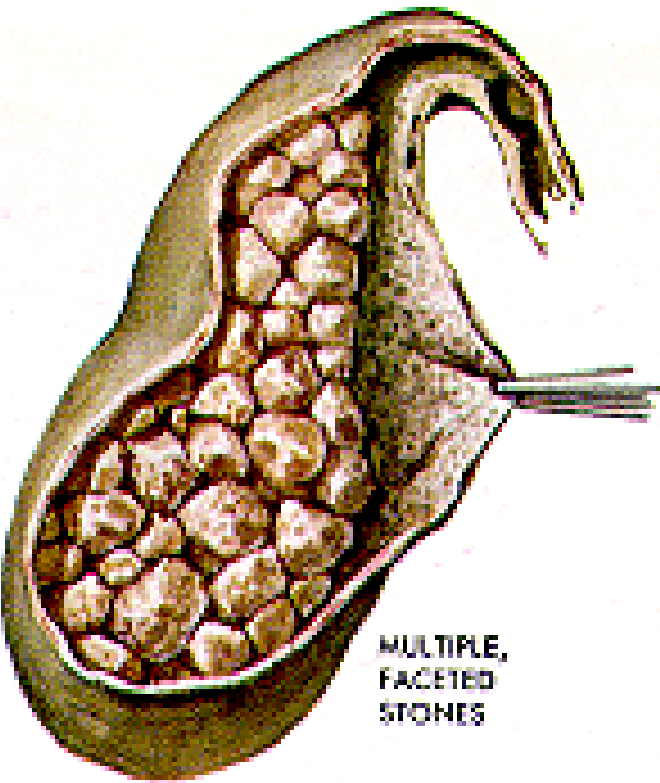
MAJOR PAPILLA (OF VATER)

*F. Net*

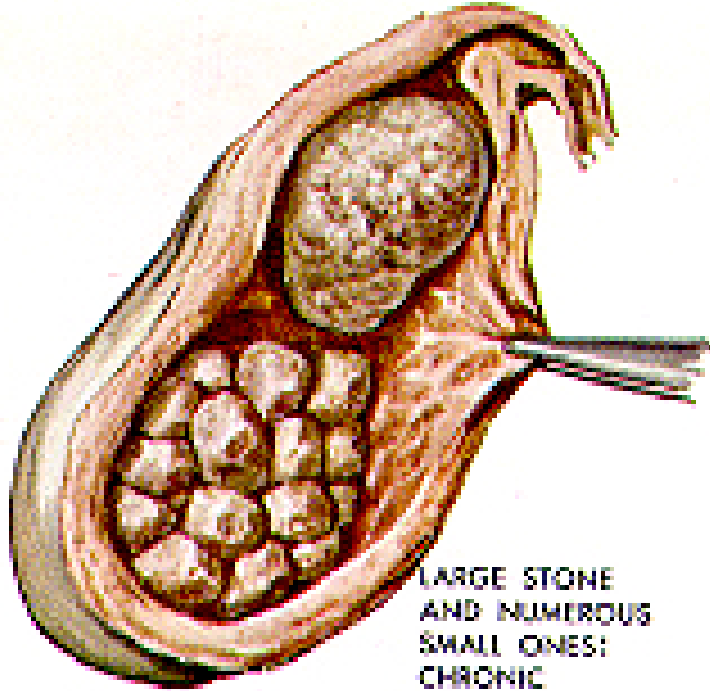




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MULTIPLE,  
FACETED  
STONES



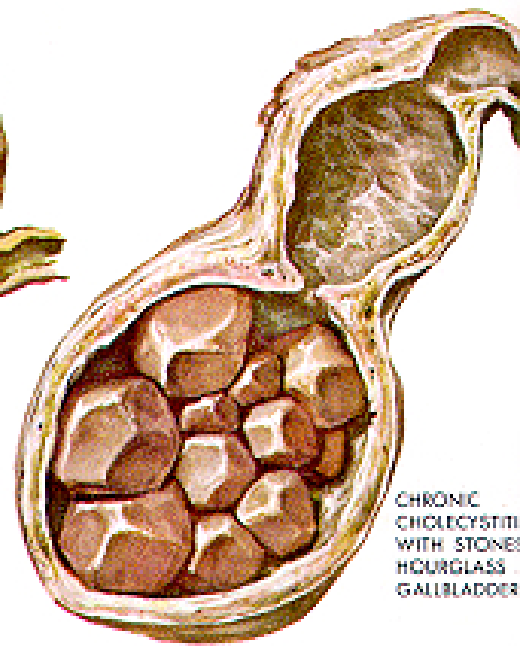
LARGE STONE  
AND NUMEROUS  
SMALL ONES;  
CHRONIC  
CHOLECYSTITIS



MARKEDLY THICKENED  
GALLBLADDER CONTRACTED  
ABOUT SOLITARY LARGE  
STONE



CALCIFICATION  
(PORCELAIN GALLBLADDER)



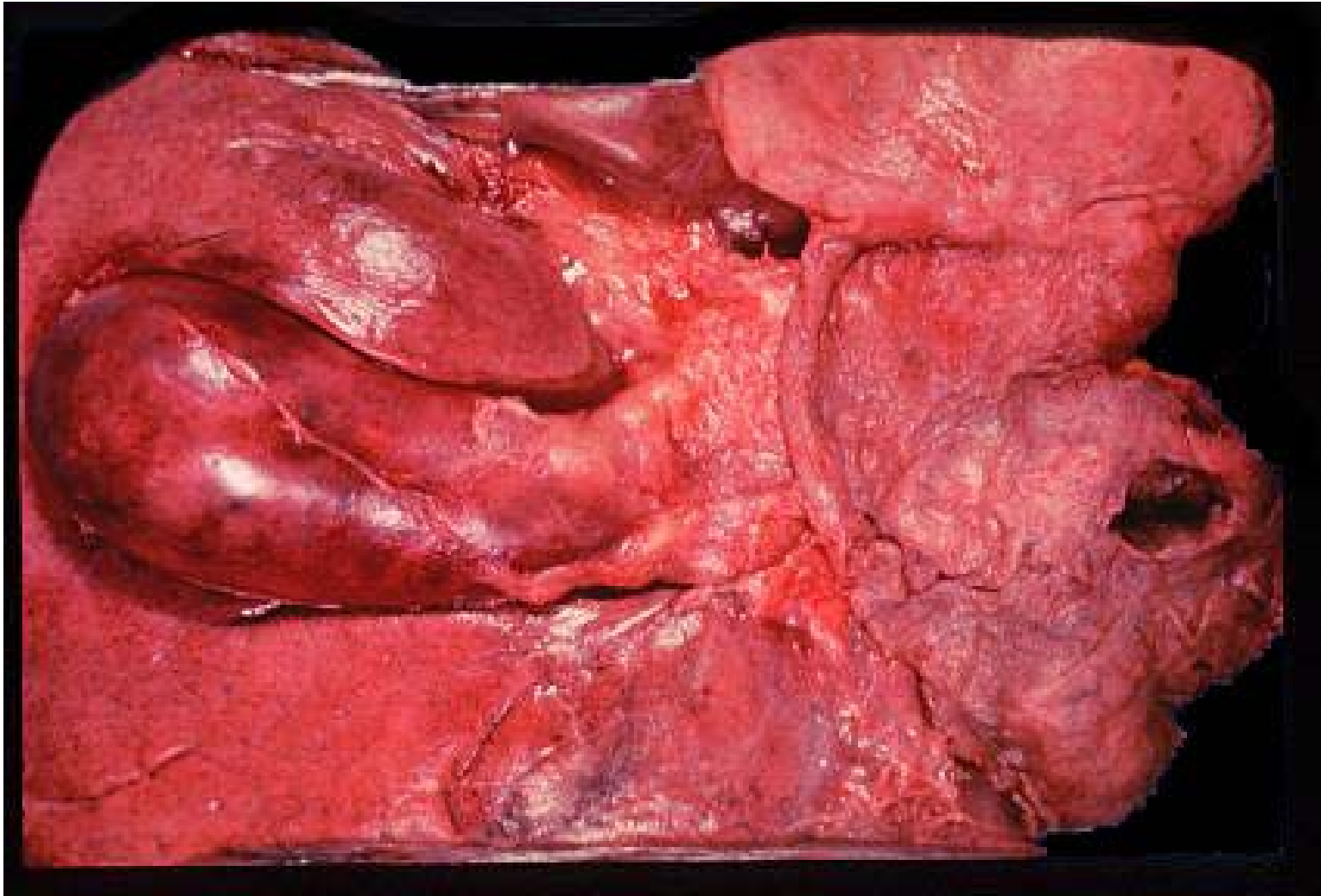
CHRONIC  
CHOLECYSTITIS  
WITH STONES  
HOURLASS  
GALLBLADDER



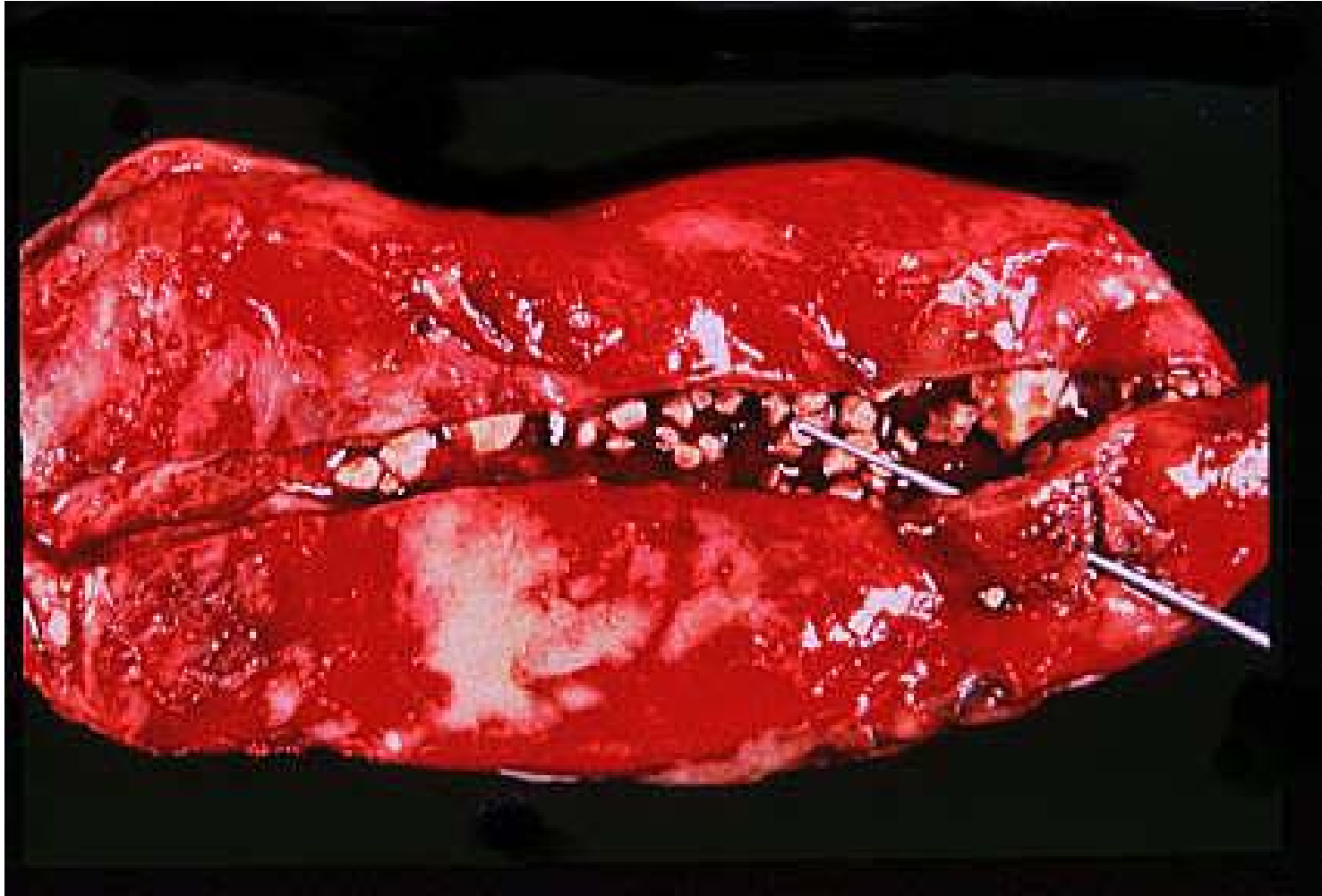
GANGRENE



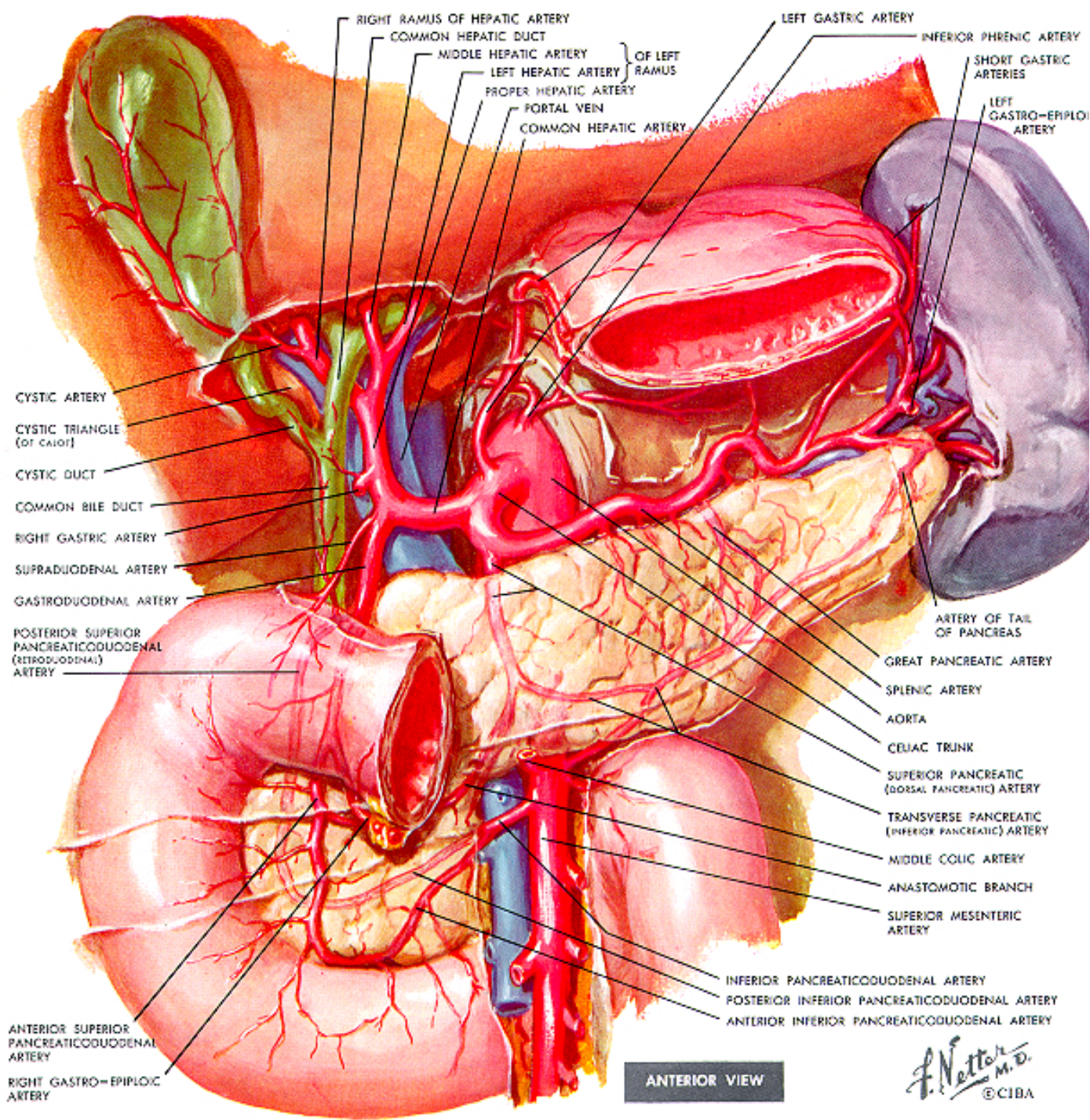
# Acute cholecystitis



# Acute cholecystitis and cholelithiasis



The serosal surface of the gallbladder is red. The gallbladder contains numerous gallstones. The probe was placed into the cystic duct and shows that the duct was patent.



ANTERIOR VIEW

*F. Netter M.D.*  
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