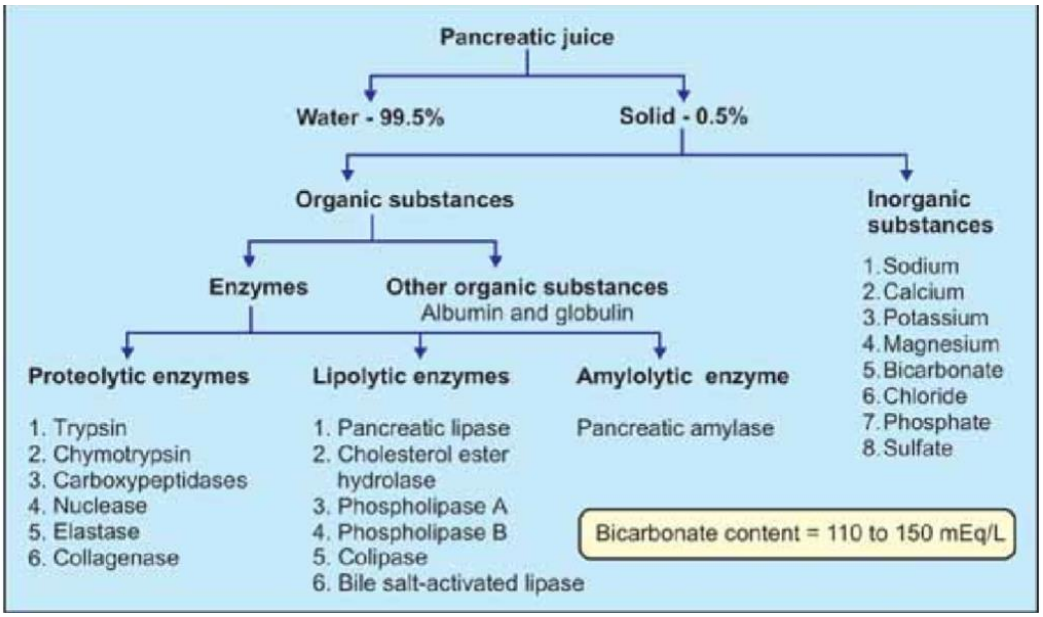
PANCREAS

FUNCTIONAL ANATOMY AND NERVE SUPPLY OF PANCREAS

Pancreas is a dual organ having two functions, the endocrine function and the exocrine function. The endocrine function is concerned with production of the hormones. The exocrine function is concerned with secretion of digestive juice called pancreatic juice.

NERVE SUPPLY TO PANCREAS

Pancreas is supplied by both sympathetic and parasympathetic fibers. The sympathetic fibers are supplied through splanchnic nerve and parasympathetic fibers are supplied through vagus nerve.



Composition of pancreatic juice

FUNCTIONS OF PANCREATIC JUICE

Pancreatic juice has digestive functions and the neutralizing action.

DIGESTIVE FUNCTIONS OF PANCREATIC JUICE

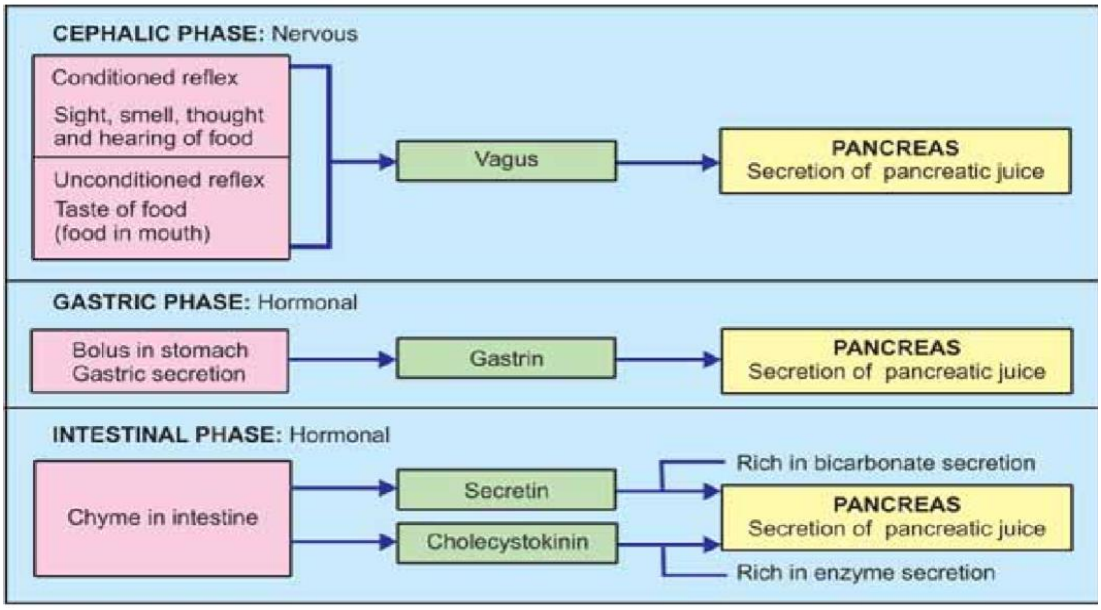
Pancreatic juice plays an important role in the digestion of proteins and lipid. It also has mild action on carbohydrate digestion.

Enzyme	Activator	Acts on	End products
1. Trypsin	Enterokinase Trypsin	Proteins	Proteoses and Polypeptides
2. Chymotrypsin	Trypsin	Proteins	Polypeptides
3. Carboxypeptidases	Trypsin	Polypeptides	Amino acids
4. Nucleases	Trypsin	RNA and DNA	Mononucleotides
5. Elastase	Trypsin	Elastin	Amino acids
6. Collagenase	Trypsin	Collagen	Amino acids
7. Pancreatic lipase	Alkaline medium	Triglycerides	Monoglycerides and fatty acids
8. Cholesterol ester hydrolase	Alkaline medium	Cholesterol ester	Cholesterol and fatty acids
9. Phospholipase A	Trypsin	Phospholipids	Lysophospholipids
10. Phospholipase B	Trypsin	Lysophospholipids	Phosphoryl choline and free fatty acids
11. Colipase	Trypsin	Facilitates action of trypsin	- - -
12. Bile salt – activated lipase	Trypsin	Phospholipids	Lysophospholipids
		Cholesterol esters	Cholesterol and fatty acids
		Triglycerides	Monoglycerides and fatty acids
13. Pancreatic amylase	- - -	Starch	Dextrin and maltose

Digestive enzymes of pancreatic juice

NEUTRALIZING ACTION OF PANCREATIC JUICE

When acid chyme enters intestine from stomach, pancreatic juice with large quantity of bicarbonate is released into intestine. Presence of large quantity of bicarbonate ions makes the pancreatic juice highly alkaline. This alkaline pancreatic juice neutralizes acidity of chyme in the intestine. Neutralizing action is an important function of pancreatic juice, because, it protects the intestine from the destructive action of acid in the chyme.



Schematic diagram showing the regulation of pancreatic secretion

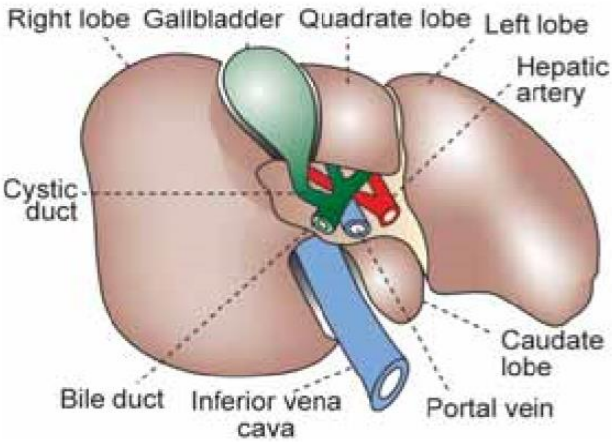
Liver and Gallbladder

FUNCTIONAL ANATOMY OF LIVER AND BILIARY SYSTEM

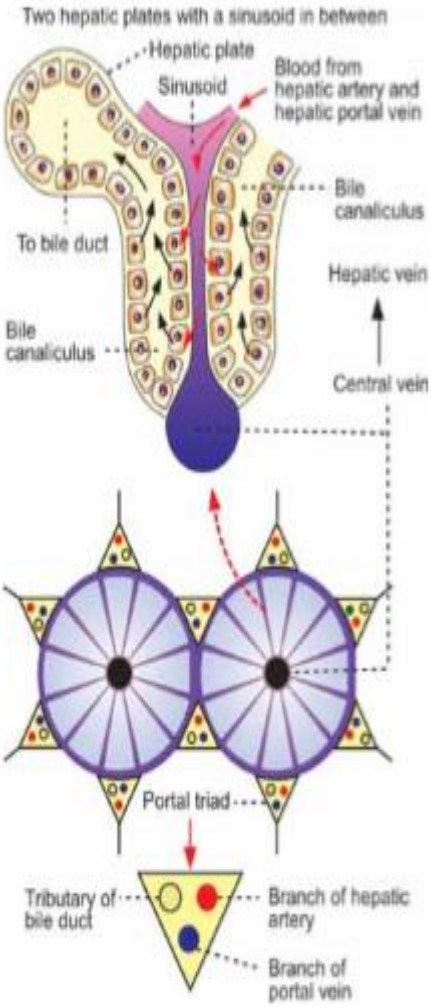
Liver is a dual organ having both secretory and excretory functions. It is the largest gland in the body weighing about 1.5 kg in man. It is located in the upper and right side of the abdominal cavity immediately beneath diaphragm.

LIVER

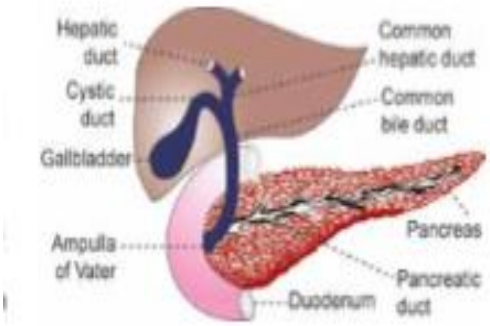
Liver is made up of many lobes called hepatic lobes. Each lobe consists of many lobules called hepatic lobules. The hepatic lobule is the structural and functional unit of liver. It is a honeycomb like structure and it is made up of liver cells called hepatocytes. Hepatocytes are arranged in hepatic plates. Each plate is made up of two columns of cells. In between the two columns of each plate lies a bile canaliculus .



Posterior surface of liver



Hepatic lobule



Biliary system

Bile is a golden yellow or greenish fluid. It enters the digestive tract along with pancreatic juice through the common opening called ampulla of Vater.

FORMATION OF BILE: Bile is secreted by hepatocytes. The initial bile secreted by hepatocytes contains large quantity of bile acids, bile pigments, cholesterol, lecithin and fatty acids. From hepatocytes, bile passes through canaliculi and hepatic ducts to reach common hepatic duct. From here it may enter the intestine or gallbladder. Sodium, bicarbonate and water are added to bile when it passes through the ducts. These substances are secreted by the epithelial cells of the ducts. The addition of sodium, bicarbonate and water increases the total quantity of bile.

BILE SALTS: Bile salts are the sodium and potassium salts of bile acids, which are conjugated with glycine or taurine. Bile salts are formed in liver.

FORMATION OF BILE SALTS: Bile salts are formed from the primary bile acids namely cholic acid and chenodeoxycholic acid which are formed in liver and enter the intestine through bile. Due to the bacterial action in the intestine these primary bile acids are converted into secondary bile acids: Cholic acid → deoxycholic acid Chenodeoxycholic acid → lithocholic acid Secondary bile acids from intestine are transported back to liver through enterohepatic circulation. In the liver the secondary bile acids are conjugated with glycine or taurine and form conjugated bile acids namely glycocholic acid and taurocholic acids. These bile acids combine with sodium or potassium ions to form the salts, sodium or potassium glycocholate and sodium or potassium taurocholate.

FUNCTIONS OF BILE SALTS: The bile salts are required for digestion and absorption of fats in the intestine.

BILE PIGMENTS Bile pigments are the excretory products in bile. Bilirubin and biliverdin are the two bile pigments and bilirubin is the major bile pigment in human being. The bile pigments are formed during the breakdown of hemoglobin, which is released from the destroyed RBCs in the reticuloendothelial system.

FORMATION AND EXCRETION OF BILE PIGMENTS

Stages of formation and circulation of bile pigments:

1. The senile erythrocytes are destroyed in reticuloendothelial system and hemoglobin is released from them

2. The hemoglobin is broken into globin and heme

3. Heme is split into iron and the pigment biliverdin

4. The iron goes to iron pool and is reused

5. The first formed pigment biliverdin is reduced to bilirubin

6. The bilirubin is released into blood from reticuloendothelial cells

7. The bilirubin circulating in the blood is called free bilirubin or unconjugated bilirubin 8. Within few hours the free bilirubin is taken up by the liver cells

9. In the liver, it is conjugated with glucuronic acid to form conjugated bilirubin 10.Conjugated bilirubin is then excreted into intestine through bile.

FATE OF CONJUGATED BILIRUBIN

Stages of excretion of conjugated bilirubin:

1. In the intestine 50% of the conjugated bilirubin is converted into urobilinogen by intestinal bacteria. First the conjugated bilirubin is deconjugated into free bilirubin which is later reduced into urobilinogen.

2. Remaining 50% of conjugated bilirubin from intestine enters the liver through

enterohepatic circulation. From liver, it is reexcreted in bile

3. Most of the urobilinogen from intestine enters liver via enterohepatic circulation. Later, it is re-excreted through bile

4. About 5% of urobilinogen is excreted by kidney through urine. In urine, due to the exposure to air, the urobilinogen is converted into urobilin by oxidation

5. Some of the urobilinogen is excreted in feces as stercobilinogen. In feces, stercobilinogen is oxidized to stercobilin

FUNCTIONS OF LIVER

Liver is the largest gland and one of the vital organs of the body. It performs many vital metabolic and homeostatic functions, which are summarized below.

1. METABOLIC FUNCTION Liver is the organ where maximum metabolic reactions are carried out such as metabolism of carbohydrates, proteins, fats, vitamins and many hormones.

2. STORAGE FUNCTION Many substances like glycogen, amino acids, iron, folic acid and vitamins A, B12, and D are stored in liver.

3. SYNTHETIC FUNCTION Liver produces glucose by gluconeogenesis. It synthesizes all the plasma proteins and other proteins (except immunoglobulins) such as clotting factors, complement factors, and hormone binding proteins. It also synthesizes steroids, somatomedin and heparin.

4. SECRETION OF BILE Liver secretes bile, which contains bile salts, bile pigments, cholesterol, fatty acids and lecithin. The functions of bile are mainly due to the bile salts. The bile salts are required for digestion and absorption of fats in the intestine. Bile helps to carry away waste products and breakdown fats, which are excreted through feces or urine.

5. EXCRETORY FUNCTION Liver excretes cholesterol, bile pigments, heavy metals (like lead, arsenic and bismuth), toxins, bacteria and virus (like that of yellow fever) through bile.

6. HEAT PRODUCTION Liver is the organ where maximum heat is produced because of the metabolic reactions.

7. HEMOPOIETIC FUNCTION In fetus (hepatic stage), liver produces the blood cells It stores vitamin B12 necessary for erythropoiesis and iron necessary for synthesis of hemoglobin. Liver produces thrombopoietin that promotes production of thrombocytes.

8. HEMOLYTIC FUNCTION The senile RBCs after the lifespan of 120 days are destroyed by reticuloendothelial cells (Kupffer's cells) of liver.

9.INACTIVATION OF HORMONES AND DRUGS Liver catabolizes the hormones such as growth hormone, parathormone, cortisol, insulin, glucagon and estrogen. It also inactivates the drugs particularly the fat soluble drugs. The fat soluble drugs are converted into water soluble substances, which are excreted through bile or urine.

10. DEFENSIVE AND DETOXIFICATION FUNCTIONS The reticuloendothelial cells (Kupffer's cells) of the liver play an important role in the defense of the body. Liver is also involved in the detoxification of the foreign bodies. i. The foreign bodies such as bacteria or antigens are swallowed and digested by

reticuloendothelial cells of liver by means of phagocytosis ii. The reticuloendothelial cells of liver are also involved in production of some substances like interleukins and tumor necrosis factors, which activate the immune system of the body. iii. Liver cells are involved in removal of toxic property of various harmful substances. The removal of toxic property of the harmful agent is known as detoxification.

GALLBLADDER

The bile secreted from liver is stored in gallbladder. The capacity of gallbladder is approximately 50 mL. The gallbladder is not essential for life. The removal of gallbladder (cholecystectomy) is often done in patients suffering from gallbladder dysfunction. After cholecystectomy, patients do not suffer from any major disadvantage. In some species, gallbladder is absent.

FUNCTIONS OF GALLBLADDER The major functions of gallbladder are the storage and concentration of bile.

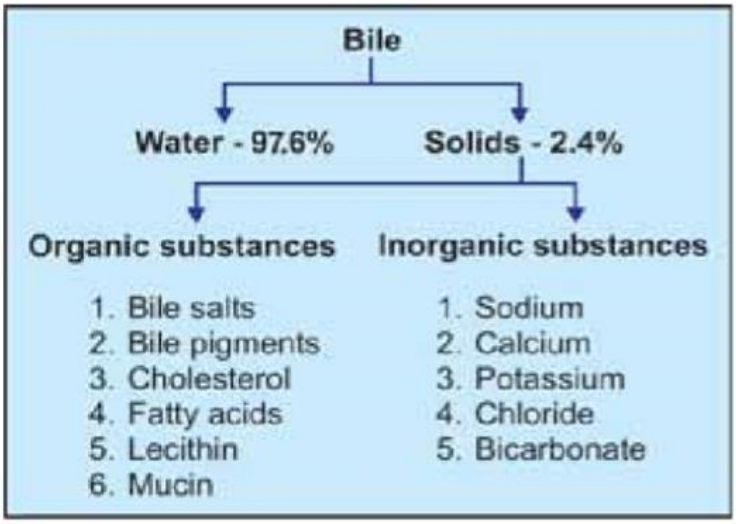
1. Storage of Bile Bile is continuously secreted from liver. But it is released into intestine only intermittently and most of the bile is stored in gall

2. Concentration of Bile Bile is concentrated while it is stored in gallbladder. The mucosa of gallbladder rapidly reabsorbs water and electrolytes except calcium and potassium. But the bile salts, bile pigments, cholesterol and lecithin are not reabsorbed. So, the concentration of these substances in bile increases 5 to 10 times.

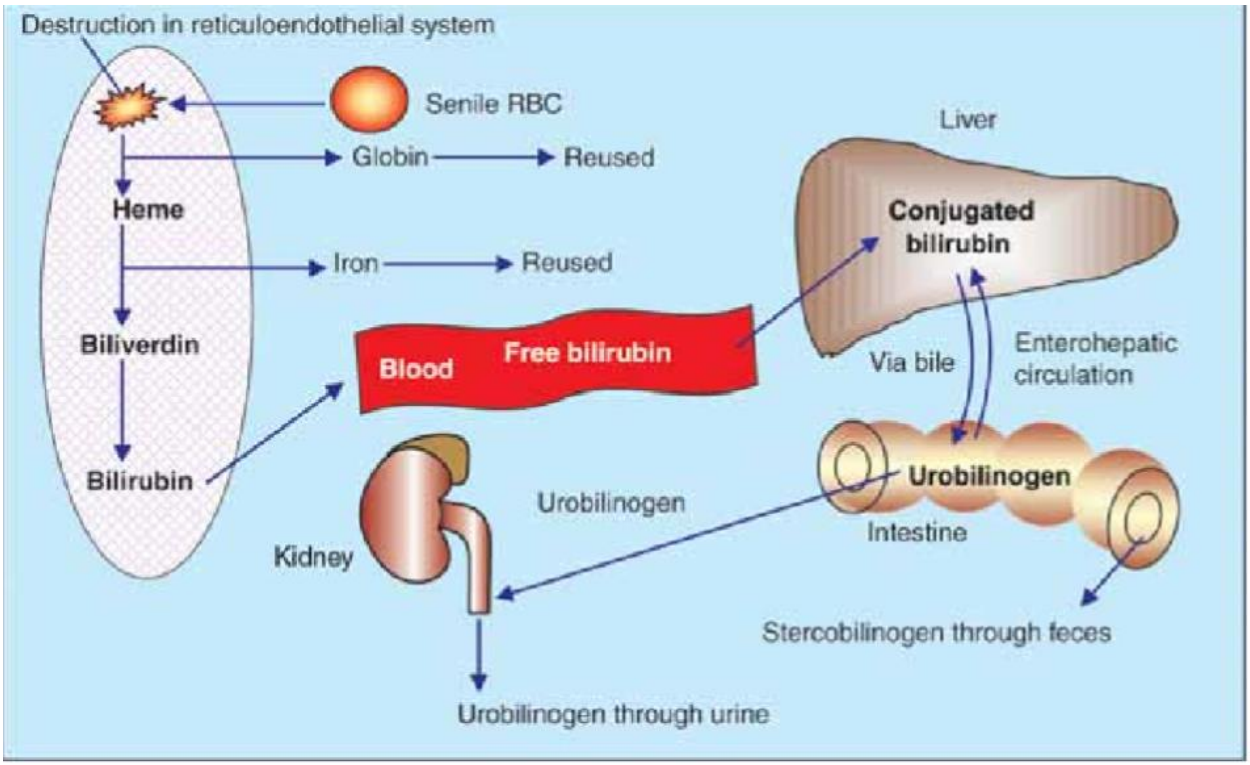
3. Alteration of pH of Bile The pH of bile decreases from 8 to 8.6 to 7 to 7.6 and it becomes less alkaline when it is stored in gallbladder.

4. Secretion of Mucin Gallbladder secretes mucin into the bile. Mucin acts as a lubricant for movement of chyme in the intestine.

5. Maintenance of Pressure in Biliary System Due to the concentrating capacity, gallbladder maintains a pressure of about 7 cm H_2O in biliary system. This pressure in the biliary system is essential for the release of bile into the intestine.



Composition of bile



Formation and circulation of bile pigments