

**Topic: Metabolism of  
chromoproteids and  
biochemistry of the liver.**

# The aim:

To study :

Major functions of liver in the body, participation of liver in the carbohydrate, lipids and proteins metabolism.

Detoxification of substances of the liver, formation of bile acids and theirs meaning.

Metabolism of hemoglobin, its structure, synthesis and meaning.

# Plan of the lecture

1. Important function of the liver
2. Chromoproteids of tissue.
3. Hemoglobin structure
4. Biosynthesis of heme
5. Metabolism of iron
6. Bile acids synthesis, significance
7. Mechanism of detoxication of toxic substances
8. The formation and fate of the bilirubin.
9. Causes of jaundice.

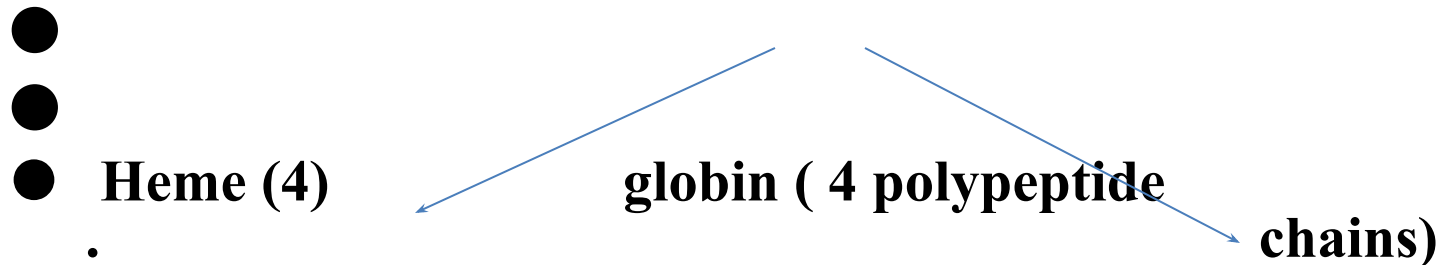
# Chromoproteides

- Chromoproteides are complex proteins the protein components and non protein components. The non protein components are called also pigment / The word "chroma" from greek language is mean paint or COLOUR.
- In our organism are present: complex proteins - include  $\text{Fe}^{2+}$  - cytochrome oxidase(heme), haemoglobin, mioglobin catalase, peroxidase,  $\text{Cu}^{2+}$  - cytochrome oxidase,  $\text{Zn}^{2+}$  - carbonic anhidrase,  $\text{Mg}^{2+}$  hexokinase, piruvate kinase, glucose - 5 phosphase and etc.

# Important function of the liver

1. Alimentary function (or formation and excretion of bile acids.)
2. Excretory for example, with bile acids from organism occur process of excretion of excess of cholesterol, iron.
3. Detoxication of toxic substances ( $\text{NH}_3$ , indirect bilirubin, hormones inactivation, amines, toxic substances after decay.
4. Liver is regulates the water-salt metabolism.
5. Liver is necessary for normal metabolism of lipids, amino acids (proteins), carbohydrates.
6. The synthesis of important substances: creatin, ketone bodies, angiotensinogen, all proteins of blood albumin, globulin, fibrinogen, kinins-local hormone, glycogen, lipoproteins, phospholipids, heparin and so on.
7. In the liver occurs process of deposition of glycogen, iron.
8. Regulatory or homeostatic functions.

- Hemoglobin is the main protein of the erythrocytes complex protein - hemoprotein - or chromoprotein.

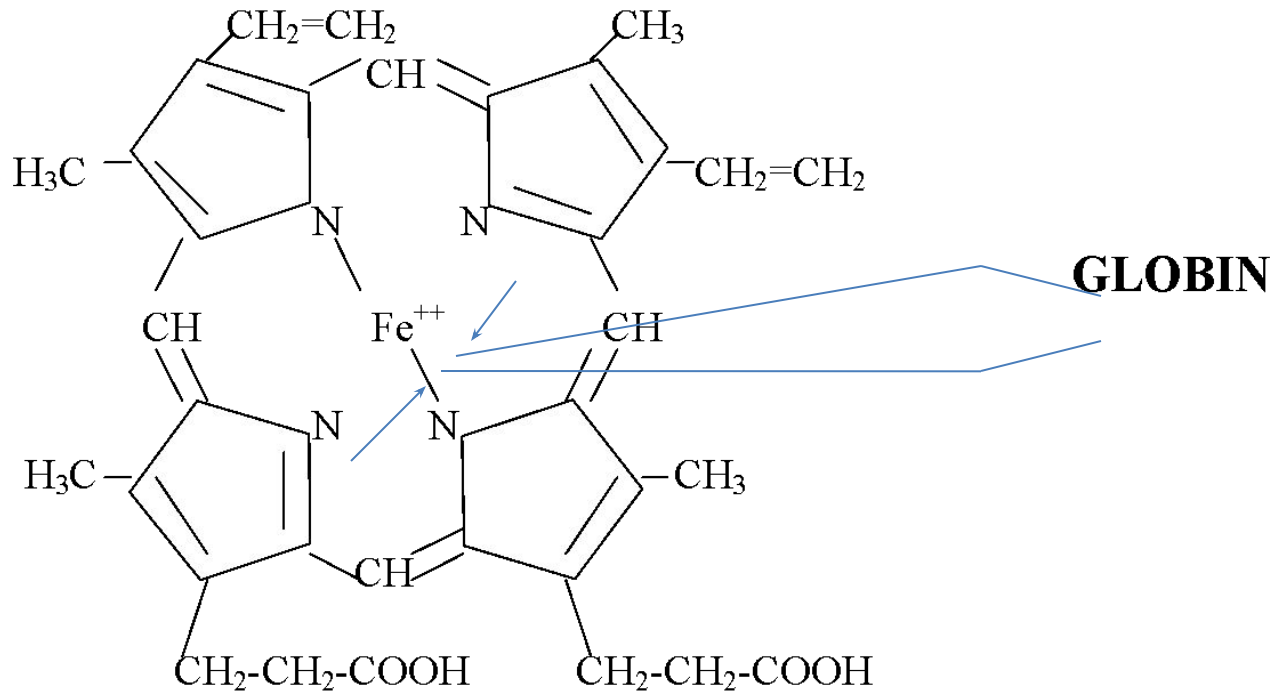


- **Hereditary change of the globin structure | some of the chain| is called hemoglobinopathias. (HBC)**

- **ANEMIA ?**

- HbA - **2 alpha, 2 beta** 97% of adult Hb
- HbA2- **2 alpha, 2 gamma** 3% of adult Hb
- HbF - **2 alpha, 2 sigma** 80% of Hb ( of newborn or infants )

Porphrin is formed by linking together of four pyrrole rings through methenyl



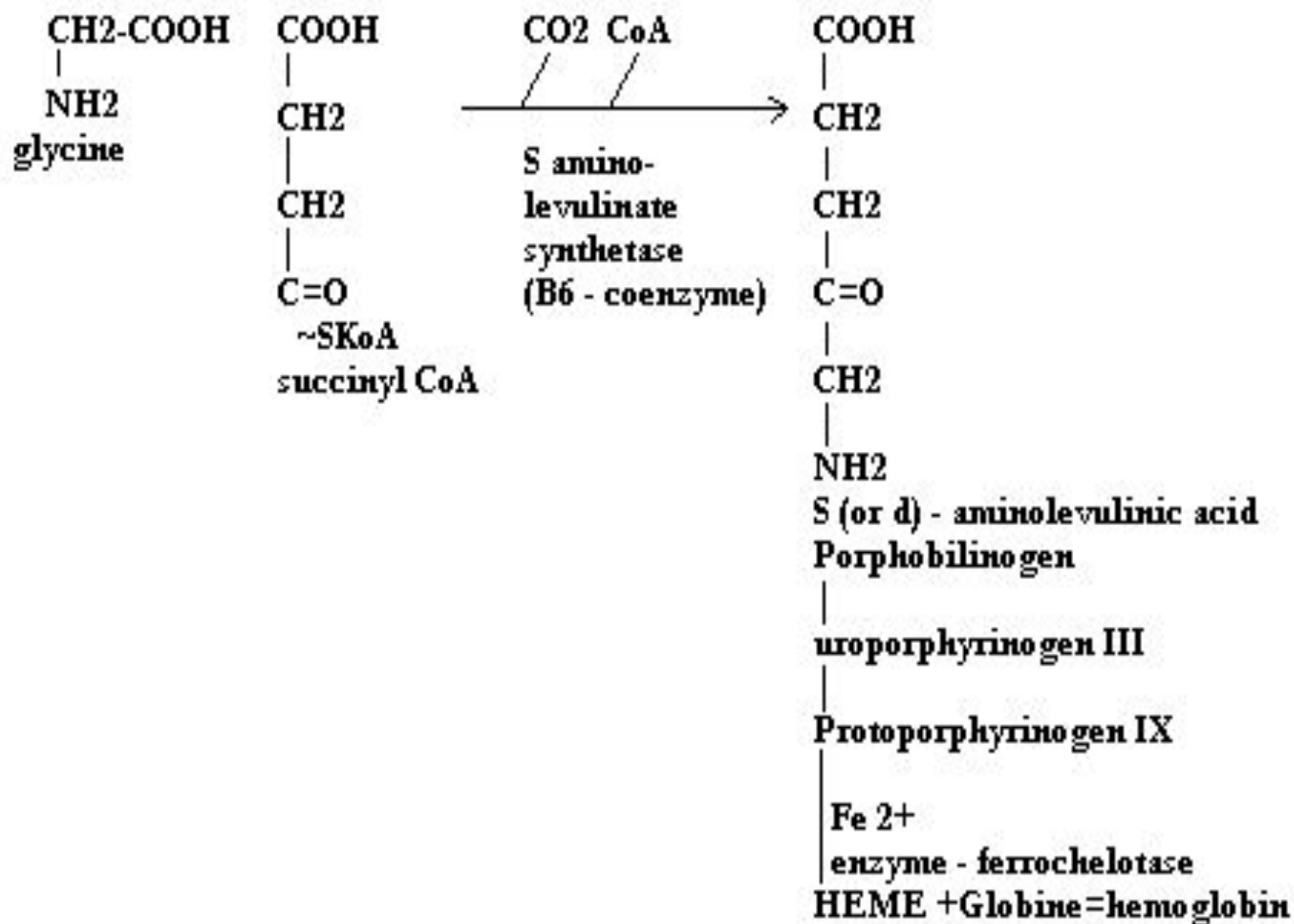
# Biosynthesis of heme.

The major main in the biosynthesis of heme are the liver and the erythrocyte - producing cells of the bone marrow, which are active in hemoglobin synthesis.

## I. Formation of A - aminolevulinic acid .

All the carbon two simple bluding blocks; glycine and succinyl CoA. Glycine and succinyl CoA condense to form A.L.A in a reaction catalyzed by ALA synthase. This reaction requires pyridoxal phosphate as a coenzyme vitamin B6, and is the rate-controlling step in porphyrin biosynthesis.





# By deficiency

By deficiency of the iron Fe is develops - iron deficiency anemia or hypochromic anemia.

Prophyrias - are caused by inherited or acquired defects in heme synthesis, resulting in the accumulation and increased excretion of porphyrins or porphyrin precursors. The porphyrias are classified as erythropoietic or hepatic depending on whether the enzyme deficiency occurs in red blood cells or the liver.

# Metabolism of iron

- Daily requirements of for our organism in the iron Fe=10-20 mg. From total iron - 65 - 70% in the structure hemoglobin 20% - contain myoglobin contain 1% - in the structure cytochromes, cytochromoxidase heme contain enzymes
- 10-15% - in the liver , bone marrow.
- Transport of iron ensure specific protein transferrin transport form of iron . In the structure this protein the iron has valency - Fe 3+ and joins with anion hydrocarbonate.

# Ferritin

- Ferritin - helps to store iron in certain tissues / liver, spleen, bone marrow/. Ferritin consists of
- 24 subunits arranged in the form of a shell around iron atoms  $Fe^{2+}$ . One apoferritin molecule encloses more than 2000-3000 ferric atoms. With passage of time lysosomal enzymes degrade ferritin to hemosiderin which is a molecule of non-specific structure / a mixture of partially degraded protein, lipid, iron.

# Hemosiderin

**Hemosiderin** another reserve form of iron. By excess of iron level of hemosiderin in the liver increase and develops hemosiderosis of liver damage the liver. Idiopathic hemochromatosis is often inherited disease. In primary hemochromatosis there is excessive accumulation of iron in tissues. Thus results in tissue damage. In the liver iron accumulation can cause cirrosis. In the pancreas it can damage beta - cells resulting in diabetes mellitus. Iron accumulation in skin can cause pigmentation of skin bronze colour. Thus the condition is called **bronze diabetes**.

# Bile acids which synthesis

Bile acids which synthesis in the liver are necessary for:

- emulsification of lipids
- absorption of fatty acids, vitamins / fat soluble A,D,E,K/, cholesterol
- favour of formation of normal pH in the small intestine
- favour of solubilization of cholesterol and excretion of from organism
- favour of excretion with bile acids also bile pigments, metabolites of hormones, toxins, drugs, salts of Ca, Na, K, albumins, globulins.

So excretory function connect with homeostatic function and regulation water - salt metabolism.

- Excess of Ca can be deposited in the liver / one part/ and another part of Ca excretory with bile acids. In the liver removed of the phosphorcontaining substances, which again excreted with bile acids. Homeostatic function - in the liver occur synthesis of proteins, which are necessary for oncotic pressure. Due to these factors the blood occurs support of normal ratio of Ca, Mg, Na, K, Ce and etc.

# Mechanism of detoxication of toxic substances

Mechanism of detoxication of toxic substances in the liver. In the liver are detoxified all toxic substances:

a/ exogenous for example drugs

b/ endogenous / indirect bilirubin,  $\text{NH}_3$ , products of decay.



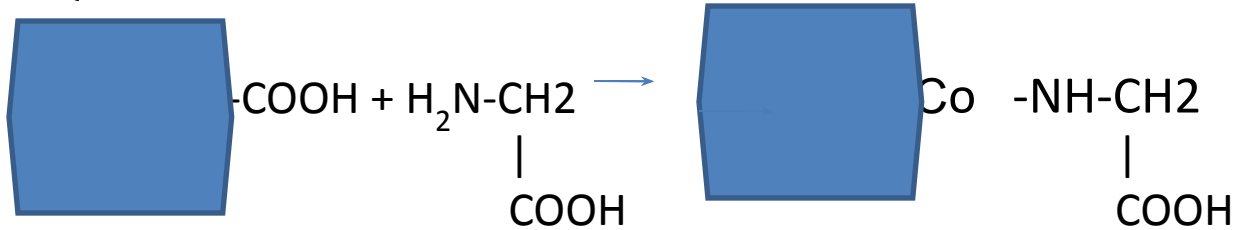
# **Mechanism of detoxication of toxic substances**

**Chemical modification.** First of all occurs the reactions of oxidation or + hydroxylation (OH), methylation (+CH<sub>3</sub>), reduction (+H<sub>2</sub>).... ets.

**II. Reaction of conjugation** with glucuronic acid / G.A/ / active form is called UDPGA / or with sulfuric acid / active form is called P.A.P.S. / or with glutamine, glycine. After this formed not toxic and watersoluble substances which transported to the kidneys and excreted from our organism by urine.

# For example:

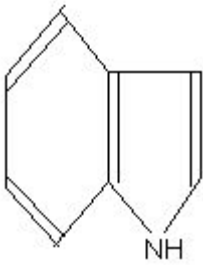
## QUICK TEST



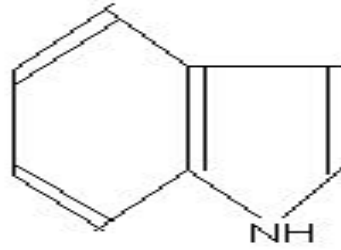
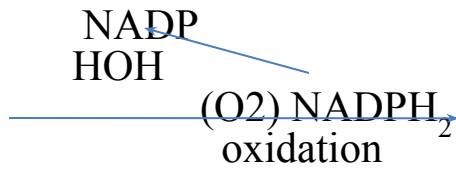
***BENZOIC ACID***

***GLYCINE***

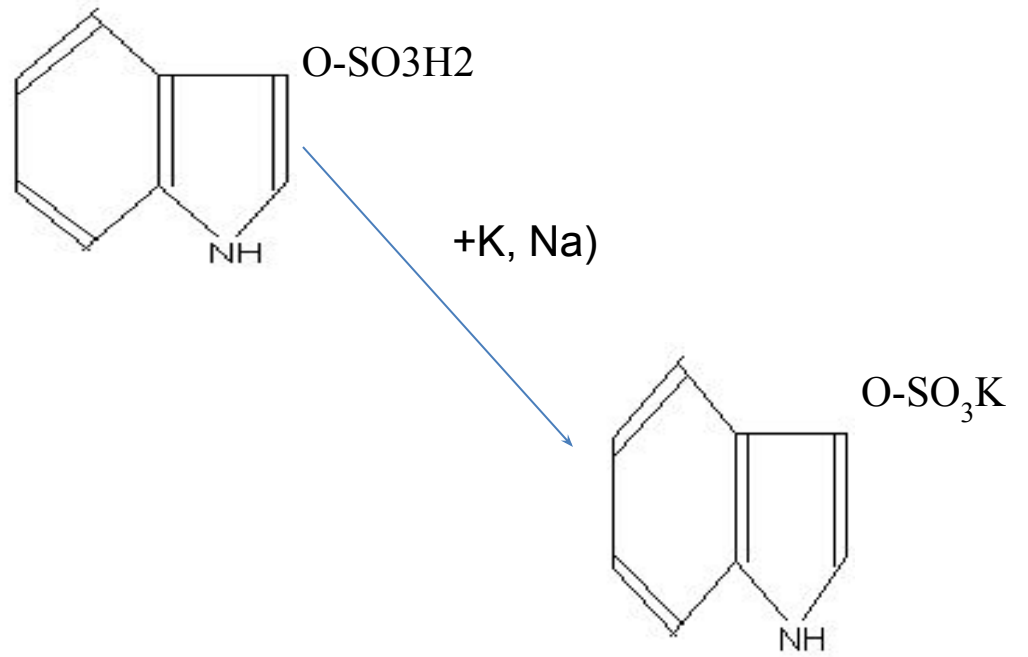
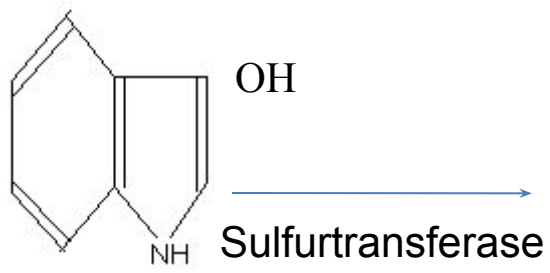
***HIPPURIC ACID***    **0.7-0.8 gr./l**



INDOLE



INDOXYL



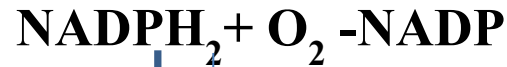
N=0.01gr./l)

- **In the liver also inactivated hormones by helping reactions of hydrolysis, methylation / for example adrenalin, noradrenalin inactivation by methylation**
- **by helping specific enzyme catechol - o - methyltransferase - C. O. M. T.**

# . The formation and fate of the bilirubin.

## Catabolism of heme

I. Reticulo-endotelial cells, system (R. E. S.) particularly in the liver and spleen.



R. E. C. hemoglobin(Hb) is converted - Verdoglobin-Fe+globin

**BILIVERDIN** (pigment – green)

|

|  $\text{NADPH}_2 - \text{NADP}$

| biliverdin reduces

**BILIRUBIN** (indirect – pigment with red-yellow color )

|

**Blood**

**bilirubin + albumin (complex) is transported to the liver.**

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## II. Liver

II. Liver      “indirect” bilirubin (unconjugated)

+ 2 UDP glucuronic acid

2 UDP (bilirubin glucuronil transferase)

detoxication of the bilirubin and is formed

Bilirubin diglucuronide (direct bilirubin or  
conjugated bilirubin)      bile pigment.

it is not toxic substances.      + bile acids



### III . Small intestine

**Small intestine**

**Mezobilirubin + H<sub>2</sub>**  
**(+2H<sub>2</sub>, 2 NADPH<sub>2</sub>) enzymes of bacterias**

**mezobilinogen decomposes** into the liver and

**Three pyrroles**

**Dipyrroles**


•

|



# IV. Large intestine

**urobilinogen**  
**+4H enzymes of bacterias**

**Stercobilinogen (pigment of feces) 250mg per day**  **part of urobilinogen or stercobilinogen is reabsorbed in blood via hemorrhoidal vessels, to the kidneys and is converted to urobilin. is oxidized**

**Stercobilin** to the brown (in (pigment ) feces)  
**Urobilin** is pigment of urine N=1-4mg. per day.

**Bile pigments and pigments of urine, feces are used for diagnose of jaundices.**

**Causes of jaundice.**

1. Hemolysis jaundice -

increase of production of bilirubin -

2. Liver - decrease excretional of bilirubin and detoxication of inderect bilirubin

• 3. Bile duct obstruction.

# Properties

- |  |   |
|--|---|
| • <i>Unconjugated, indirect bilirubin</i>  | • <b>Conjugated direct bilirubin</b>                                    |
| • <i>insoluble in the water</i>  | • <b>Soluble in the water</b>   |
| • <i>NO</i>  | • <b>Can pass across renal filter in pathology only</b>                 |
| • <i>Gives indirect reaction with diazoreagent (only after sedimentation of the albumin)</i> | • <b>Conjugation with glucuronic acid</b>                               |
| • <i>Toxic substance</i>   | • <b>Gives direct .</b>   |
| • <i>The normal amount in plasma, serum blood 75%</i>  | • <b>Not toxic</b>  |
| • <i>Plasma level-raised</i>   | • <b>25%</b>  |
| • <i>Pre-hepatic jaundice hemolytic</i>  | • <b>Hepatic and post hepatic jaundice or obstructive jaundice or .</b> |
| • <i>Formed in the reticule-endothelial cells</i>  | • <b>Hepatocellular</b>   |
|  | • <b>Formation in the liver</b>   |

# Types of jaundice:

**Hemolytic jaundice:** The liver has the capacity to conjugate and excrete over 300 mg bilirubin per day, whereas the normal production bilirubin is only 300 mg/day. This excess capacity allows the liver to respond to increased heme degradation with a corresponding increase in conjugation and secretion of bilirubin diglucuronide. However, massive lysis of red blood cells / for example, in patients with sickle cell anemia, malaria/ may produce bilirubin faster than the liver can conjugate it. More bilirubin is excreted into the bile the amount of urobilinogen entering the enterohepatic circulation is increased, and urinary urobilinogen is increased. Unconjugated bilirubin is elevated in blood / stercobilinogen too is increased in the feces/.

# Obstructive jaundice:

**Obstructive jaundice:** In this instance is not due to overproduction of bilirubin, but results from obstruction of the bile duct. For example, the presence of hepatic tumor, or bile stones may block the bile ducts, preventing passage of bilirubin into the intestine. Patients with obstructive jaundice experience pain, nausea, and produce stools that are pale, clay color /infringement or disorder of degradation of the, heme in the small and large intestine decrease or not formation the stercobilin - pigment of feces and urobilin - pigment of urine/. Direct bilirubin / or conjugated bilirubin/ transported into the blood, than kidneys which is excreted in the urine. The color of urine may be change - formed brown / the color of beer/ dark.

# Hepatocellular jaundice:

**Hepatocellular jaundice:** Damage to liver cells for example in patients with cirrhosis or hepatitis/ causes a decrease in both bilirubin uptake and production of conjugated bilirubin. Unconjugated bilirubin occurs in the blood and decreased urobilinogen in the urine. The urine is dark in color and stools are pale, clay color. Plasma levels of ALT / alanine aminotransferase/ / 4,5 forms/ organospecific enzyme, is elevated and the patient experiences nausea and anorexia.

# Jaundice in newborns:

**Jaundice in newborns:** Newborn infants, particularly premature babies, often accumulate bilirubin because the activity of hepatic bilirubin glucuronyl transferase is low at birth and reaches adult levels in about two weeks. Elevated bilirubin, in excess of the binding capacity of albumin, can diffuse into the basal ganglia and cause toxic encephalopathy. Thus, newborns with markedly elevated bilirubin levels are treated with blue fluorescent light, which converts bilirubin to more polar and, hence, water-soluble isomers. These photoisomers can be excreted into the bile without conjugation to glucuronic acid. Also for treatment of the jaundice in newborns, the drug phenobarbital is used. This drug increases the activity of the enzyme - UDP glucuronyl transferase and decreases the concentration of toxic indirect bilirubin in the serum of blood of the infants.

- **N= 8,5-20,5  $\mu\text{mol/l}$  of total bilirubin In the plasma of blood**



# Questions ?

1. Hemoglobin, structure ?
2. What is hemoglobinopathy ?
3. Bile pigments ?
4. Pigment of the feces ?
5. Pigments of the urine ?
6. Types of jaundice ?

THANKS FOR  
ATTENTION !!!