

D3 - FUNCTIONS OF THE LIVER



D3 - Understandings

	Statement	Guidance
NOS	Educating the public on scientific claims – scientific studies have shown that high-density lipoprotein could be considered “good” cholesterol	
D3.U1	The liver removes toxins from the blood and detoxifies them	
D3.U2	Components of red blood cells are recycled by the liver	
D3.U3	The breakdown of erythrocytes starts with phagocytosis of red blood cells by Kupffer cells	
D3.U4	Iron is carried to the bone marrow to produce hemoglobin in new red blood cells	
D3.U5	Surplus cholesterol is converted to bile salts	
D3.U6	Endoplasmic reticulum and golgi apparatus in hepatocytes produce plasma proteins	
D3.U7	The liver intercepts blood from the gut to regulate nutrient levels	
D3.U8	Some nutrients in excess can be stored in the liver	

D3 - Applications and Skills

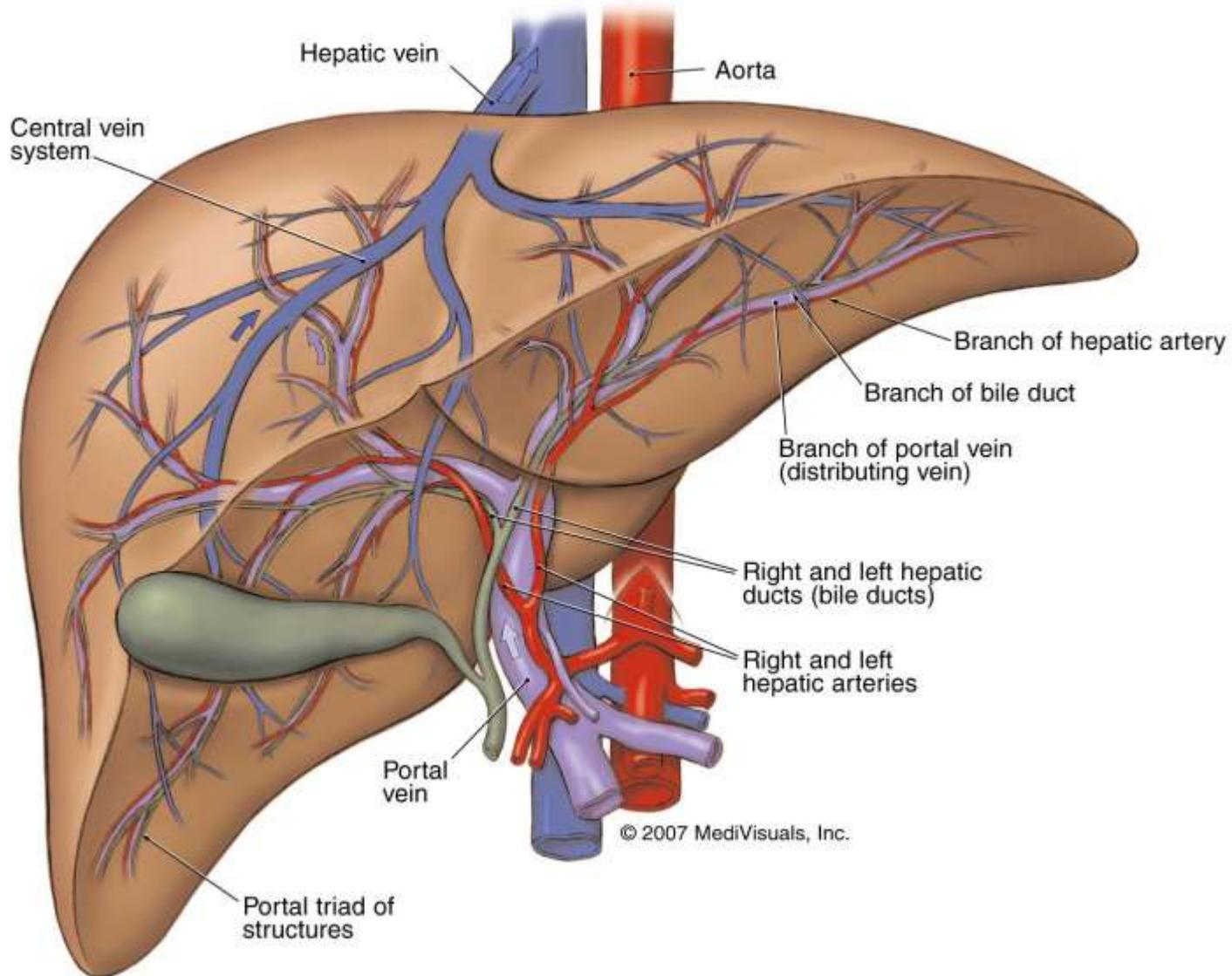
	Statement	Guidance
D3.A1	Causes and consequences of jaundice	
D3.A2	Dual blood supply to the liver and differences between sinusoids and capillaries	

The Liver



- The largest gland in the body
- The second largest organ (after the skin)
- About 1.5 kg in mass
- Located just below the diaphragm and over the upper portion of the stomach

Internal Anatomy of Liver



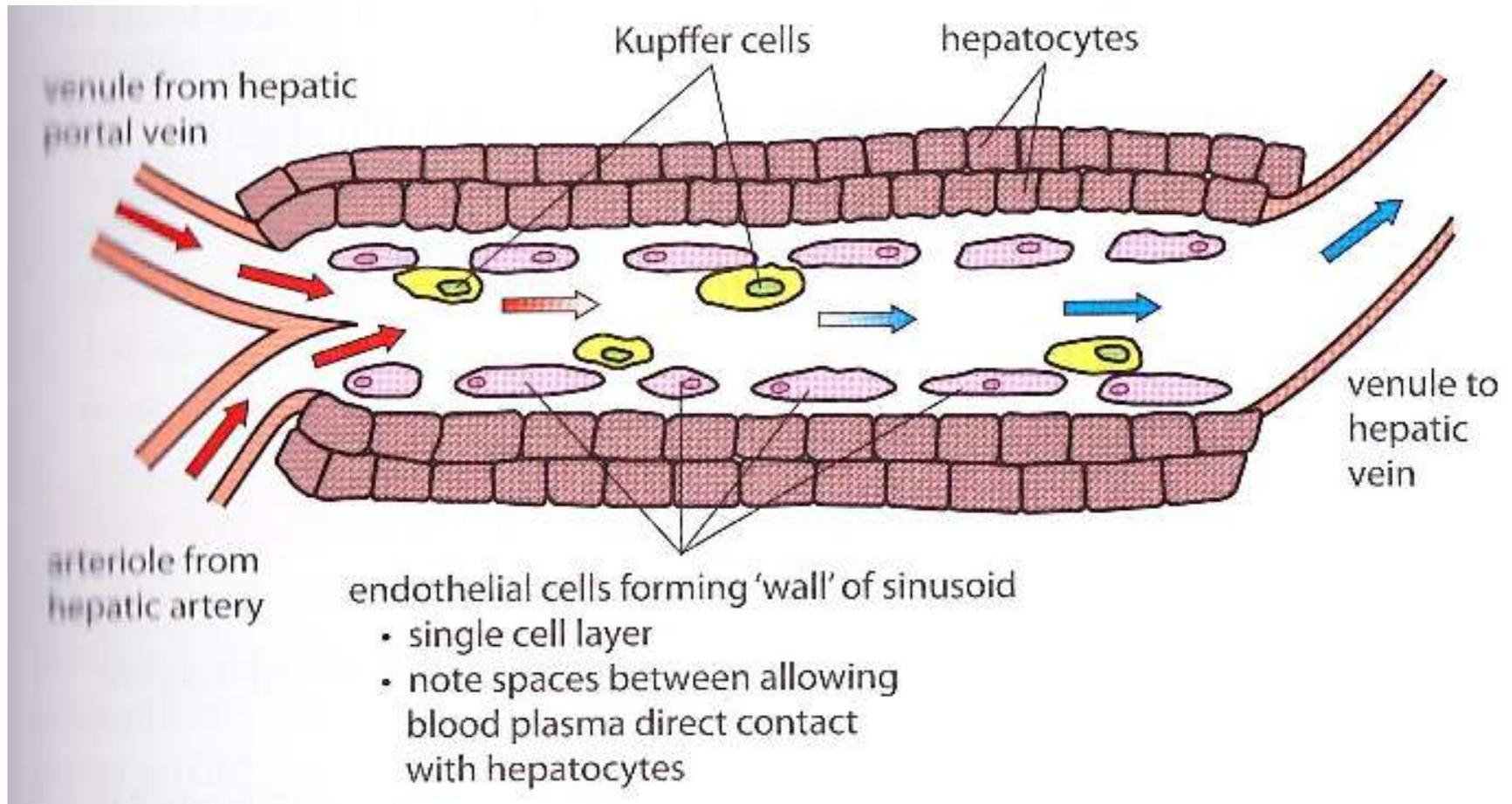
Circulation of Blood to and from the Liver

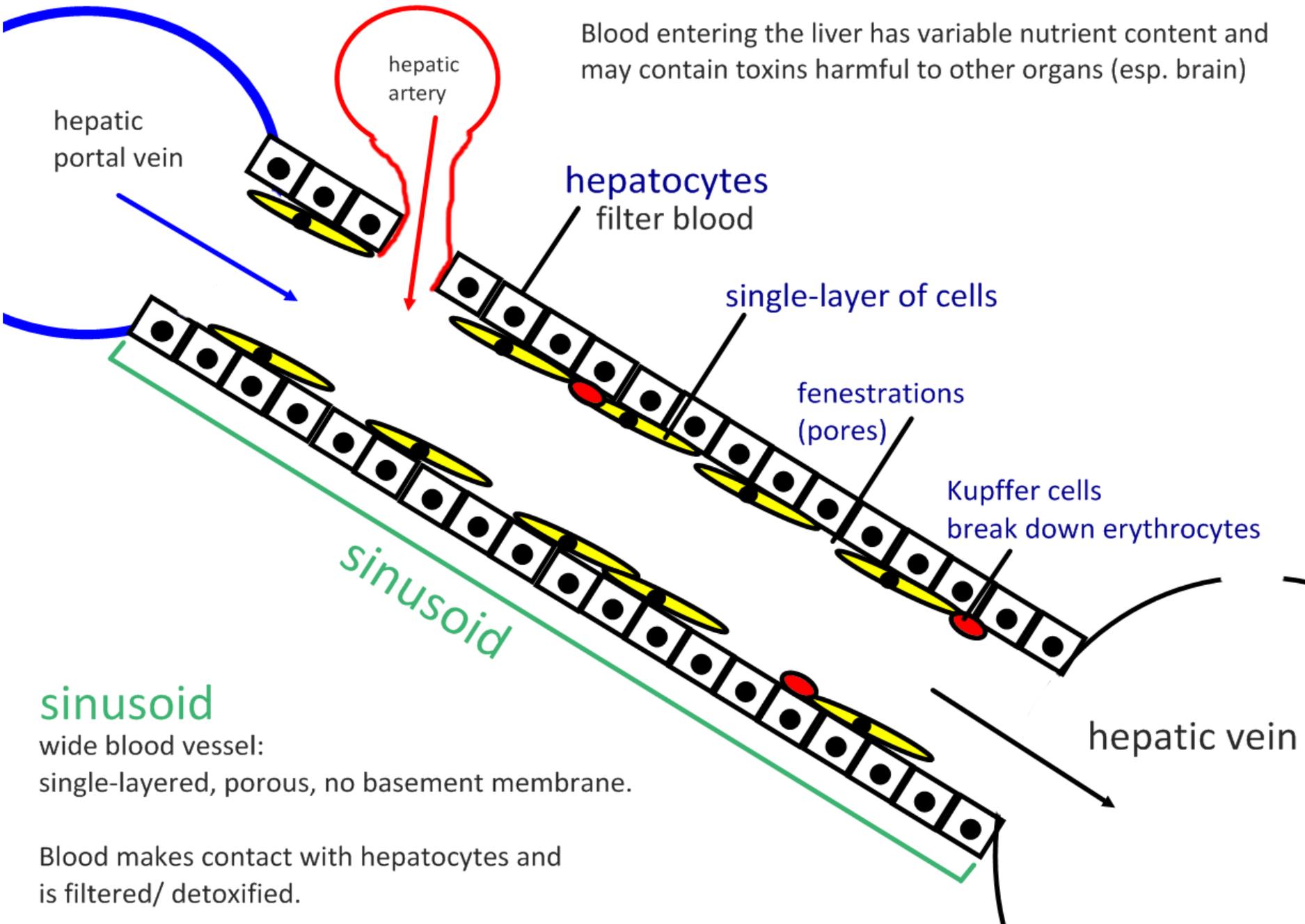
- The liver receives blood from 2 major blood vessels and blood leaves the liver by 1 blood vessel
- The **HEPATIC ARTERY** is a branch of the aorta
- It carries oxygenated blood (from the heart) to the liver tissues.
- The **HEPATIC PORTAL VEIN** brings deoxygenated blood from the digestive tract (villi in S.I.) to the liver
- This blood is unique because its nutrient quantity and composition is dependent on what was consumed.
- The hepatic artery and hepatic portal vein carry blood into the “capillaries” of the liver, called the **SINUSOIDS**.
- Blood leaves the liver through the **HEPATIC VEIN** and (does not vary much in nutrient composition)

Sinusoids: The Capillaries of the Liver

- A major function of the liver is to remove some things from the blood and to add others to it.
- This is done by **hepatocytes** (liver cells)
- O₂-rich blood from the hepatic artery, and (sometimes) nutrient-rich blood from the hepatic portal vein, both flow into the **sinusoids** of the liver.
- **Sinusoids** are where the exchange of materials occur between blood and hepatocytes.

Sinusoids





Blood entering the liver has variable nutrient content and may contain toxins harmful to other organs (esp. brain)

hepatic portal vein

hepatic artery

hepatocytes filter blood

single-layer of cells

fenestrations (pores)

Kupffer cells break down erythrocytes

sinusoid

hepatic vein

sinusoid

wide blood vessel:
single-layered, porous, no basement membrane.

Blood makes contact with hepatocytes and is filtered/ detoxified.

Sinusoids vs Capillary Beds

- Sinusoids differ from a typical capillary bed in the following ways:
 1. Sinusoids have larger lumens
 2. Sinusoids have Kupffer cells that breakdown rbc for recycling
 3. Sinusoids are lined by endothelial cells with gaps between them.
 - These gaps allow large molecules (like proteins) to be exchanged between hepatocytes and the bloodstream
 - Hepatocytes are in direct contact with blood components making all exchanges with the bloodstream more efficient

1) Liver Removes Toxins

1) Kupffer Cells – specialized leukocytes (WBC's)

- Line the inside of sinusoids
- Engulf old RBC and bacteria from blood by phagocytosis

2) Hepatocytes

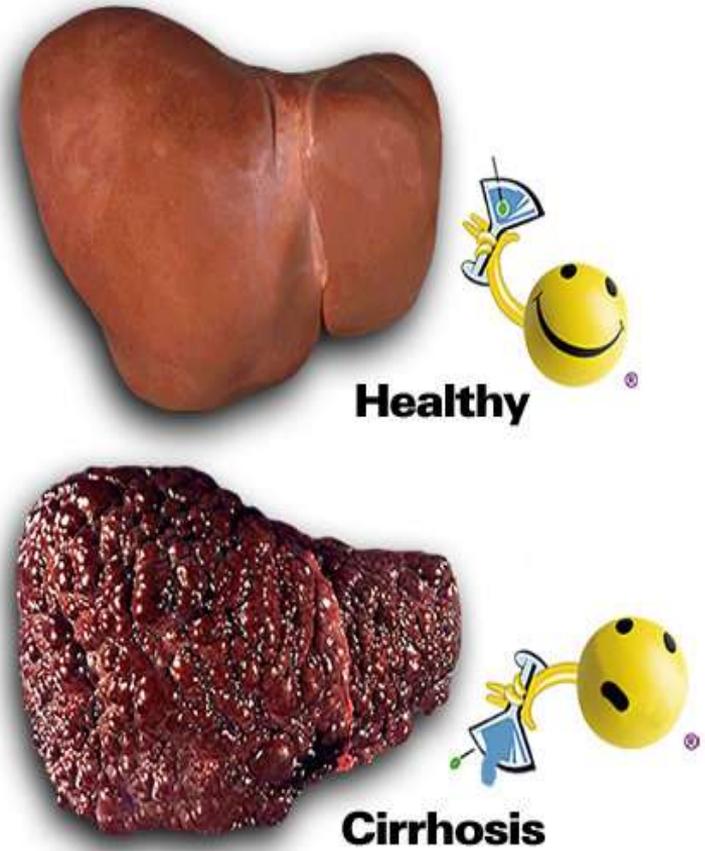
- Pesticides, medicines, food additives, alcohol, and other toxins (lactate, H_2O_2) are removed from the blood and broken down
- Toxins are chemically modified to make them less toxic
- Chemical components are added to make them water soluble for excretion
- The liver does not extract all excess glucose, toxins etc in a single trip through the sinusoids
- The chemicals within the blood will be acted on by hepatocytes multiple times as blood continuously makes circuits through the liver.

Alcohol & the Liver

- After drinking alcohol, each time blood passes through the liver, hepatocytes attempt to remove the alcohol from the bloodstream.
- The breakdown of alcohol produces free radicals and other reactive molecules that damage proteins, lipids and DNA.

Alcohol & the Liver

- Long term alcohol abuse causes:
 - 1) Cirrhosis – scar tissue forms when hepatocytes have been destroyed. This area no longer functions
 - 2) Fat accumulation – damaged areas will build up fat in place of normal tissue
 - 3) Inflammation – swelling of damaged tissue (alcoholic hepatitis)





Stages of liver damage

Healthy Liver



Fatty Liver



Deposits of fat lead to liver enlargement

Liver Fibrosis



Scar tissues forms

Cirrhosis

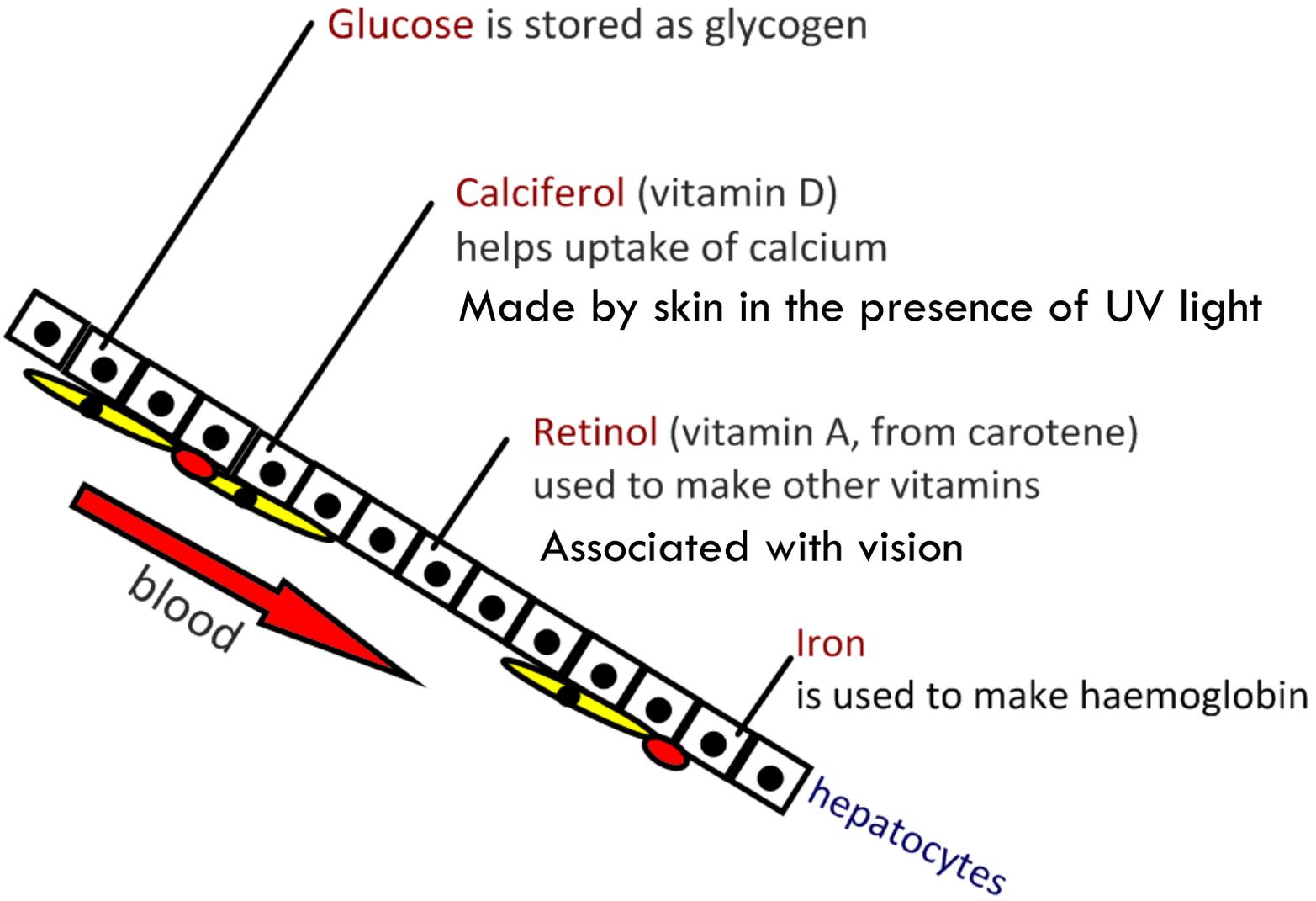


Growth of connective tissue destroys liver cells

2) Liver Regulates Nutrients in the Blood

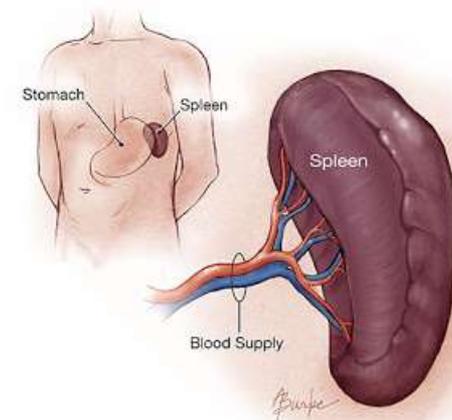
- Each type of solute dissolved in blood plasma has a normal homeostatic range.
- Concentrations below or above this range creates physiological problems in the body.
- The liver helps regulate the levels of nutrients in the blood and maintain homeostatic ranges.

Hepatocytes absorb and store nutrients in the liver

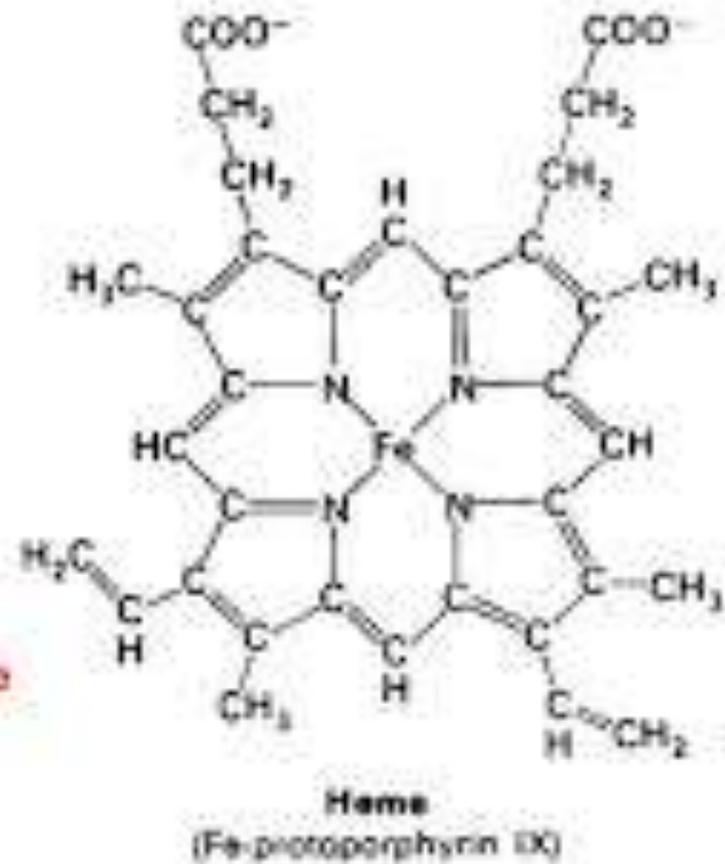
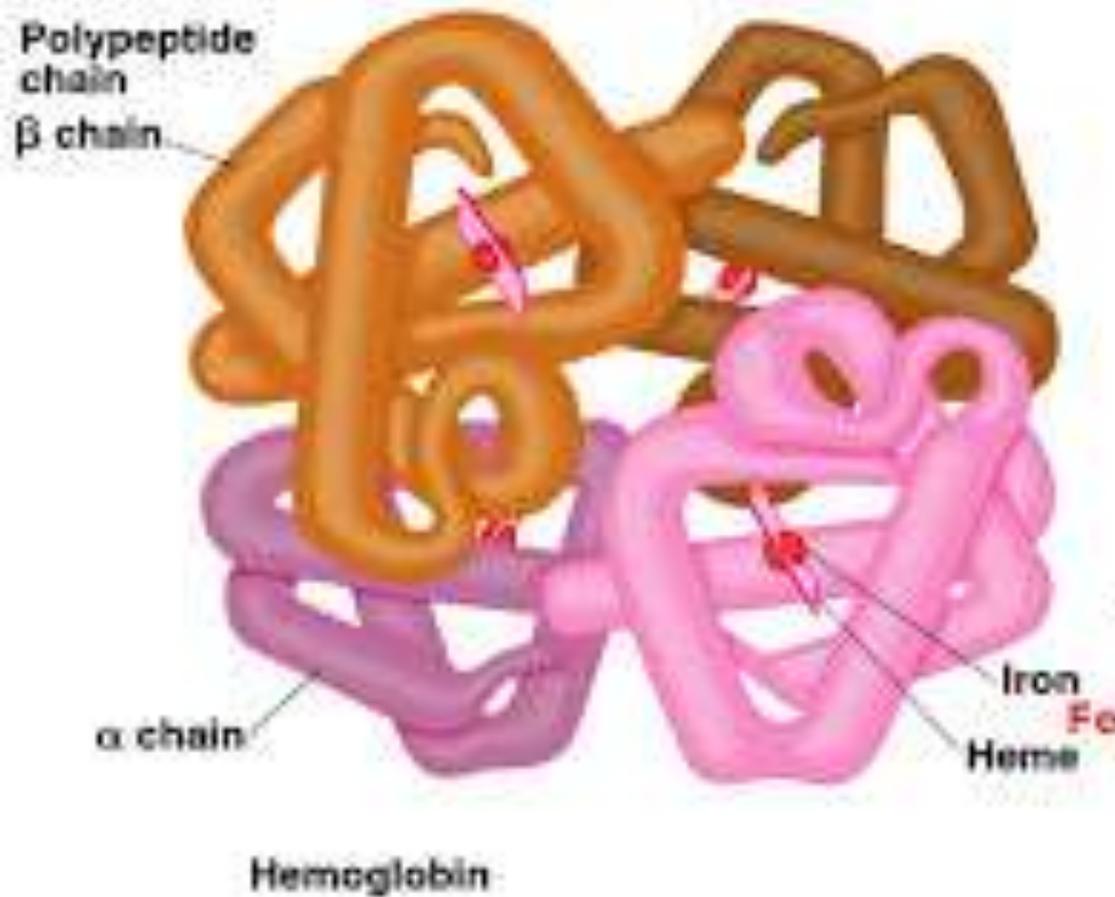


3) Recycling of Erythrocytes (RBCs)

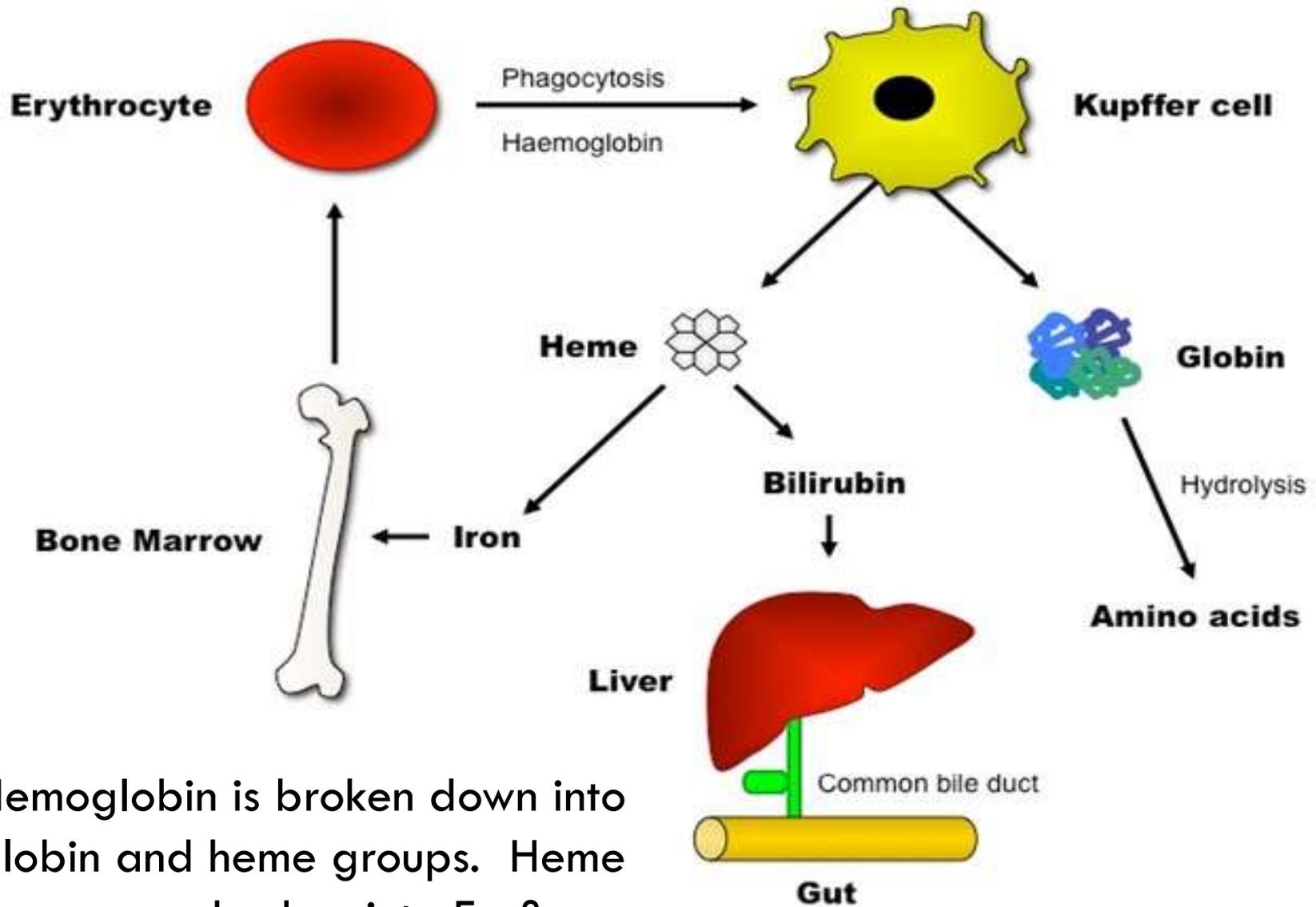
- Erythrocytes have a life span of about 120 days
- They do not have a nucleus so, they are destroyed (do not undergo mitosis – remember, new rbc come from bone marrow)
- When rbc get to 120 days, their cell membranes become weak and eventually ruptures releasing hemoglobin molecules
- This usually occurs in the spleen



Hemoglobin



Hemoglobin molecules are absorbed by Kupffer cells by phagocytosis



Hemoglobin is broken down into globin and heme groups. Heme groups are broken into Fe & Bilirubin

Globin Proteins



- Hydrolyzed into amino acids
- These amino acids absorbed into blood stream and sent to cells.
- Can be reused to make other proteins
- Can be deaminated and used for energy

Heme Group

- Contains the iron component
- Fe removed and stored in the liver
- Fe transported to the bone marrow to make new RBCs

- The remainder of the **heme group** become **biliverdin** (a green bile pigment), which is then converted into **bilirubin** (a yellow pigment) that is secreted into the small intestine via bile duct with bile.
- Bilirubin is what gives feces its characteristic reddish brown colour

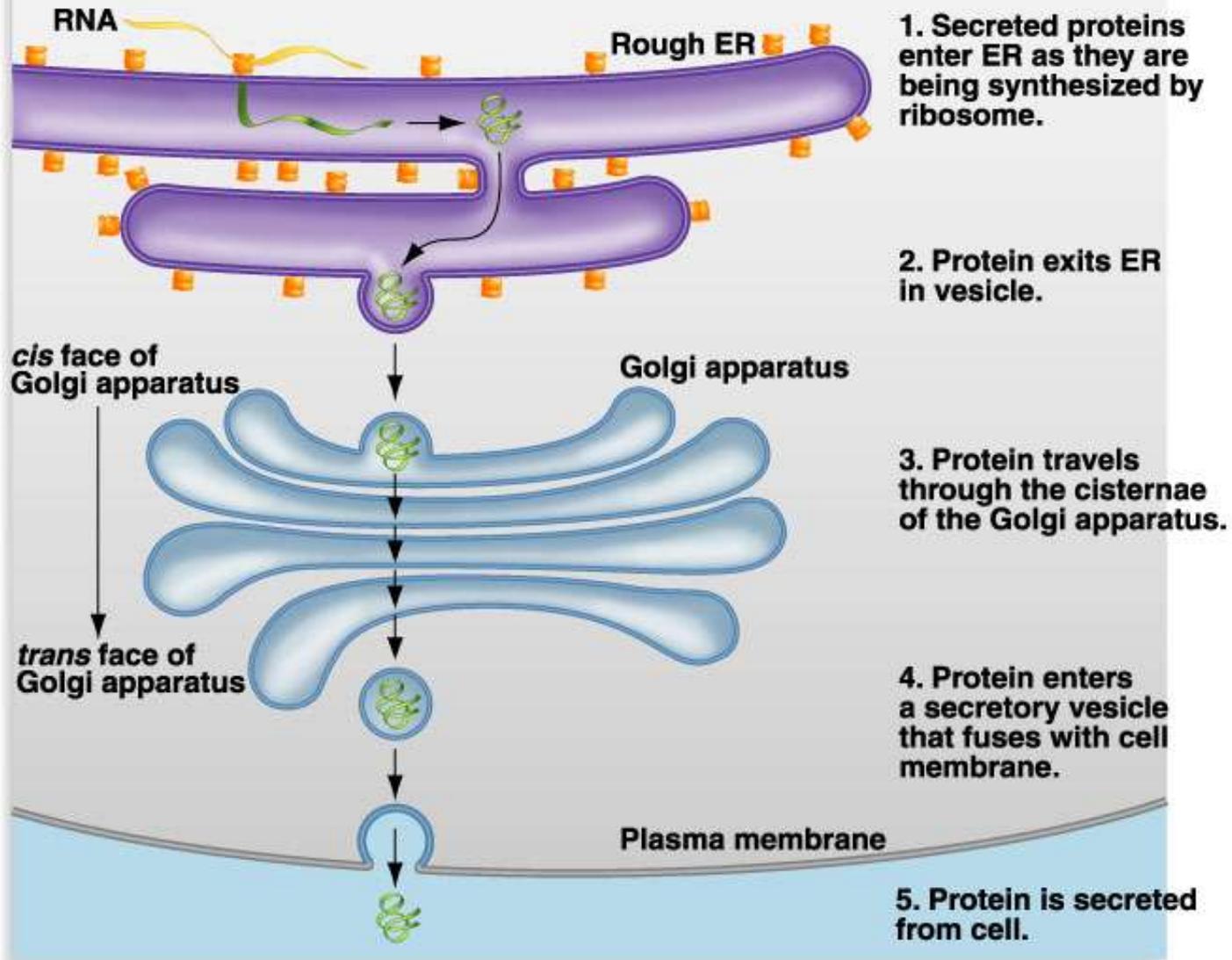
Production of Bile

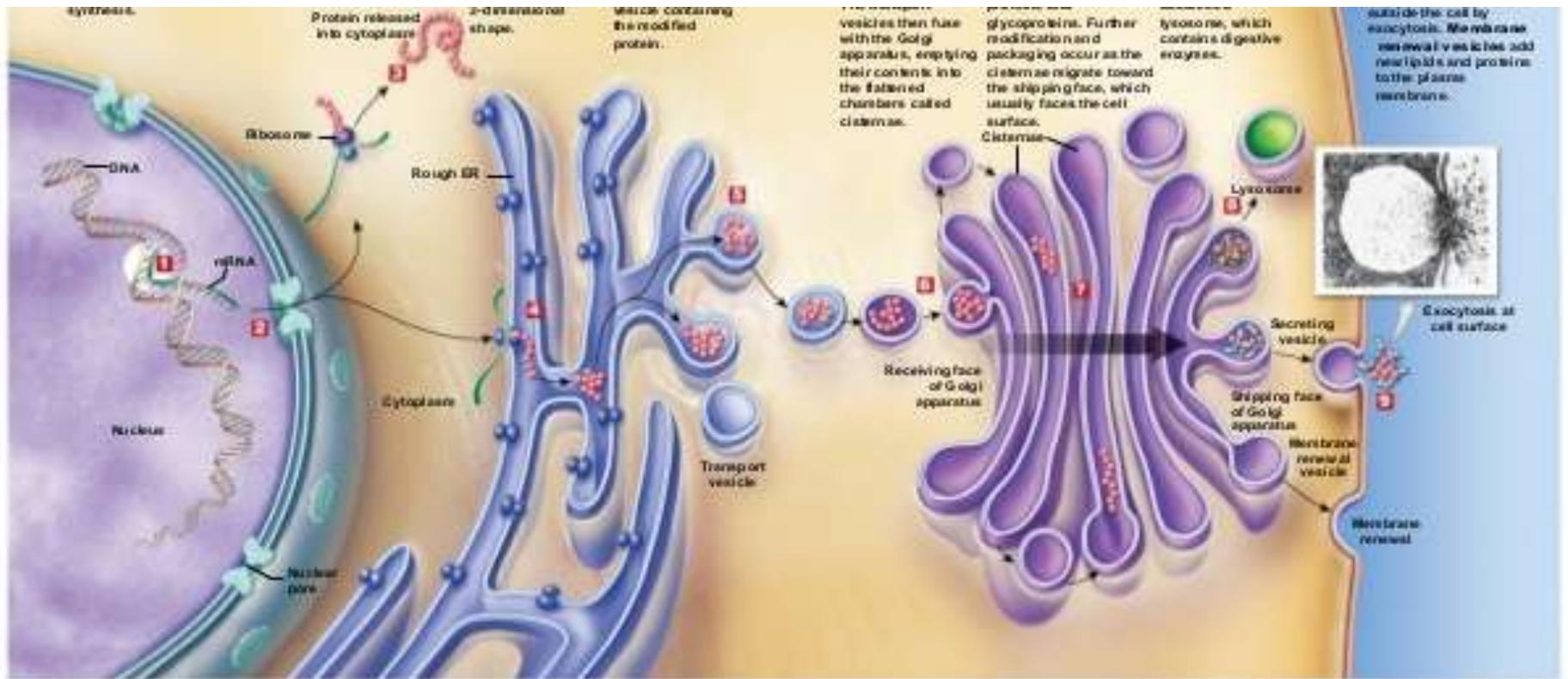
- Hepatocytes convert excess cholesterol → bile salts
- Bile salts + Bilirubin = Bile

Synthesis of Plasma Proteins

- Plasma Proteins: (blood proteins)
 - ▣ **ALBUMIN** – regulates osmotic pressure of fluids in the body. Carrier for bile salts
 - ▣ **FIBRINOGEN** – involved in forming blood clots.
 - ▣ **GLOBULINS** – antibodies (defend the body from foreign invaders)
- Plasma proteins made in liver must be secreted by hepatocytes
 - ▣ **Can you explain this process?**
 - **Q - Explain how plasma proteins are made in the liver and excreted to blood plasma.**

(b) THE SECRETORY PATHWAY: A MODEL





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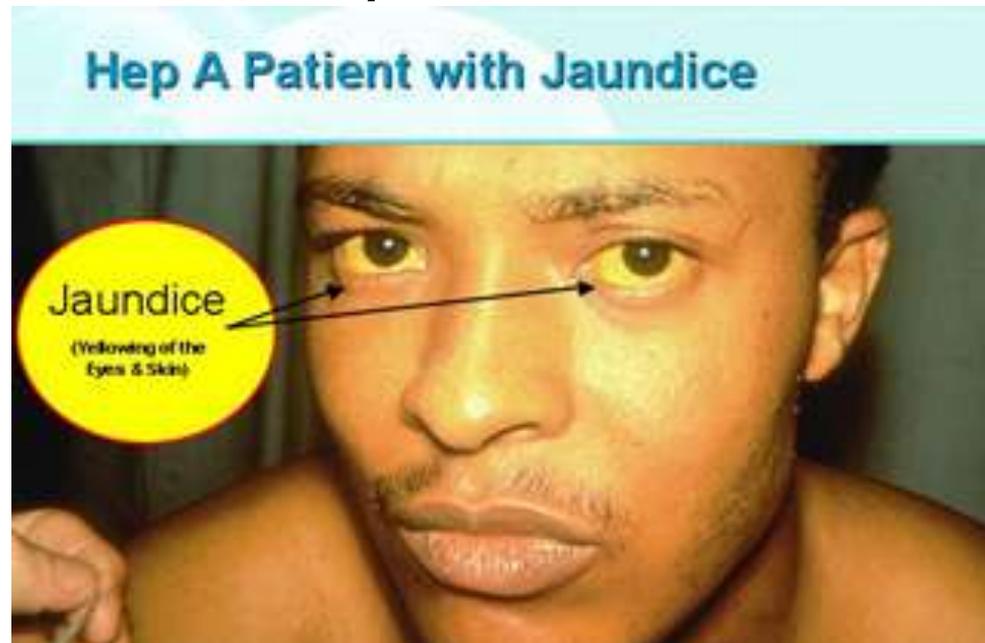
Synthesis of Cholesterol

□ Cholesterol

- ▣ Some cholesterol is ingested but *MOST* is made by the liver
- ▣ Used to produce bile
- ▣ Used to make cell membranes
- ▣ Used to make lipid based hormones (testosterone, estrogen)

Jaundice

- **Cause:** Buildup of bilirubin (yellow pigment) due to immature or non-functioning liver
- **Consequence:** Yellowing of tissues – most notably the skin and whites of the eyes.
 - Dark urine



Hepatitis



- Inflammation of the liver
- Often leads to jaundice, lack of appetite, and general discomfort
- Most cases are caused by a hepatitis virus; can also be caused by the ingestion of toxins (such as alcohol)

Jaundice

Infant Jaundice

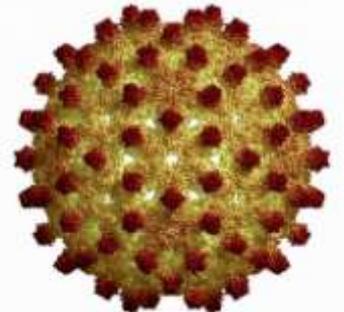
- Often premature babies with underdeveloped livers
- Treatment – UV Phototherapy
 - ▣ Changes bilirubin structure so it can be eliminated by babies urine and stool
 - ▣ Excess bilirubin is toxic
 - ▣ Causes acute bilirubin encephalopathy (brain condition)



Jaundice

Adult Jaundice

- Same symptoms and consequences as infant
- Cause depends on the problem that lead to improper functioning of liver
- Could be due to hepatitis infection (viral)
 - ▣ Hepatitis A – transmission oral-fecal
 - ▣ Hepatitis B – sexually-transmitted disease
 - ▣ Hepatitis C – Blood borne



Hep A Patient with Jaundice

