Anatomy and Physiology

For

The First Class

2nd Semester

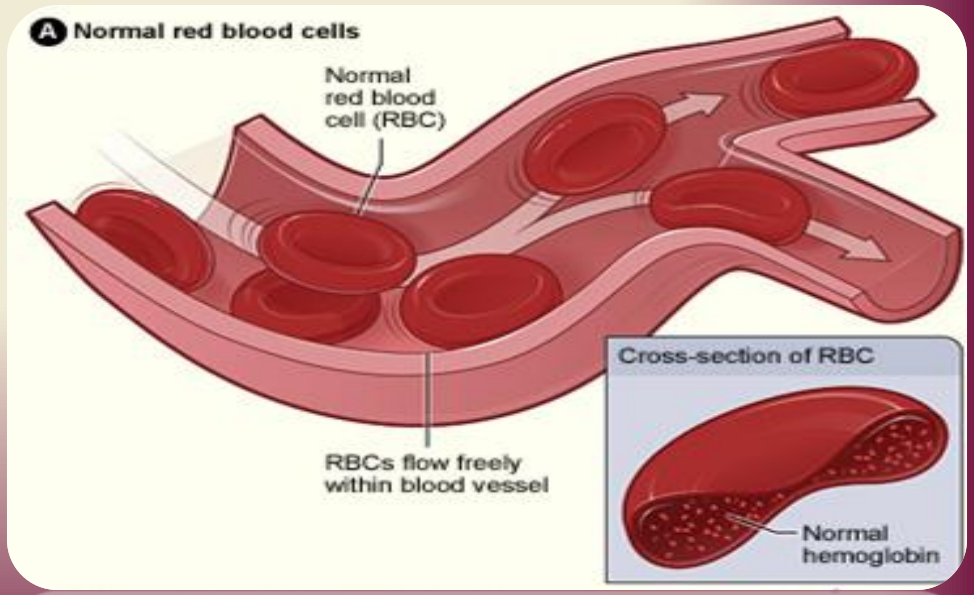
Hematologic System

Erythrocytes = Red Blood Cells (RBC)

Erythrocytes = Red Blood Cells

- Red blood cells are biconcave discs, they have **no nucleus and cytoplasmic organelles**. They contain a red coloured protein called **hemoglobin**. Their main function is in gas transport, mainly of O2 but they also carry some CO2.
- Human erythrocytes are 7.5 μm in diameter, 2.6 μm thick at the rim and 0.8 μm thick in the center.
- The biconcave shape **increases their surface area for gas exchange**, and the thinness of the central portion **allows fast entry and exit of gases.**
- The cells are flexible so they can squeeze through narrow capillaries.
- The normal concentration of erythrocytes in blood is approximately **3.9- 5.5 million per microliter** in women and **4.1-6 million per microliter** in men.

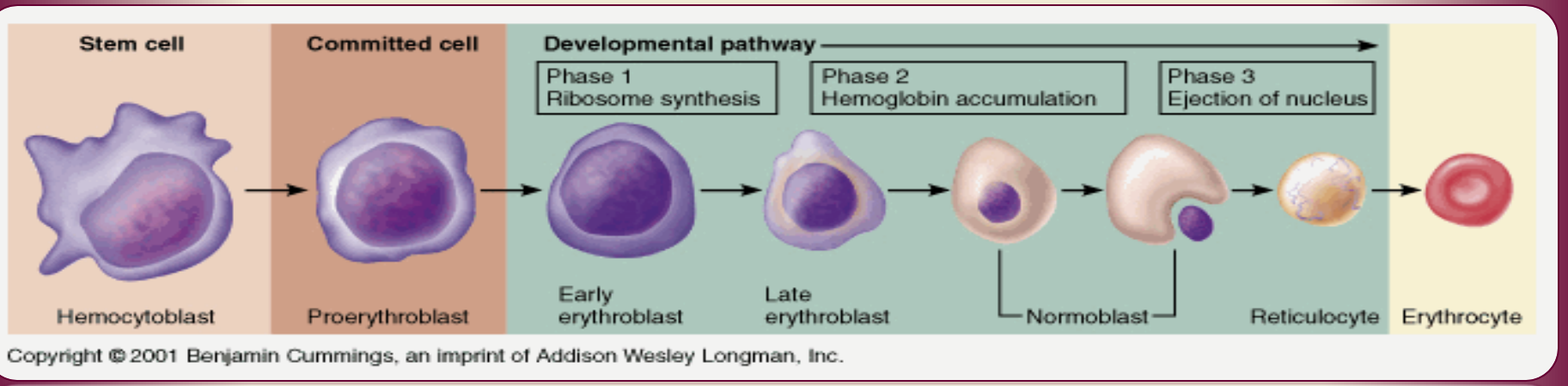
Biconcave shape of RBC

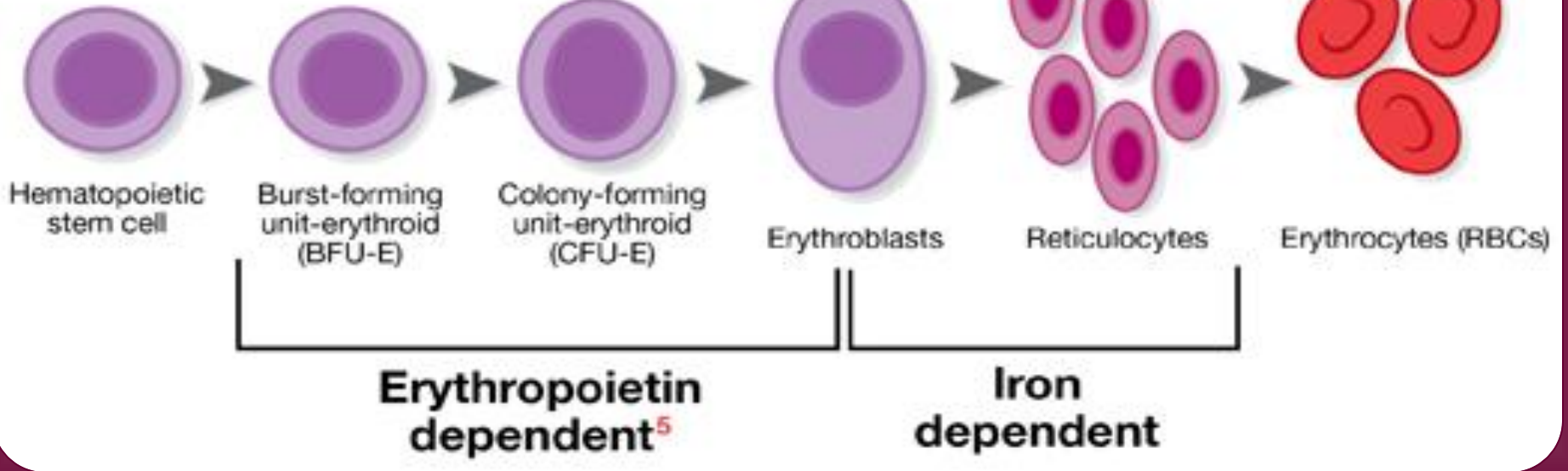


Life Span and Formation of Red Blood Cells

- Erythrocytes are produced in **red bone marrow** (in the ends of long bones and in flat and irregular bones).
- They pass through several stages of development before entering the blood.
- Their life span in circulation is about **120 days**.
- The process of RBC development from stem cells takes about **7 days** and is called **erythropoiesis.**
- The immature cells are released into the blood stream as **reticulocytes** and then **mature** into erythrocytes over **1-2 days** within circulation. During this time, they *lose their nucleus and therefore become incapable of division.*
- The hormone **erythropoietin** and substances such as **iron**, **folic acid**, and **vitamin B12** are essential for the production of erythrocytes.
- **Erythropoietin hormone** is a glycoprotein hormone produced in the kidneys and stimulates the production of globin (the protein component of Hb), enhances the release reticulocytes in the circulation and enhances reticulocytes maturation to mature RBC.

Erythropoiesis





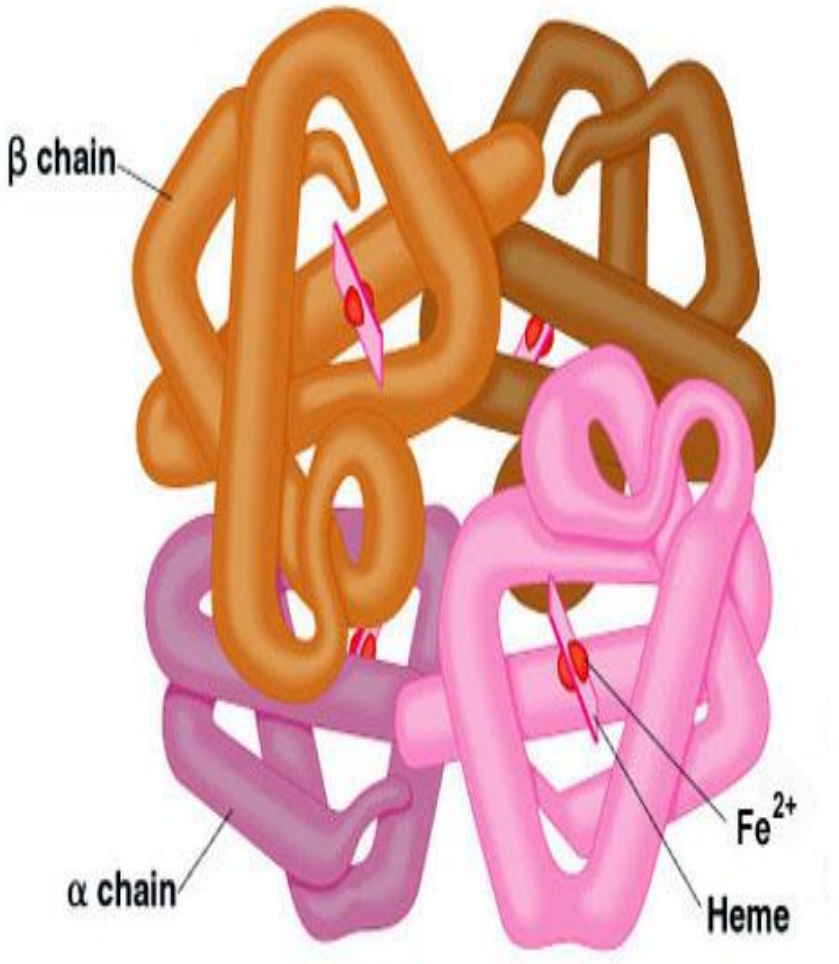
Physiological Factors influencing RBC number

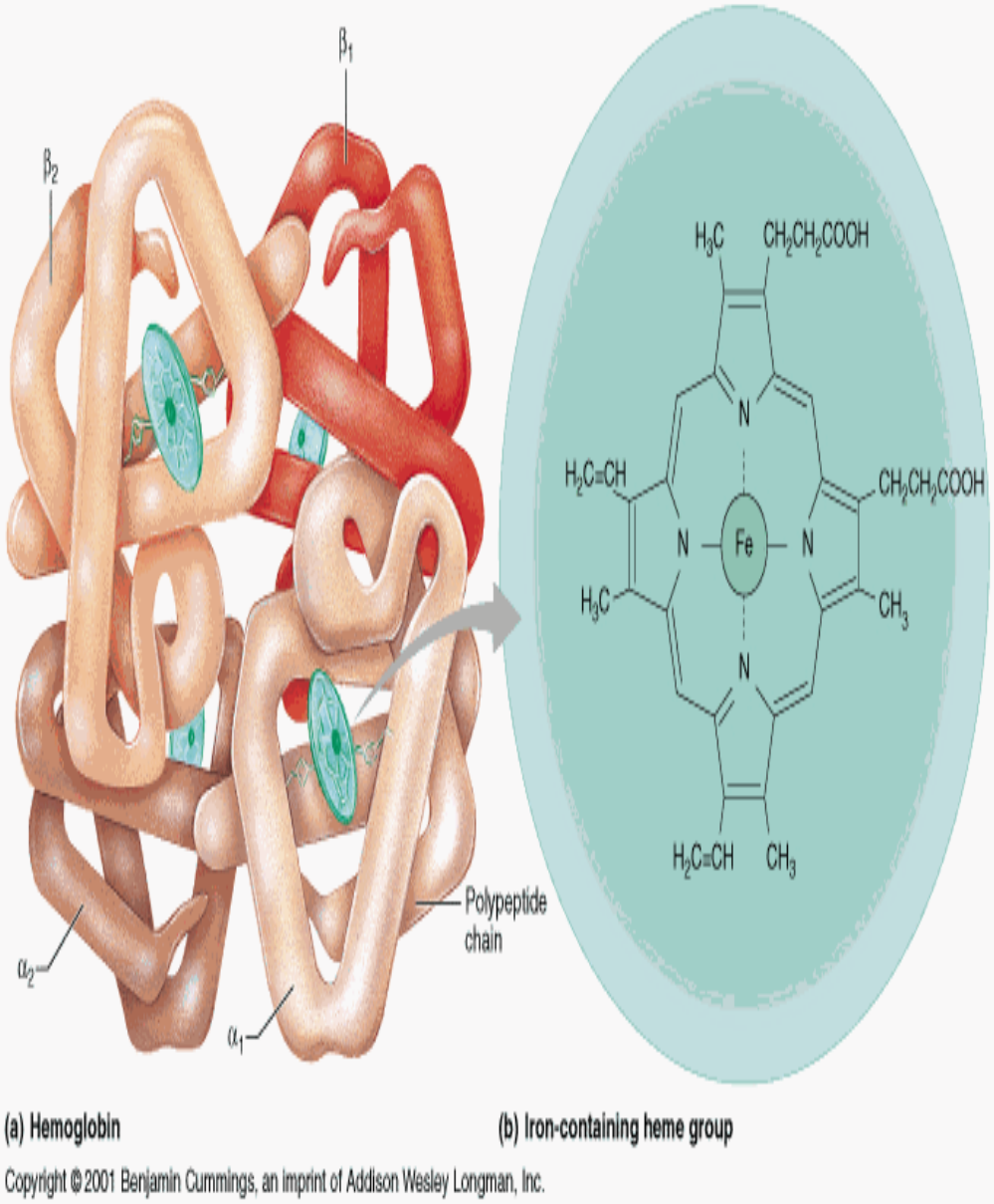
- RBC count is very high at birth (8-10 million\mm.
- The count is higher in children than in adults.
- RBC count is raised at high altitude, in warm temperature, during excitement.
- In women RBC count is relatively low during pregnancy.
- A fall in RBC count is seen low altitude.

Hemoglobin (Hb)

- Hb is the most important constituent of red blood cells. It is responsible for transport of O2 from lungs to tissues and CO2 from tissues to lungs.
- The normal value in a normal male adult is **13-18 g\100ml** and in female is **11.5- 16.5 g\100ml**.
- Molecules of hemoglobin is large and complex. They are made up of **heme** and **globin.**
- **Heme** is made up of **iron** (in ferrous form) and **porphyrin**.
- **Globin** is a protein that has **4 polypeptides chains** (*2 alpha and 2 beta*).
- Each unit of Hb contains **4 units of heme** that are united together by the alpha and beta chains of globin.
- Each unit of heme can combine with one molecule of O2. So one molecule of Hb can carry **4 molecule of O2**.
- Each RBC carries **about 280 million Hb molecules**, therefore each RBC has ability to carry **over a billion O2 molecules**.
- Hb with O2 is called **oxyhemoglobin,** and Hb without O2 called deoxyhemoglobin.

Hb Structure





Types of Normal Hb

- **Fetal hemoglobin Hb F** (α_2 and γ_2): presents in the fetus during the last seven months of development in the uterus. and replaced by adult Hb within 6 month after birth.
- **Adult hemoglobin Hb (Hb A)** consists of :

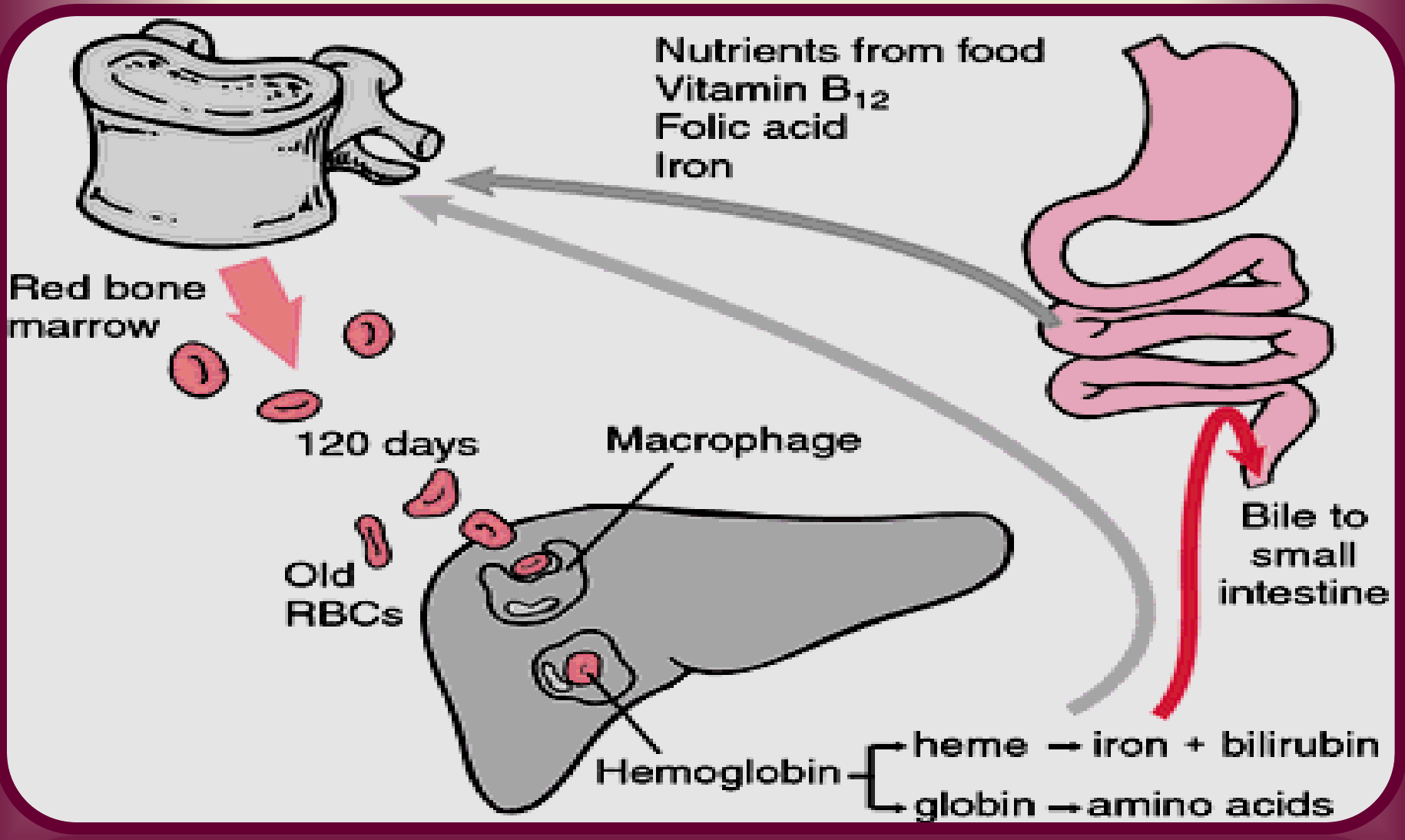
  - HbA ($\alpha_2 \beta_2$) 95%

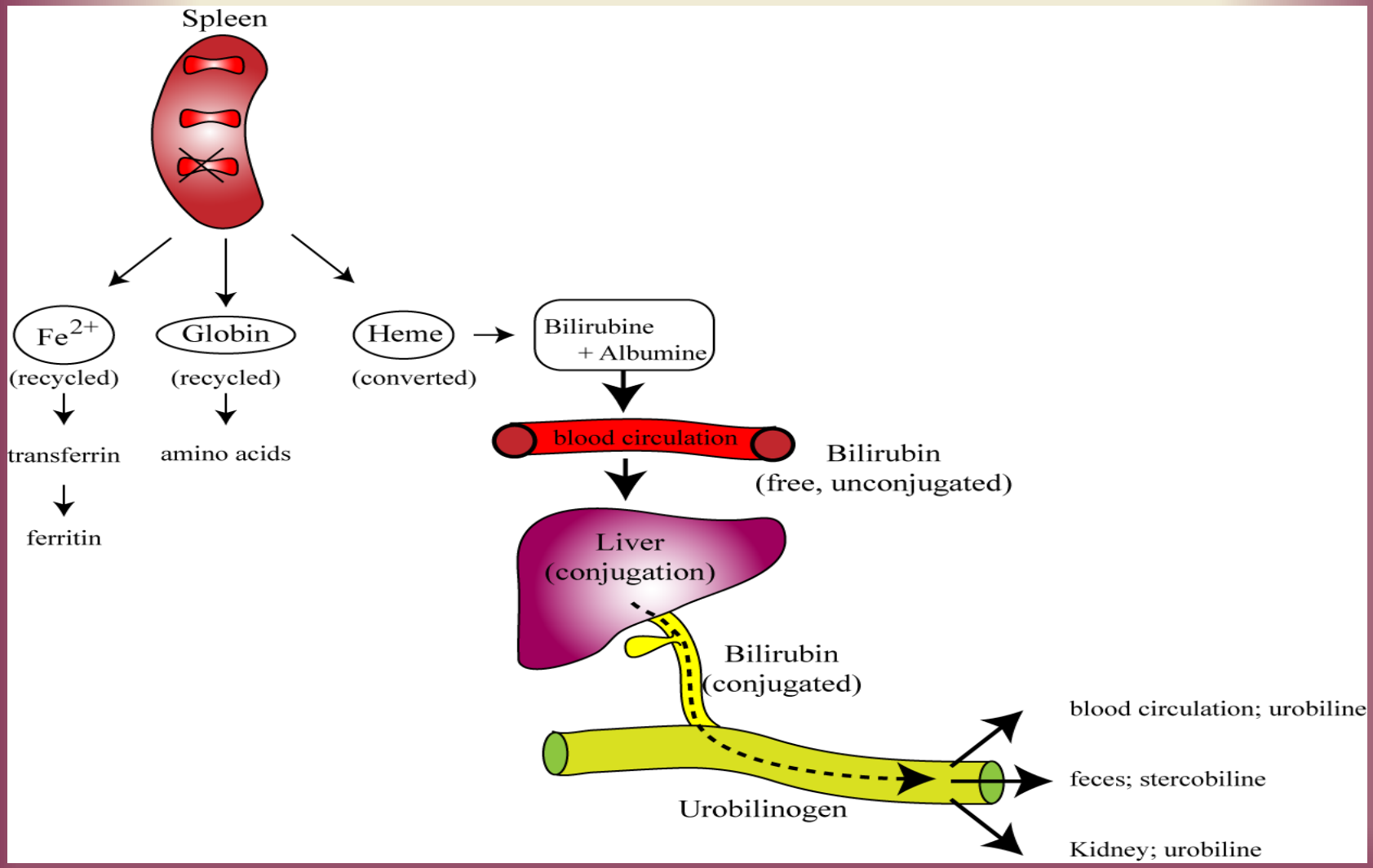
  -Hb A2 ($\alpha_2 \delta_2$) 1.5- 3%

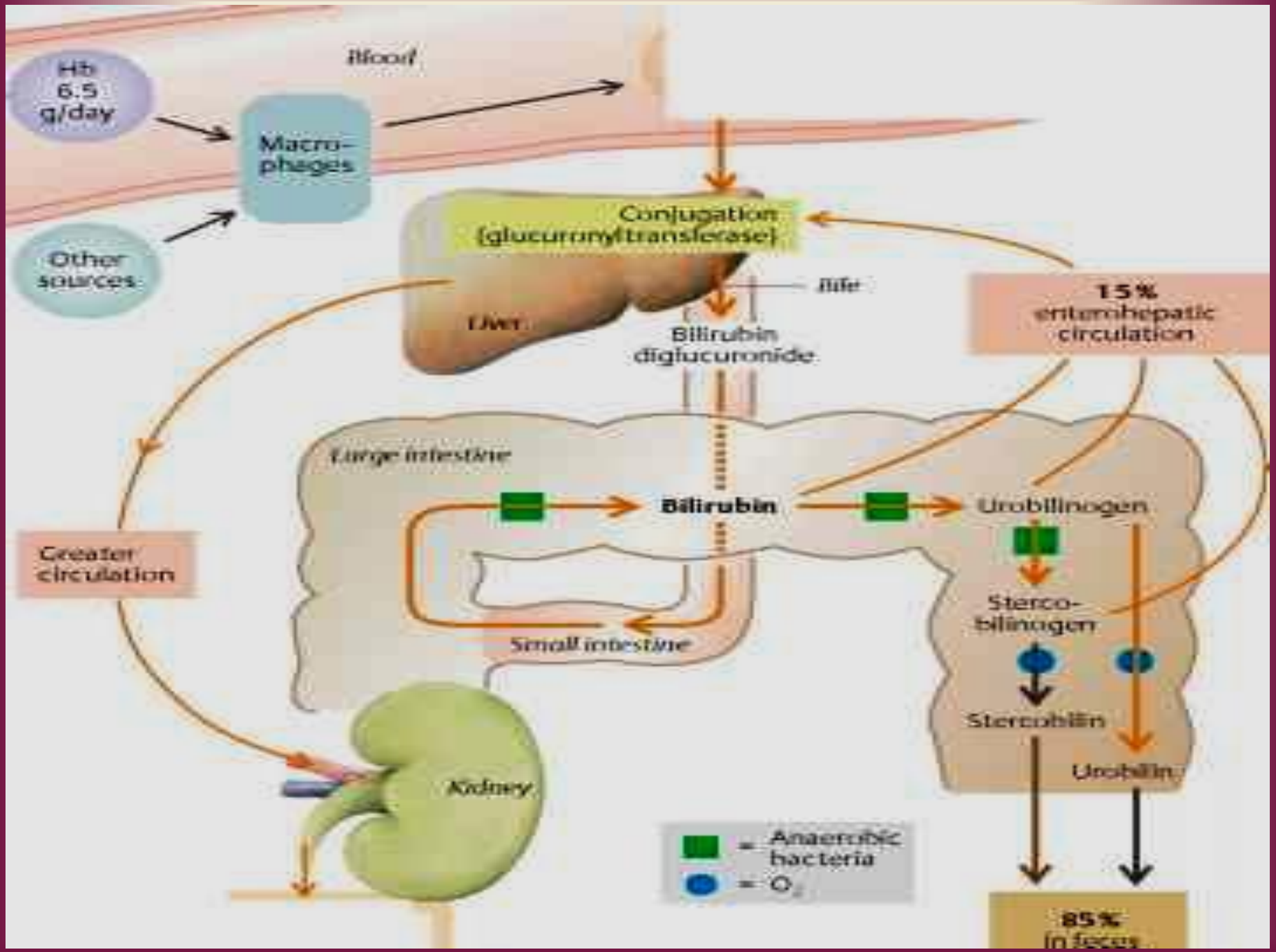
  - Very small amounts of Hb F ($\alpha_2 \gamma_2$)

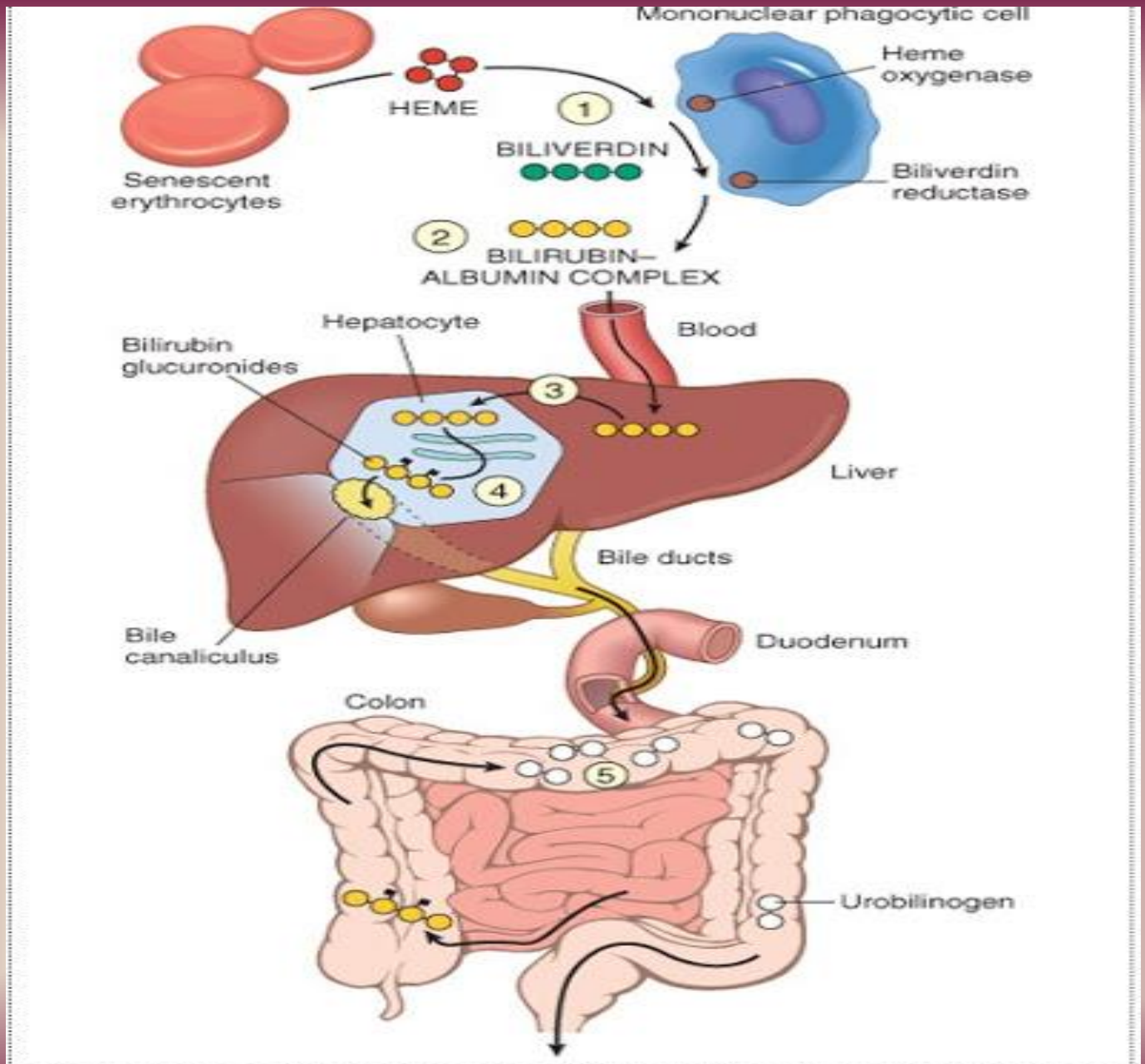
Recycling RBC

- At the end of erythrocytes life spine, their constituents (Hb) are broken dawn (to **heme** and **globin**) and *reused to form new erythrocytes*.
- **Iron** released from heme is carried by **transferrin protein** into the blood and then to various tissues (bone marrow, liver)
- **Porphyrin** released from heme is converted into a yellow pigment called **bilirubin**.
- **Bilirubin** is insoluble (unconjugated form). It is taken by liver cells changed to soluble form (conjugated form) and excreted into bile.
- In the large intestine conjugated bilirubin is converted into **stercobilinogen** (by action of bacteria) and then into **stercobilin** which is responsible for brown color of feces
- Some **stercobilinogen** is absorbed into blood and excreated into urine which called **urobilinogen** exposure to air converts into **urobilin.**


Nutrients from food
Vitamin B_{12}
Folic acid
Iron
Red bone marrow
120 days
Macrophage
Old RBCs
Bile to small intestine
Hemoglobin
heme → iron + bilirubin
globin → amino acids


Spleen
Fe2+
(recycled)
transferrin
ferritin
Globin
(recycled)
amino acids
Heme
(converted)
Bilirubine
+ Albumine
blood circulation
Bilirubin
(free, unconjugated)
Liver
(conjugation)
Bilirubin
(conjugated)
Urobilinogen
blood circulation; urobiline
feces; stercobiline
Kidney; urobiline

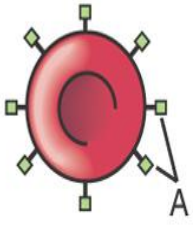
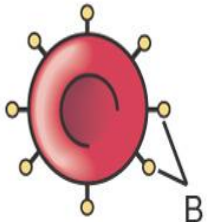
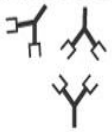
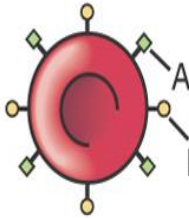
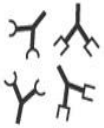

Hb
6.5
g/day
Blood
Macro-
pheges
Other
sources
Conjugation
(glucuronyltransferase)
Liver
Bile
Bilirubin
diglucuronide
15%
enterohepatic
circulation
Large intestine
Bilirubin
Urobilinogen
Greater
circulation
Sterco-
bilinogen
Small intestine
Stercobilin
Urobilin
Kidney
= Anaerobic
bacteria
= O2
85%

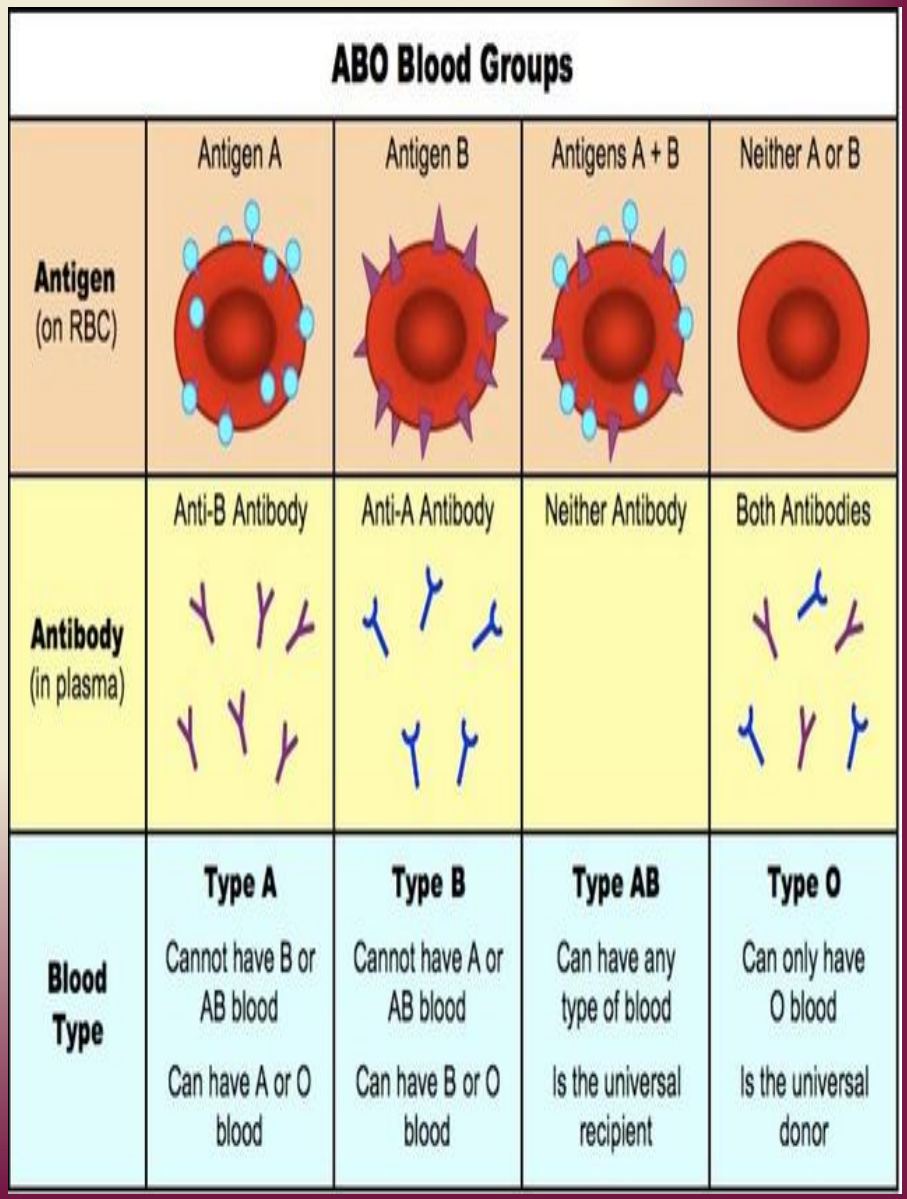


Blood Groups

- The plasma membrane of erythrocytes are composed of lipids and proteins.
- Several types of proteins are present including A, B proteins (antigens) and Rh (D) factor responsible for person's blood group.
- Individuals make antibodies to these antigens but not to own type of antigen
- Persons of blood group A have antigen of type A on their red blood cells. Their serum contains antibodies of type B.
- Persons of blood group B have antigen of B on their red blood cells. Their serum contains antibodies of type A.
- Persons of blood group AB have antigens of both types A and B. they do not have type A or type B antibodies.
- Persons of blood group O have neither A nor B. antibodies of both types A and B are present.
- Rh factor or antigen (Rhesus factor), about 85% of people have this antigen own cell membrane of RBC.

Blood Groups

Blood Type	Antigen (RBC membrane)	Antibody (plasma)	Can receive blood from	Can donate blood to
A (40%)	 A antigen	Anti-B antibodies 	A, O	A, AB
B (10%)	 B antigen	Anti-A antibodies 	B, O	B, AB
AB (4%)	 A antigen B antigen	No antibodies	A, B, AB, O	AB
O (46%)	 No antigen	Both Anti-A and Anti-B antibodies 	O	O, A, B, AB



Anemia and Polycythemia

- Anemia means decrease in the capacity of RBC to carry O2. it occurs due to decrease RBC number or amounts of Hb.
- Decrease in the RBC number occurs in case: -hemorrhage,

  -hemolysis

  -defect production of red blood cells by bone marrow
- Diminish amounts of Hb occurs in case of nutritional deficiency like in iron deficiency, vitamin B12 deficiency.

Polycythemia

- An increase in the number of erythrocytes is called erythrocytosis or polycythemia.
- Polycythemia may be a physiologic condition like in people who live at high altitudes, were O2 tension is low.

Jaundice

- It is yellow pigmentation of the tissues, seen in the skin and conjunctiva, caused by excess blood bilirubin.
- Occurs due to:

  - Hemolysis

  - liver disease

  - Obstruction in the bile duct.