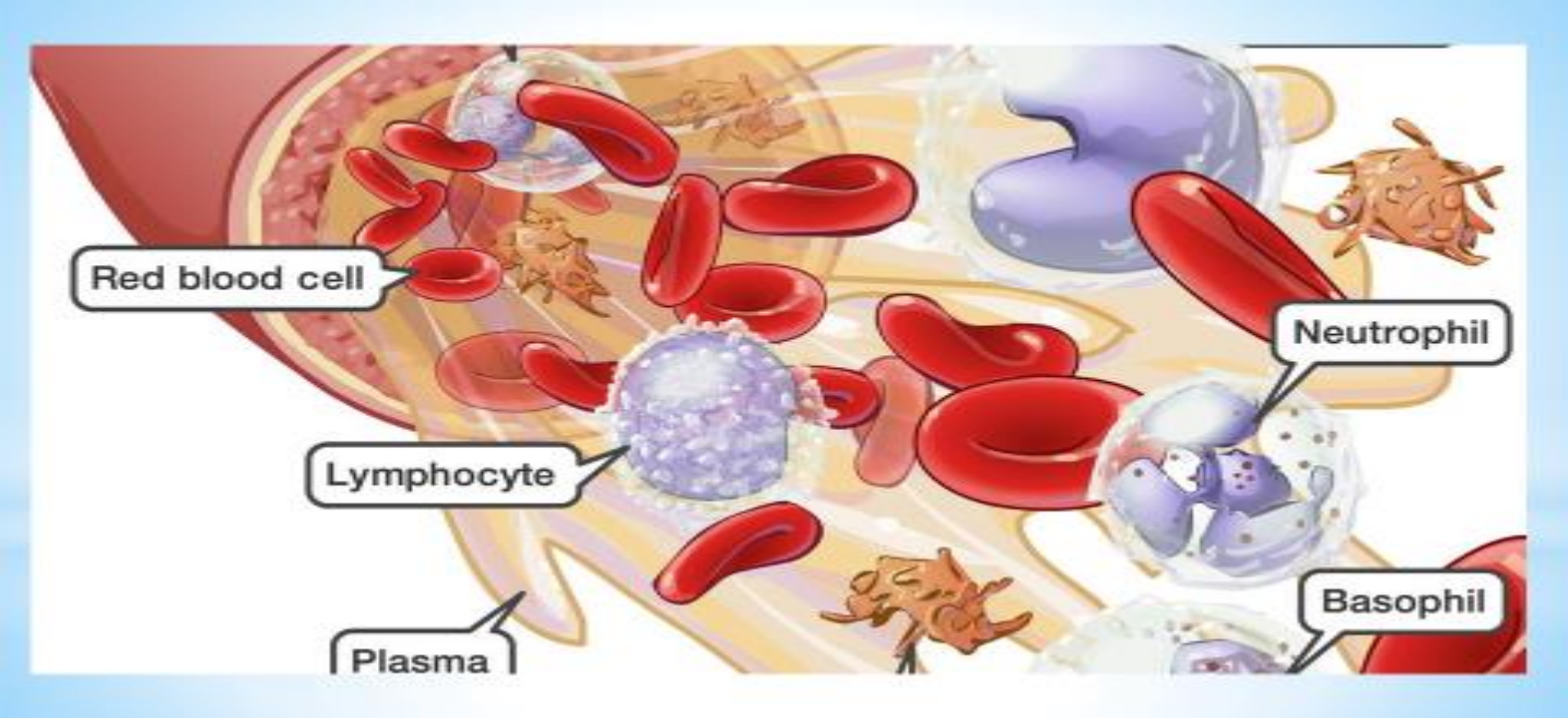
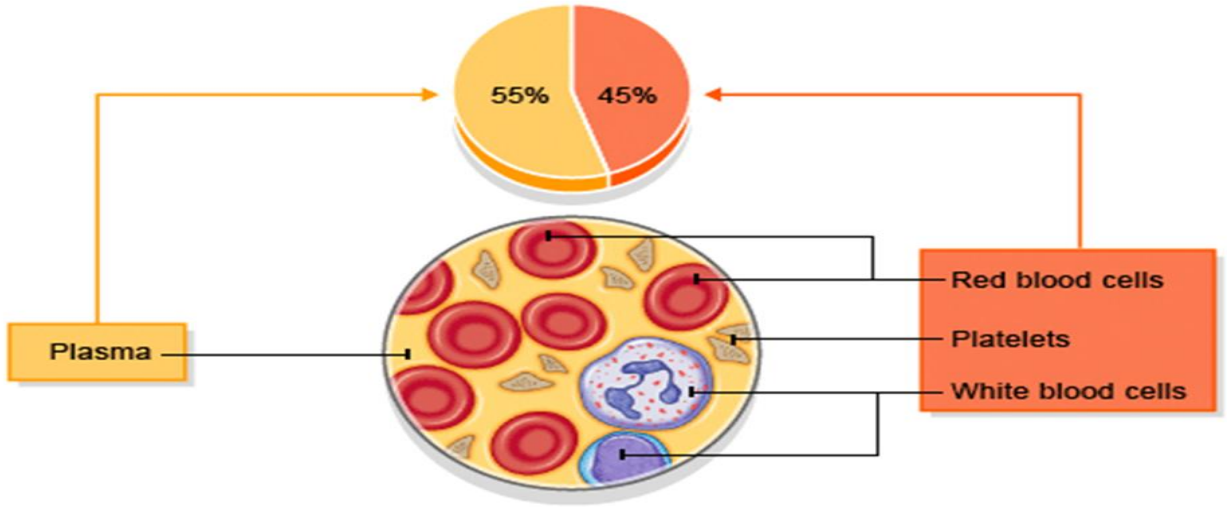


physiology of blood,
lecture1, (Red blood cell),
Dr.sahar Jabbar,2019

Medical collage ,Ibn Sina university



Blood

is a viscous fluid which circulates in a closed system of blood vessels.

Blood consist of 2 parts:-

A-plasma:-yellow fluid

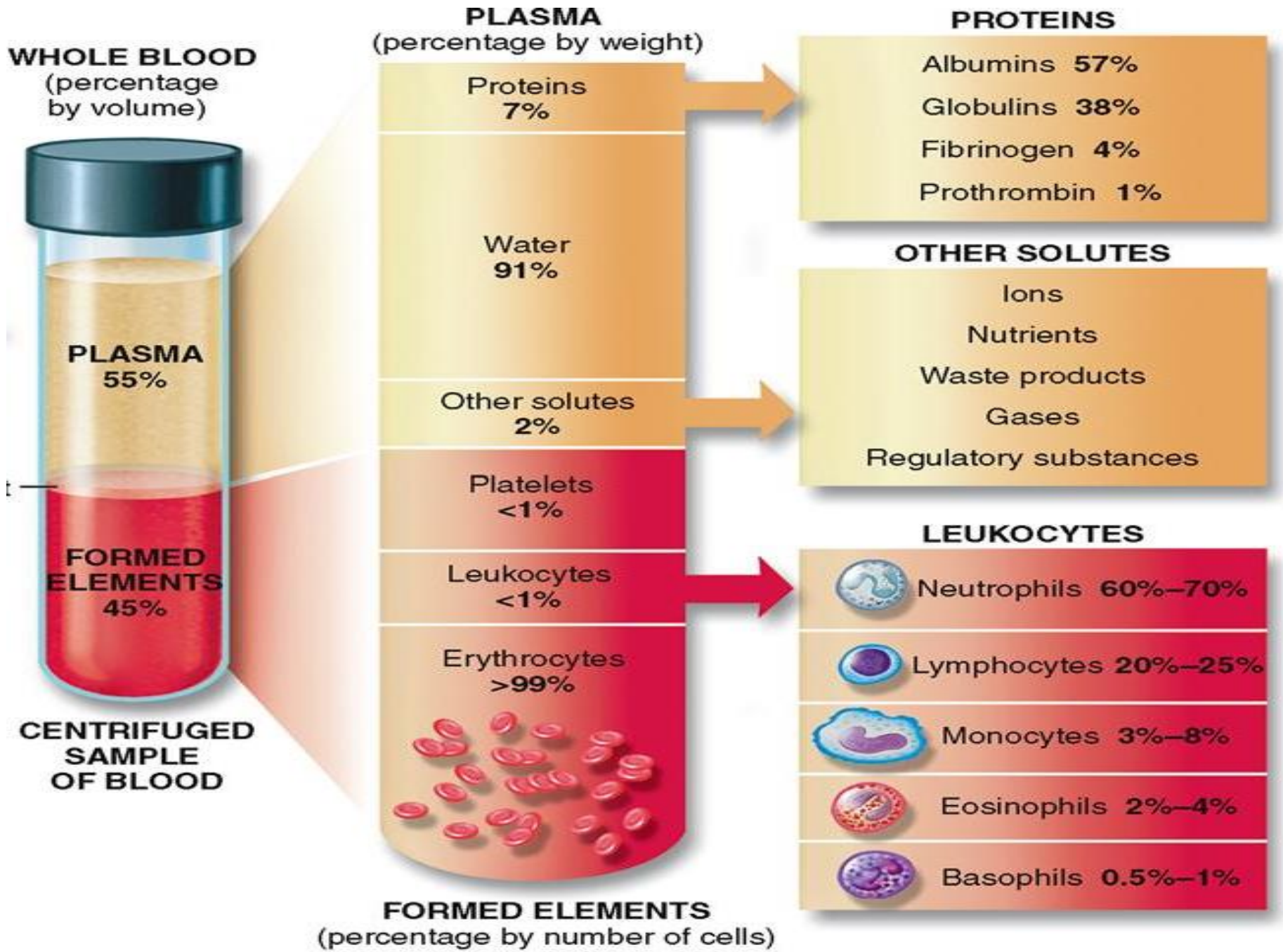
B- cellular elements of deferent types of cells

Functions of Blood

1. Deliver O_2, nutrients to all body cells
2. Transport waste products from cells for elimination
3. Transport hormones
4. Maintain body temp (distribute heat)
5. Maintain pH (carry buffers)
6. Maintain fluid volume
7. Prevent blood loss (clotting)
8. Prevent infection (WBCs, antibodies)

- **Blood volume in liters =7% of body weight (kg).**
  - **Blood volume in adult male 5-6 liters .**
  - **in adult female 4-5 liters.**

- **Plasma 50-60% of blood volume**
- **More than 90% of plasma is water**
- **Blood PH 7.35-7.45**


WHOLE BLOOD
(percentage by volume)
PLASMA
55%
FORMED ELEMENTS
45%
CENTRIFUGED SAMPLE OF BLOOD
PLASMA
(percentage by weight)
Proteins
7%
Water
91%
Other solutes
2%
Platelets
<1%
Leukocytes
<1%
Erythrocytes
>99%
FORMED ELEMENTS
(percentage by number of cells)
PROTEINS
Albumins 57%
Globulins 38%
Fibrinogen 4%
Prothrombin 1%
OTHER SOLUTES
Ions
Nutrients
Waste products
Gases
Regulatory substances
LEUKOCYTES
Neutrophils 60%–70%
Lymphocytes 20%–25%
Monocytes 3%–8%
Eosinophils 2%–4%
Basophils 0.5%–1%

Plasma composition

Plasma is the fluid of blood that contain

- **1-plasma protein (7%)**
- **2- Water(91%)**
- **3-solutes(2%)**
  - **-ions**
  - **-organic nutrients**
  - **-organic wastes**

the total value of plasma protein is about 7 gram/100 ml of plasma

Types of proteins in plasma

1-Albumin 57%

2-Globolin 38%

3-Fibrogen 4%

4-special plasma regulatory proteins ,enzymes,hormones ,pro hormones(1%)

1- Albumin

the concentration of it, 4.5 gm. /dl

1-its act as oncotic pressure at the capillary membrane.

2-trasport of the fatty acids, thyroid hormones , steroid hormones.

2-Globolin

-Its concentration 2.5gm/dl are divided into 3 types

- **-Alfa globulin**
- **-Beta globulin**
- **-Gama globulin**

Functions:-

1-Its either Antibodies called immunoglobulin's or

2- Its transport globulin for:-

- Hormone binding proteins

- Metalloproteins

- Apolipoproteins

- Steroid binding proteins

3-fibrinogen

Molecules forms clots produce long insoluble strands of fibrin.(important clotting factor for coagulation)

- **Origin of plasma proteins**
  - **-90% made in liver**
  - **-Antibodies made in plasma cells and B lymphocytes**
  - **-Peptide hormones in endocrine organs**

Solutes

a-Ions essential for vital cellular activity

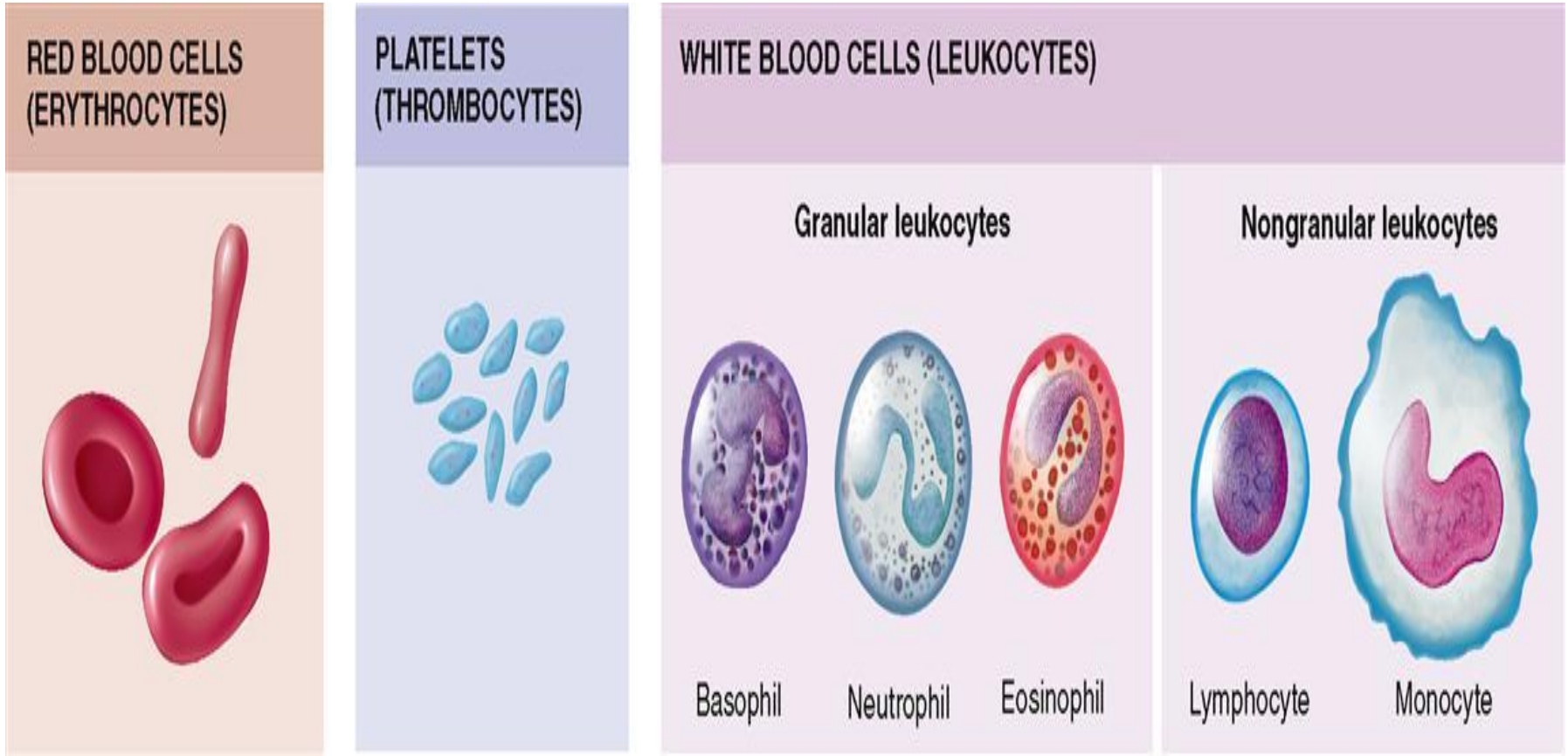
Na,K,Mg,Cl,HCO3,Hpo4,SO4.

b-Organic nutrient ,used for ATP production

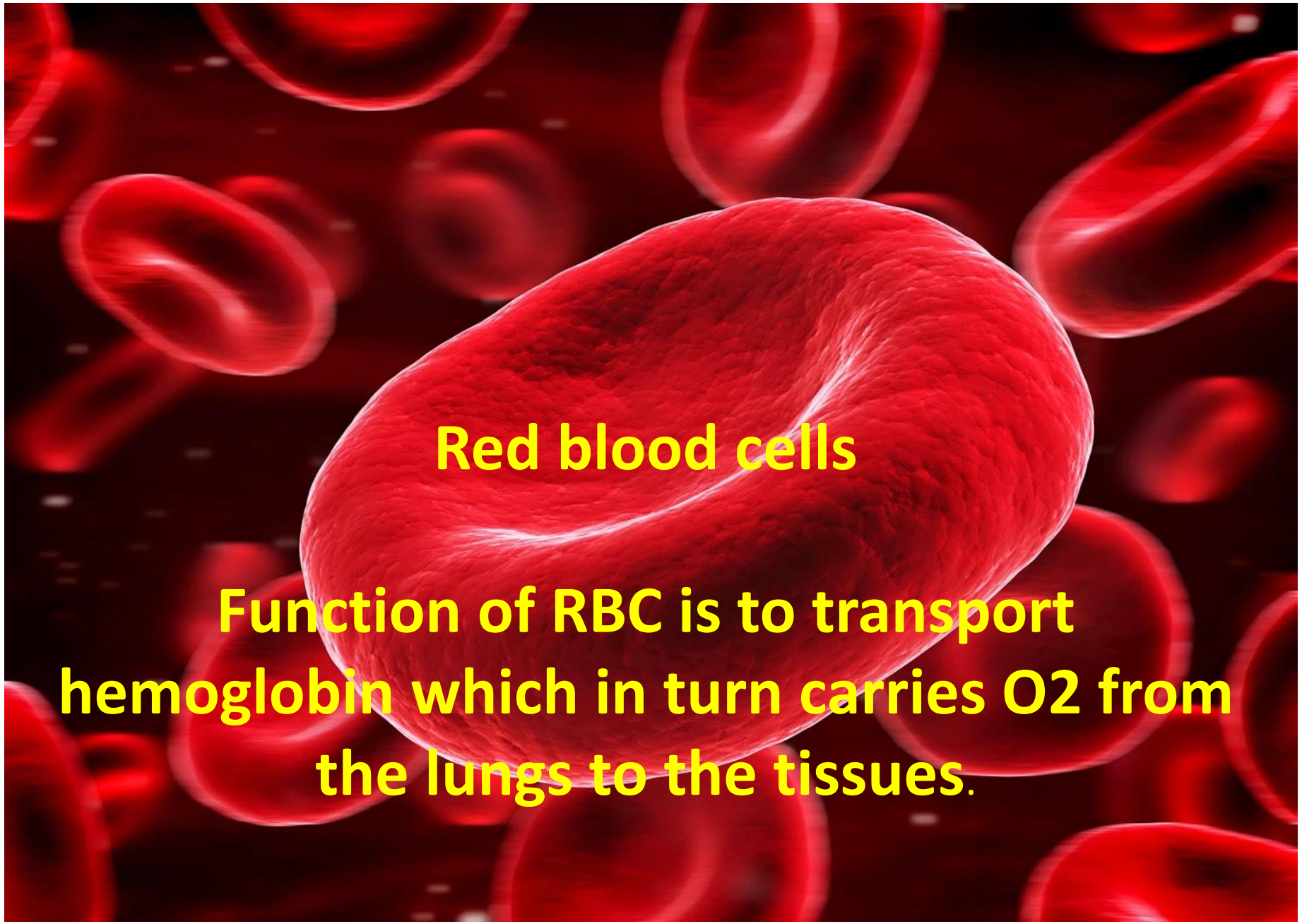
Lipid ,fatty acid , cholesterol ,glycerides ,CHO carbohydrates ,glucose and amino acid.

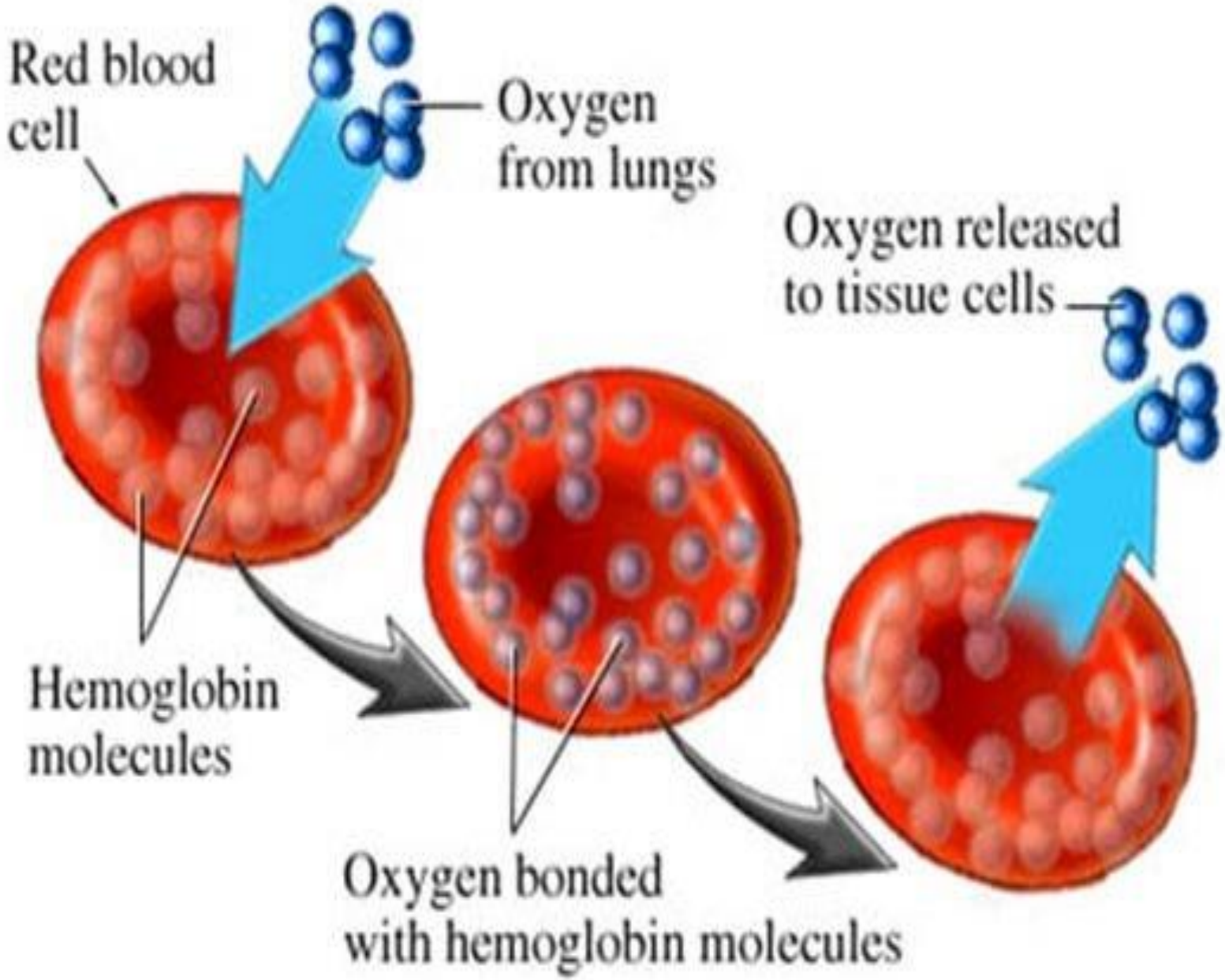
c-Organic wastes for breakdown and excretion.

- **-Urea**
- **Uric acid**
- **-Creatinine**
- **-Bilirubin**


RED BLOOD CELLS
(ERYTHROCYTES)
PLATELETS
(THROMBOCYTES)
WHITE BLOOD CELLS (LEUKOCYTES)
Granular leukocytes
Nongranular leukocytes
Basophil
Neutrophil
Eosinophil
Lymphocyte
Monocyte

Blood cells


Red blood cells
Function of RBC is to transport hemoglobin which in turn carries O2 from the lungs to the tissues.

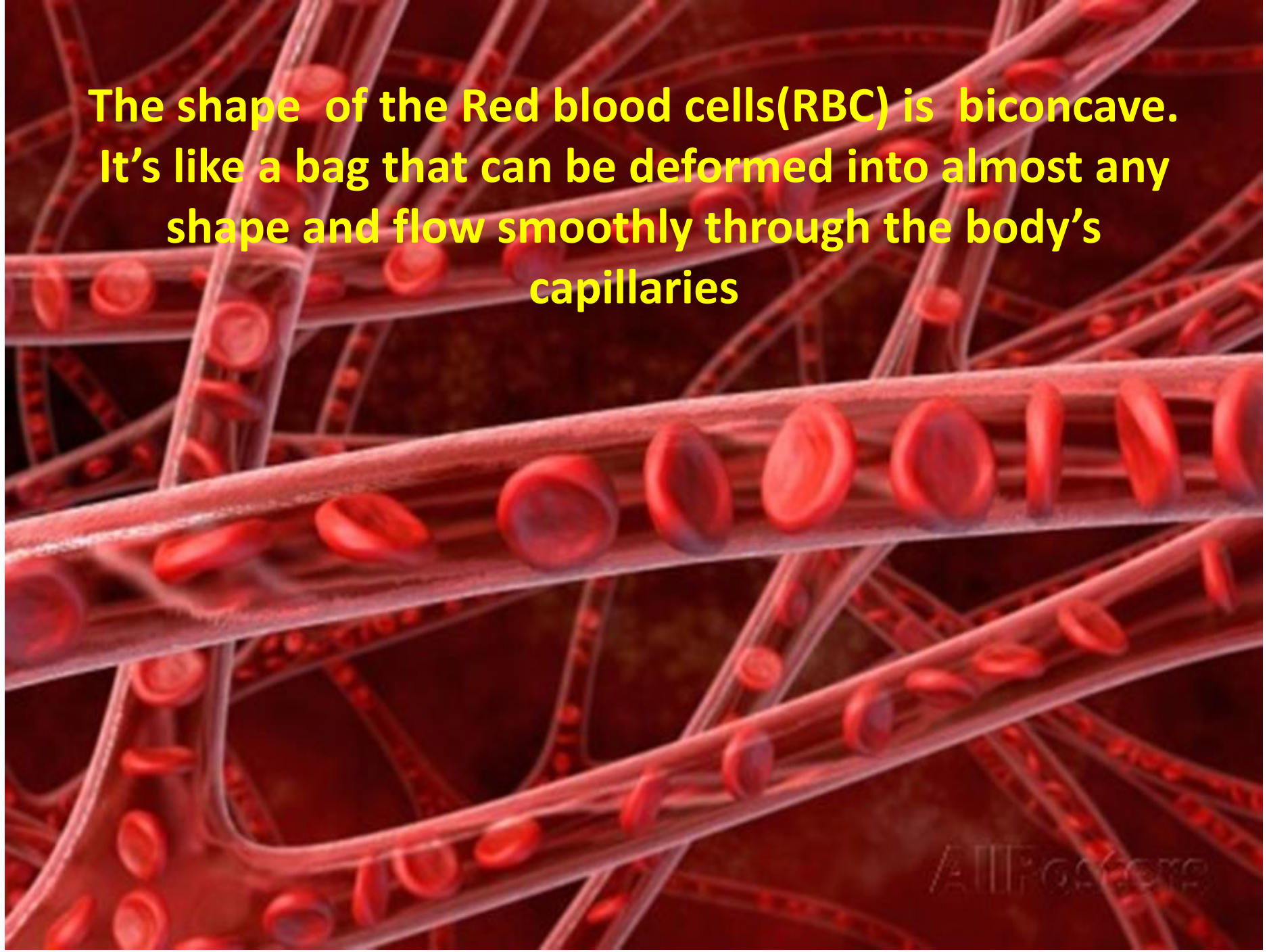

Red blood cell
Oxygen from lungs
Oxygen released to tissue cells
Hemoglobin molecules
Oxygen bonded with hemoglobin molecules

-the mean diameter of RBC about 7.5micrometers.

-the thickness of RBC is

2.5 micrometers at the thickest point and 1 micrometer or less in the center.

-The average volume of the red blood cell is 90 to 95 cubic micrometers

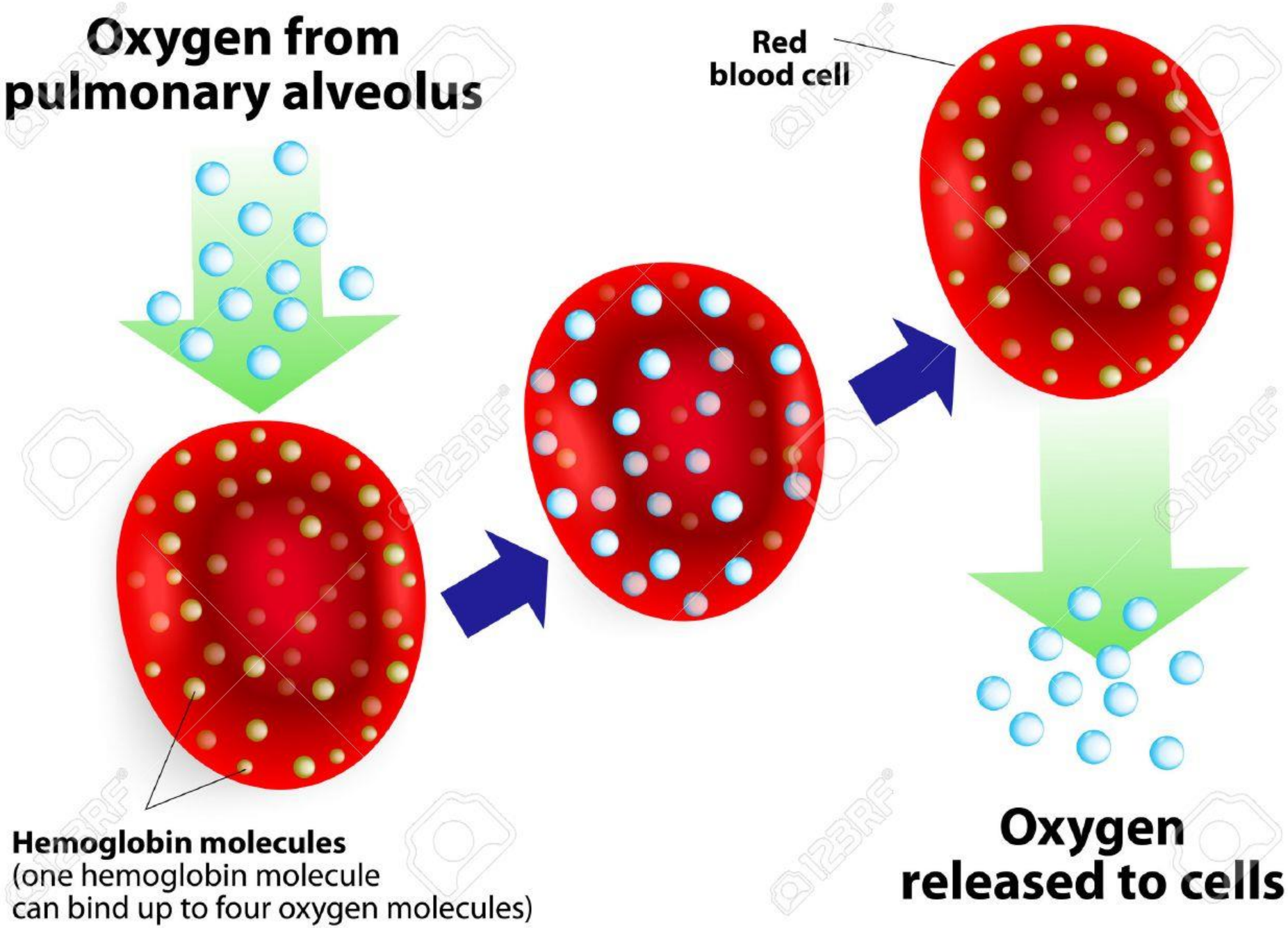

The shape of the Red blood cells(RBC) is biconcave. It’s like a bag that can be deformed into almost any shape and flow smoothly through the body’s capillaries

- **Red blood cells are considered cells, but they lack a nucleus, DNA, and organelles like the endoplasmic reticulum or mitochondria.**

- **Red blood cells cannot divide or replicate like other body cells. They cannot independently synthesize proteins.**

- **The blood’s red color is due to presence of hemic iron ions in hemoglobin.**

- **Each human red blood cell contains approximately 280 million hemoglobin molecules, each carrying four heme groups to which oxygen binds.**


Oxygen from pulmonary alveolus
Red blood cell
Hemoglobin molecules
(one hemoglobin molecule
can bind up to four oxygen molecules)
Oxygen released to cells

- the average concentration of Hb in the male is about 16gm/100 ml blood .in female is about 14gm/100ml of blood.

- Every 1gm of Hb can combine with 1.39 ml 0f O2.

- In male each 100 ml of blood contain over 21 ml of O2,

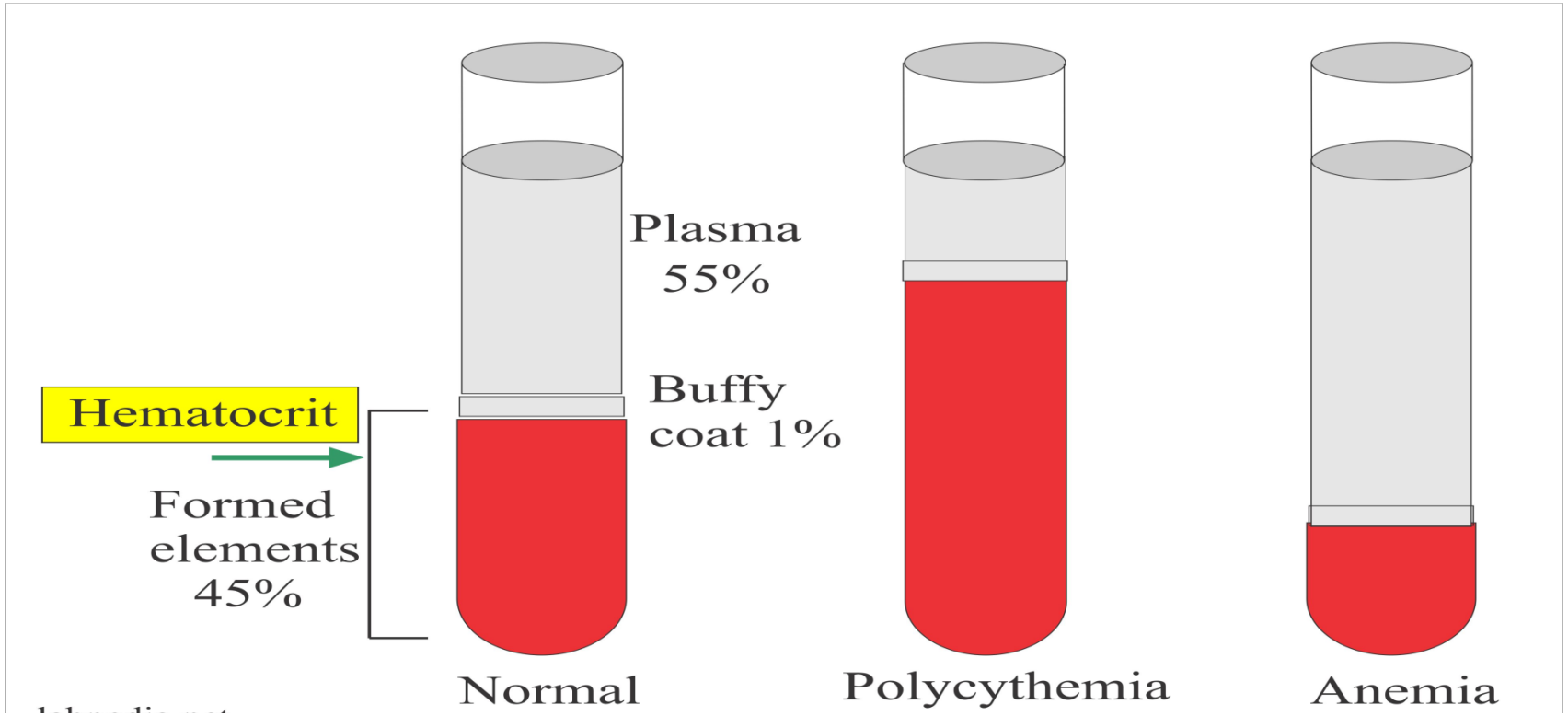
- in female it contain 19 ml of O2.

- **In normal men, the average number of red blood cells per cubic millimeter is 5,2millions (±300,000) mm^3**

- **in normal women, it is 4,7millions (±300,000)/mm^3 .**

Persons living at high altitudes have greater numbers of Red blood cells.

-half life OF RBC 120 days,removed by spleen .



Hematocrit (packed Cell volume PCV)

the ratio of the volume of red blood cells to the total volume of blood as determined by separation of red blood cells from the plasma usually by centrifugation.

HEMATOCRIT

- the ratio between plasma and cellular elements is 55%plasma to 45%cellular elements this ratio called hematocrit or packed cell volume.

- when percentage of RBC is below 45% this causes anemia while percentage above 45% this cause polycythemia

Erythropoiesis

Def: formation of RBCs

- Sites of erythropoiesis

During fetal life	After birth
1) **Yolk sac**: in the first 6 w 2) **Liver & spleen**: from 6 w – 6 m 3) **Bone marrow BM**: from 6 m until after birth	**Active (red) BM**: **In infancy** & childhood red BM present nearly in all bones **In adult** red BM is restricted in ends of long bones, vertebrae, ribs, sternum, skull, pelvic bones

Genesis of RED BLOOD CELLS

- Red blood cells are derived from the cell known Hemocytoblast

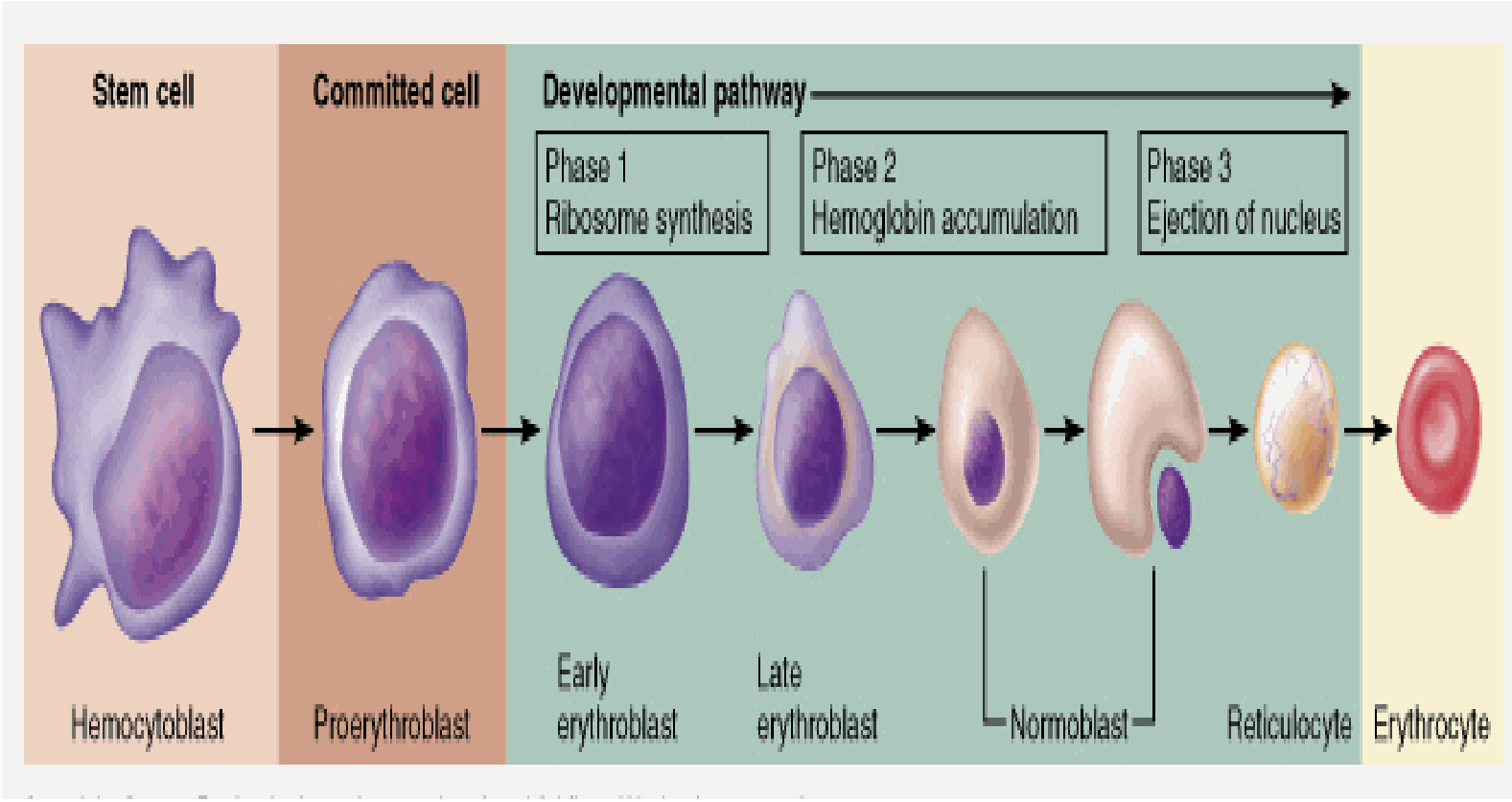
which formed from Primodial stem cells located in bone marrow.

- -The Hemocytoblast form the

Basophil erythroblast (early Erythroblast).

Then become:-

Poly Chromatophil Erythroblast (late erythroblast).


Stem cell
Committed cell
Developmental pathway
Phase 1
Ribosome synthesis
Phase 2
Hemoglobin accumulation
Phase 3
Ejection of nucleus
Hemocytoblast
Proerythroblast
Early
erythroblast
Late
erythroblast
Normoblast
Reticulocyte
Erythrocyte

- then the nucleus shrinks and the cell become normoblast.
- then the nucleus extruded, at the same time endoplasmic reticulum reabsorbed and the cell called reticulocyte.
- when the endoplasmic reticulum completely reabsorbed then the cell called mature erythrocyte.

For maturation of RBC need

-VITAMINEB12

-FOLIC ACID

FACTORS AFFECT ON ERYTHROPOISIS

❑-**TISSUE OXIGINATION**

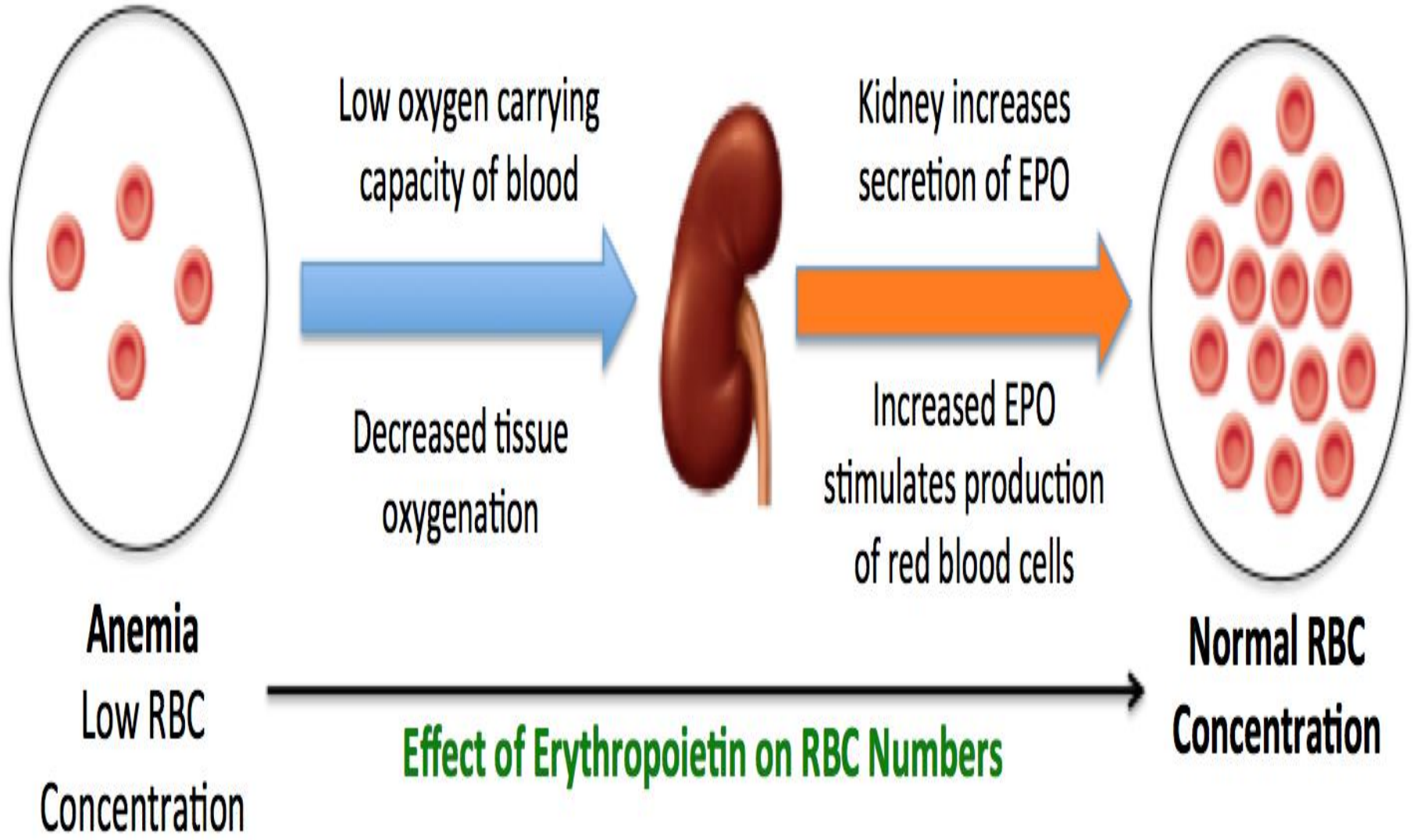
Decrease O2 (hypoxia) in the tissue due to

- **anemia**
- **High altitude**
- **Cardiac disease**
- **Lung disease**

→will stimulate production of

Erythropoietin which is

is glycoprotein produced by kidney, stimulate production of RBC from bone marrow.

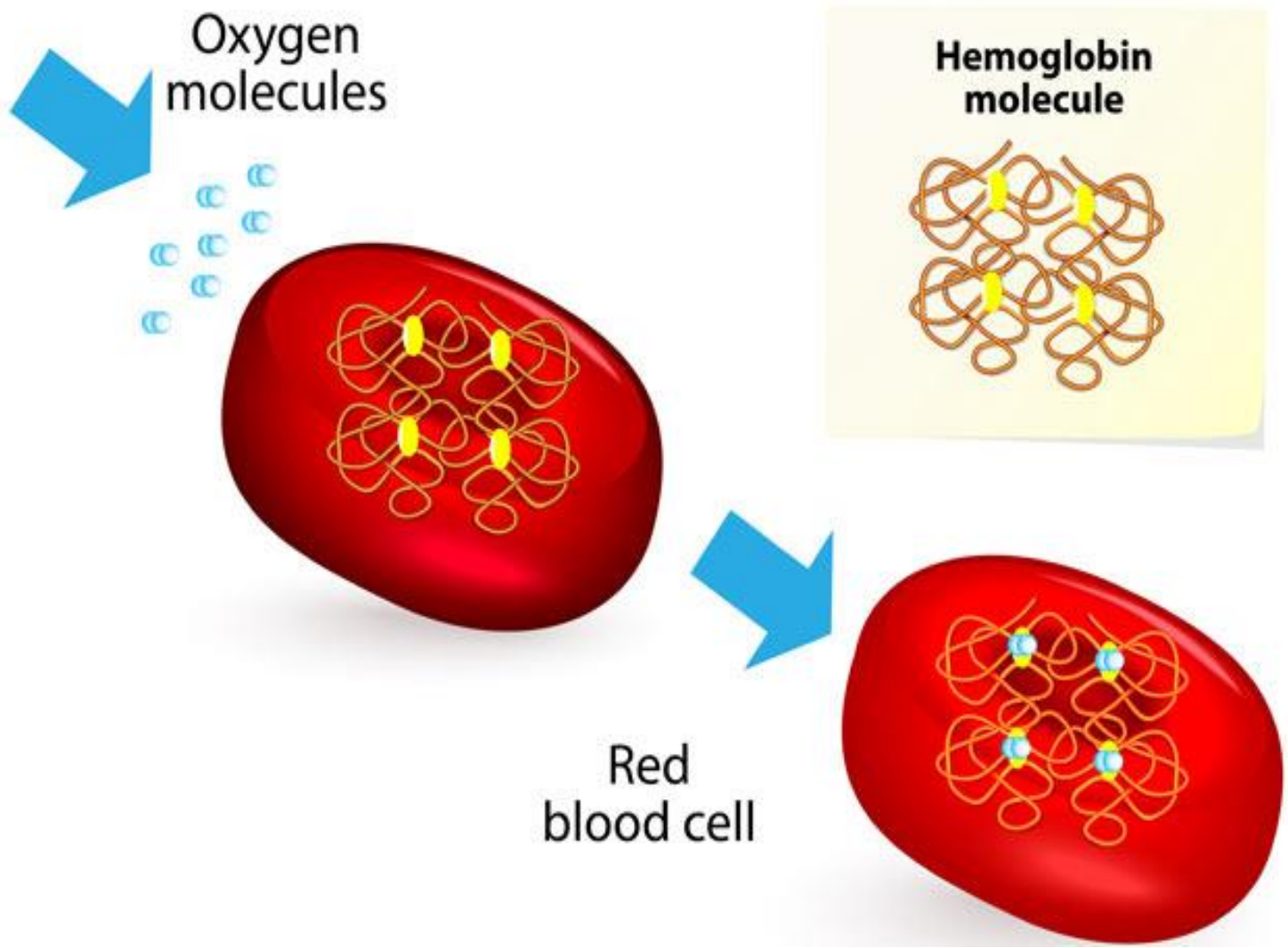

Low oxygen carrying capacity of blood
Decreased tissue oxygenation
Kidney increases secretion of EPO
Increased EPO stimulates production of red blood cells
Anemia
Low RBC Concentration
Normal RBC Concentration
Effect of Erythropoietin on RBC Numbers

Hemoglobin A (HbA)

- is pigment in R.B.C.
- its protein with molecular weights (64,458).
- the normal value of Hb is14-16gm/100mlBlood.
- synthesis OF Hb begins in the erythroblasts and continue through the normoblasts and reticulocytes stage.
- Heme protein of Hb is synthesized

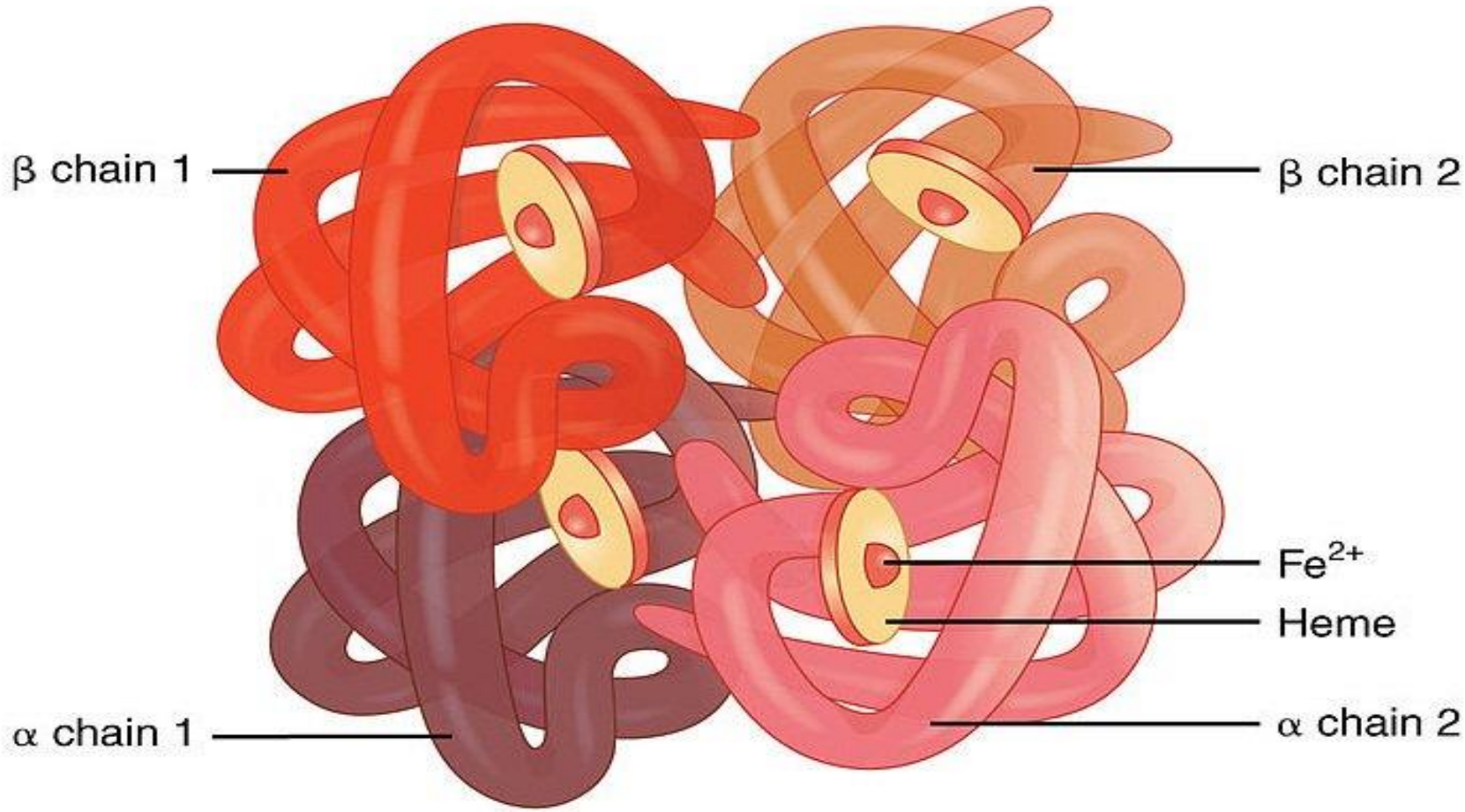
- Mainly from acetic acid and glycine and that→ most of this synthesis occur in mitochondria

HUMAN HEMOGLOBIN



Steps For Formation Hemoglobin

1. 2 succinyl-coA+2 glycine →pyrrole
2. 4 pyrrole → protoporphyrin 1X
3. protoporphrin 1X+fe → Heme
4. heme+polypeptide (globin)→ hemoglobin chain alfa α or beta β.
5. 2 alfa α +2 beta βchains → Hemoglobin A molecule.



(a)

- **HbA consist of 4 proteins chain called globins.**
- **2 of these α chains ,are 141 amino acids longs,**
- **and other 2 ,the βchains are 146 aminoacid long.**
- **Each chain is conjugated with a non protein moiety called heme group .**
- **Each heme can carry one molecule of O2**

- **The Hb molecule contain 4 iron atoms that bind 4 oxygen molecules or 8 oxygen atom as a whole can transport up to 4 O2.**
- **About 20%of carbon dioxide in blood stream is also transported by Hb.**

- -About 2.5% of Hb is in form of HbA2,which has 2delta chains (δ) in place of the beta chains.
- the fetus produce a form called fetal Hb which has 2 gamma chains in the place of the beta chains.

- **HbA :- 2Alpha, 2 Beta chains**
- **HbA2:- 2 Alpha,2 Delta chains**
- **Hbf :- 2 Alph,2 Gama chains**

- Fetal Hb has higher oxygen binding capacity than adult HbA and enables the fetus to extract oxygen from the mothers blood stream .
- The delta and gamma chains are the same length as the beta chains but differs in amino acid sequence .
- HbF is converted into Hb A, but is some cases is not converted .

Iron metabolism

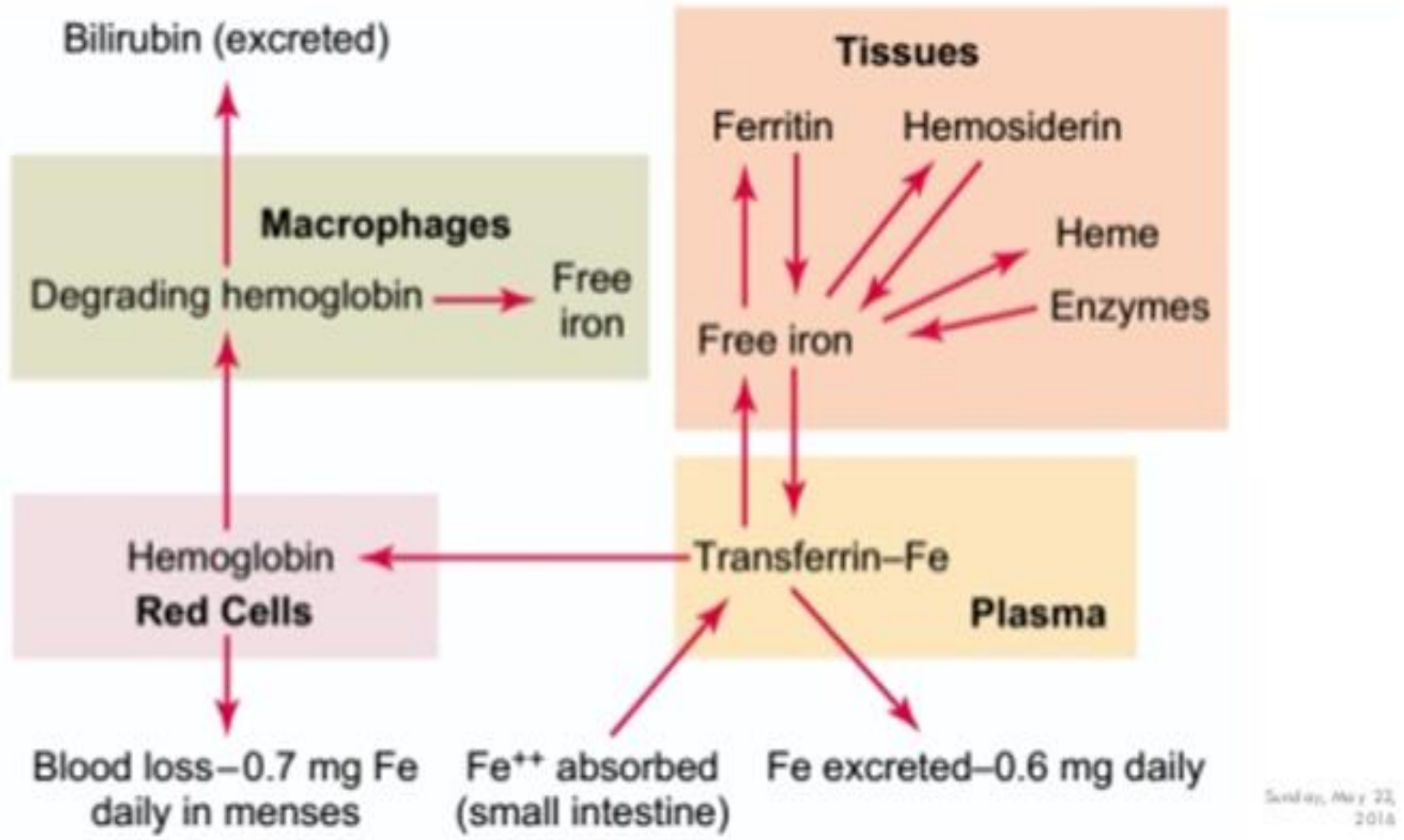
- -Iron is important for formation of
- **- Hb**
- **- myoglobin**
- **- cytochromes oxidase ,peroxides and catalase.**
- -The total quantity of iron in the body average 4-5 grams.
- about 65% of which is in the form of Hb.
- About 4% is in the form of myoglobin
- 1% is in the form of various heme compounds that promote intracellular oxidation.

- **0.1**% is combined with the protein transferrin in blood plasma.
- **15-30%** is stored mainly in the reticuloendothelial system and liver parenchymal cells ,principally in form of **ferritin**.

- A man excretes about **1mg of iron** each day ,mainly into **feces**.

- When iron is absorbed from the small intestine →combines in the blood plasma with beta globulin (apotransferrin) to form→ **transferrin** ,which is then transported in the plasma.

Iron transport



- .Excess iron in the blood is deposited in all cells of the body but especially in liver hepatocytes .in the cell cytoplasm ,it combines mainly with a protein, apoferritin to form →**ferritin.**

- The iron stored as ferritin is called **storage iron** .

- smaller quantities of the iron in the storage pool are stored in an insoluble form called **hemosiderin** .

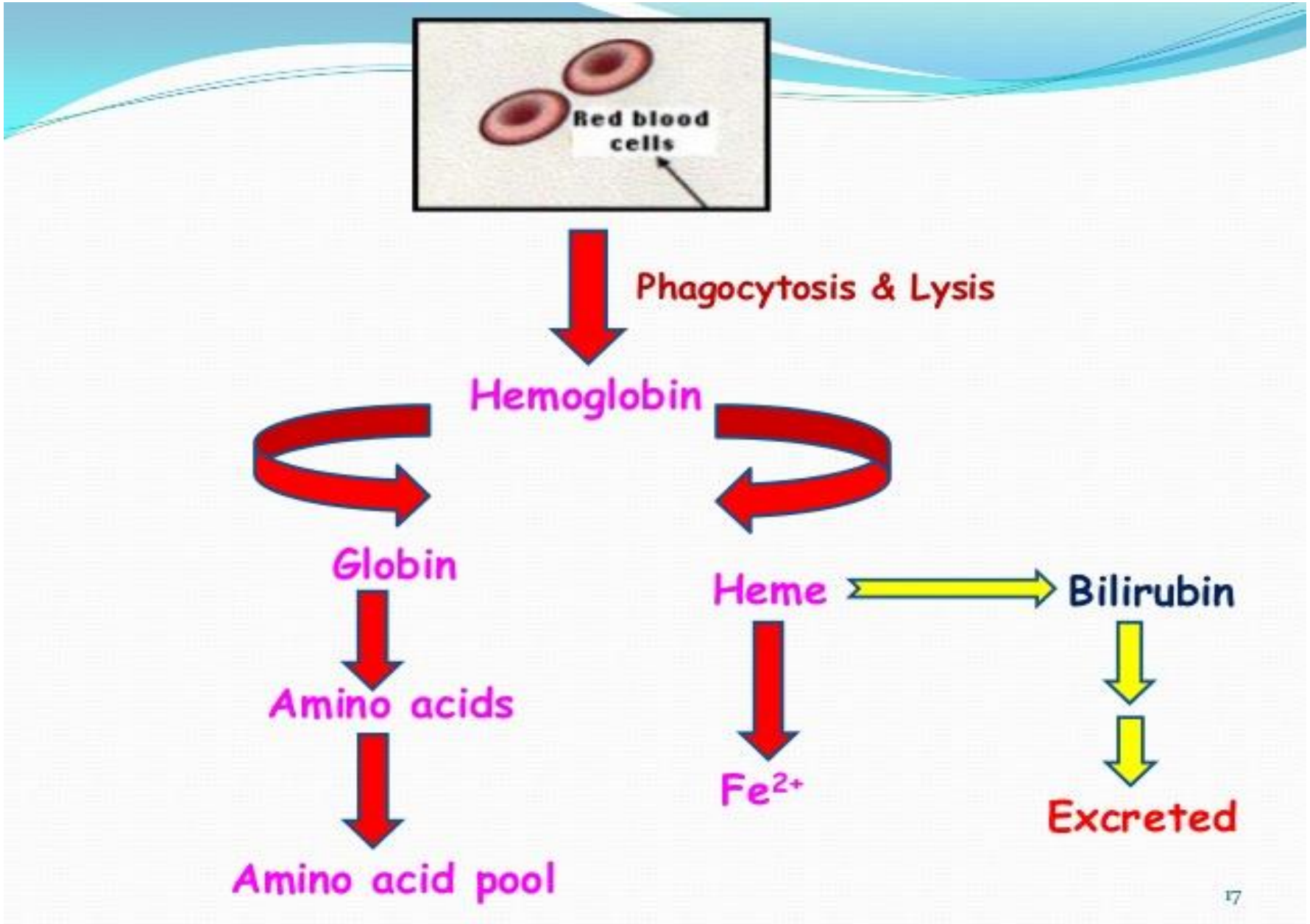
- when the quantity of iron in plasma falls very low,
- iron is removed from ferritin quite easily ,but much less easily from hemosiderin.
- when red blood cells have lived their life span 120 days and are destroyed the Hb released from the cells is ingested by the cells of the monocytes macrophage system .
- there free iron is liberate, and it is mainly stored in the ferritin pool for formation of new Hb.

Destruction of Hb

The Hb released from the cells when they burst is phagocytized almost immediately by macrophages in many parts of the body ,but especially in liver (kupffer cells) ,spleen and bone marrow .

- During the next few hours to days ,the macrophages release the iron from the Hb back into the blood to be carried by transferrin either to bone marrow for production of new RBC or to the liver and other tissues for storage in the form of ferritin

- **the porphyrin portion of the Hb molecule is converted by the macrophages ,through series of stages ,into bile pigment bilirubin ,which released into the blood and later secreted by the liver into the bile .**


Red blood cells
Phagocytosis & Lysis
Hemoglobin
Globin
Amino acids
Amino acid pool
Heme
Fe2+
Bilirubin
Excreted

Hb compounds

1-oxyhemoglobin :-this results from combination of O2 with Hb

Hb+O2----HbO2

2-Carboxy Hb this results from union of Co gas with Hb ,CO gas is avery poisonous gas even if it present in very small amounts it displaces O2 in OxyHb so that carboxy Hb is produced

3-Sulfa Hb this compound results from the combination of Hb with sulpher compounds.

4-Carbamino Hb

this results from the combination of Hb with CO2 gas with Hb.

5-methemoglobin if Hb subjected to O2 in presence of an oxidizing agent, oxidation of $fe^{+2} \rightarrow fe^{+3}$ occurs and a new compound is produced is called Met Hb , which is cannot carry 02

Polycythemia

mean the-increase red blood cell counts.

ITS 2 types:-

1-physiological polycythemia(secondary)

2 –pathological polycythemia(vera)

Physiological polycythemia

- Whenever the tissue becomes hypoxic because of too little oxygen in the atmosphere ,such as at high altitude.

- or failure of delivery of oxygen to tissue in cardiac failure and respiratory failure this stimulate production of large quantities of RBCS the RBC count reach 6-7 millions.

PATHOLOGICAL POLYCYTHEMIA

due to pathological problem like cancer ,this stimulate production of great numbers of RBCs

7-8millions /mm3.

and hematocrit 60-70%.

Effect of polycythemia on circulatory system.

- -Increased blood volume
- -Decrease rate of venous return to heart
- -Sluggish blood flow through blood vessels
- -Increase circulation time
- -Increase deoxygenated blood