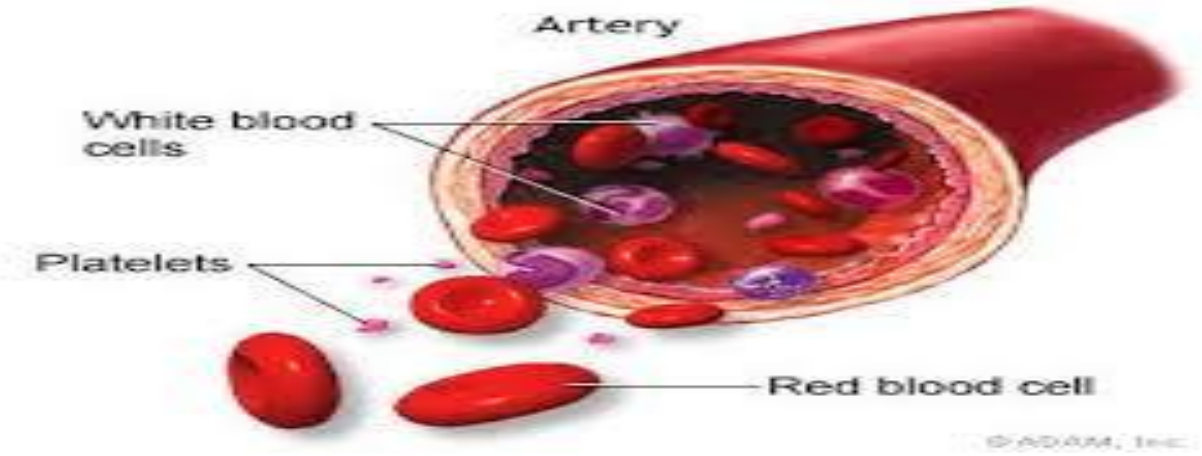
BLOOD



***Hematology*: is the science which deals with the study of the blood.**

Blood

INTRODUCTION

Blood is a connective tissue in fluid form. It is considered as the **'fluid of life'** because it carries oxygen from lungs to all parts of the body and carbon dioxide from all parts of the body to the lungs. It is known as **'fluid of growth'** because it carries nutritive substances from the digestive system and hormones from endocrine gland to all the tissues. The blood is also called the **'fluid of health'** because it protects the body against the diseases and gets rid of the waste products and unwanted substances by transporting them to the excretory organs like kidneys.

COMPOSITION OF BLOOD

Blood contains the blood cells which are called formed elements and the liquid portion known as plasma.

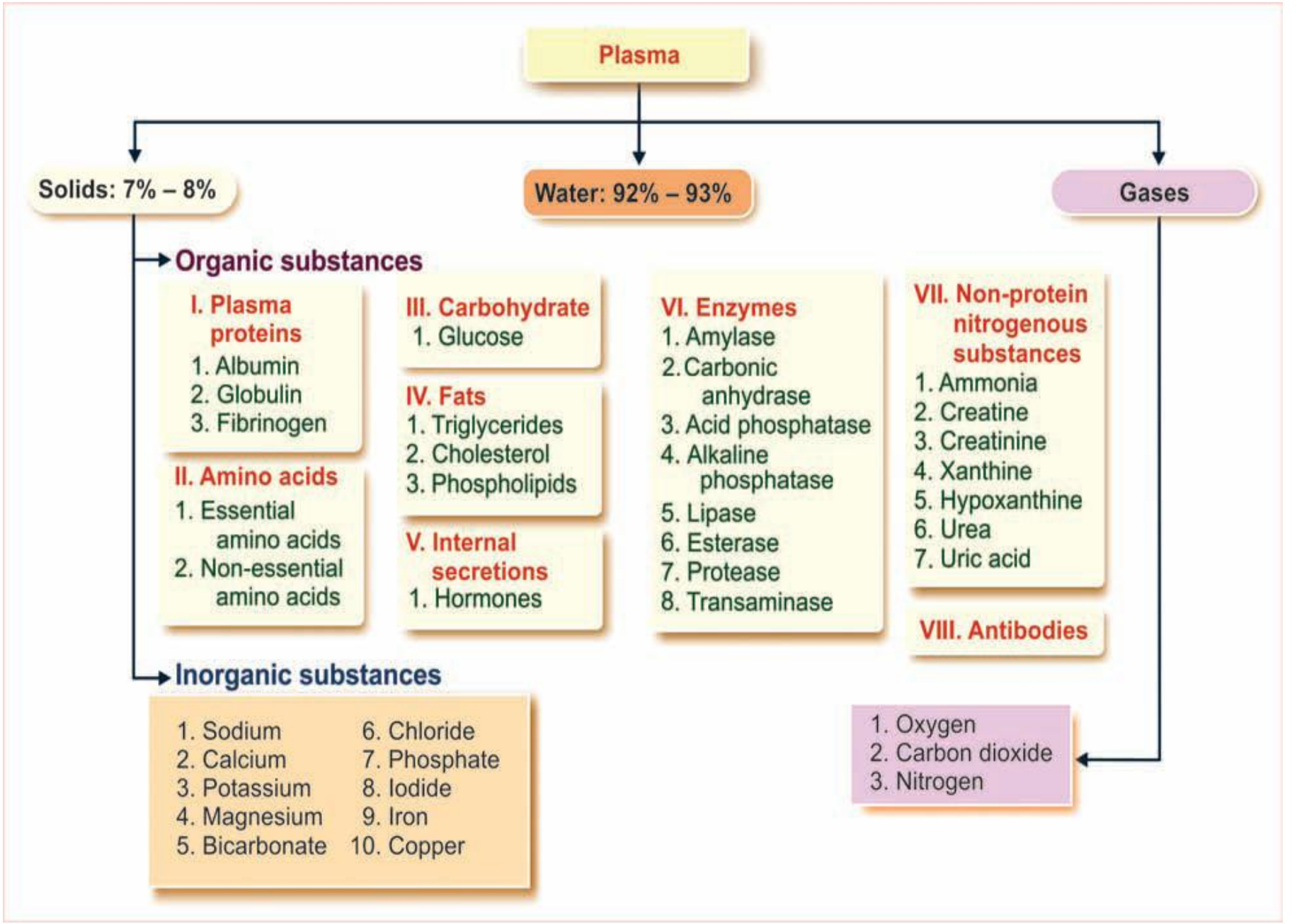
BLOOD CELLS

Three types of cells are present in the blood:

1. Red blood cells or erythrocytes
2. White blood cells or leukocytes
3. Platelets or thrombocytes.

Normal values of some important substances in blood

Glucose 100 to 120 mg/dL
Creatinine 0.5 to 1.5 mg/dL
Cholesterol Up to 200 mg/dL
Plasma proteins 6.4 to 8.3 g/dL
Bilirubin 0.5 to 1.5 mg/dL
Iron 50 to 150 µg/dL
Copper 100 to 200 mg/dL
Calcium 9 to 11 mg/dL
4.5 to 5.5 mEq/L
Sodium 135 to 145 mEq/L
Potassium 3.5 to 5.0 mEq/L
Magnesium 1.5 to 2.0 mEq/L
Chloride 100 to 110 mEq/L
Bicarbonate 22 to 26 mEq/L


Plasma
Solids: 7% – 8%
Water: 92% – 93%
Gases
Organic substances
I. Plasma proteins
1. Albumin
2. Globulin
3. Fibrinogen
II. Amino acids
1. Essential amino acids
2. Non-essential amino acids
III. Carbohydrate
1. Glucose
IV. Fats
1. Triglycerides
2. Cholesterol
3. Phospholipids
V. Internal secretions
1. Hormones
VI. Enzymes
1. Amylase
2. Carbonic anhydrase
3. Acid phosphatase
4. Alkaline phosphatase
5. Lipase
6. Esterase
7. Protease
8. Transaminase
VII. Non-protein nitrogenous substances
1. Ammonia
2. Creatine
3. Creatinine
4. Xanthine
5. Hypoxanthine
6. Urea
7. Uric acid
VIII. Antibodies
Inorganic substances
1. Sodium
2. Calcium
3. Potassium
4. Magnesium
5. Bicarbonate
6. Chloride
7. Phosphate
8. Iodide
9. Iron
10. Copper
1. Oxygen
2. Carbon dioxide
3. Nitrogen

PLASMA

Plasma is a straw-colored clear liquid part of blood. It contains 91% to 92% of water and 8% to 9% of solids. The solids are the organic and the inorganic substances.

SERUM

Serum is the clear straw-colored fluid that oozes from blood clot. When the blood is shed or collected in a container, it clots. In this process, the fibrinogen is converted into fibrin and the blood cells are trapped in this fibrin forming the blood clot. After about 45 minutes, serum oozes out of the blood clot.

For clinical investigations, serum is separated from blood cells and clotting elements by centrifuging. Volume of the serum is almost the same as that of plasma (55%). It is different from plasma only by the absence of fibrinogen, i.e. serum contains all the other constituents of plasma except fibrinogen. Fibrinogen is absent in serum because it is converted into fibrin during blood clotting. Thus,

Serum = Plasma – Fibrinogen

Blood performs three major functions:

- transport through the body of
  - oxygen and carbon dioxide
  - food molecules (glucose, lipids, amino acids)
  - ions (e.g., Na^+, Ca^{2+}, HCO_3^-)
  - wastes (e.g., urea)
  - hormones
- defense of the body against infections and other foreign materials. All the WBCs participate in these defenses.
- Homeostatic functions

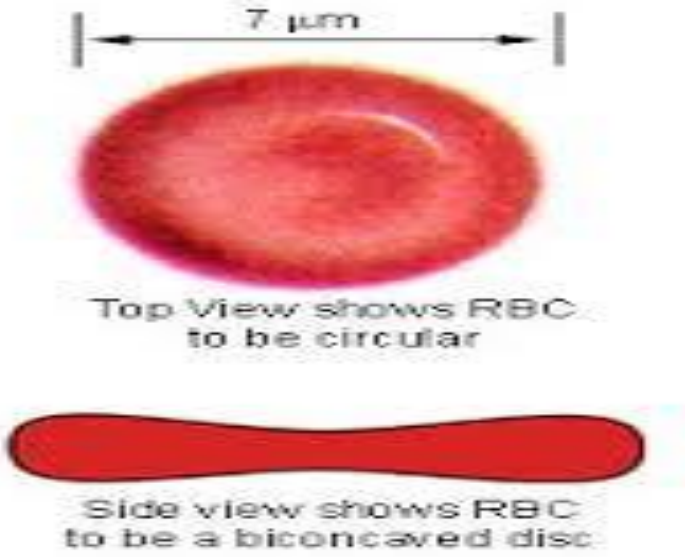
  - heat
  - water- salt balance
  - Acid – base balance

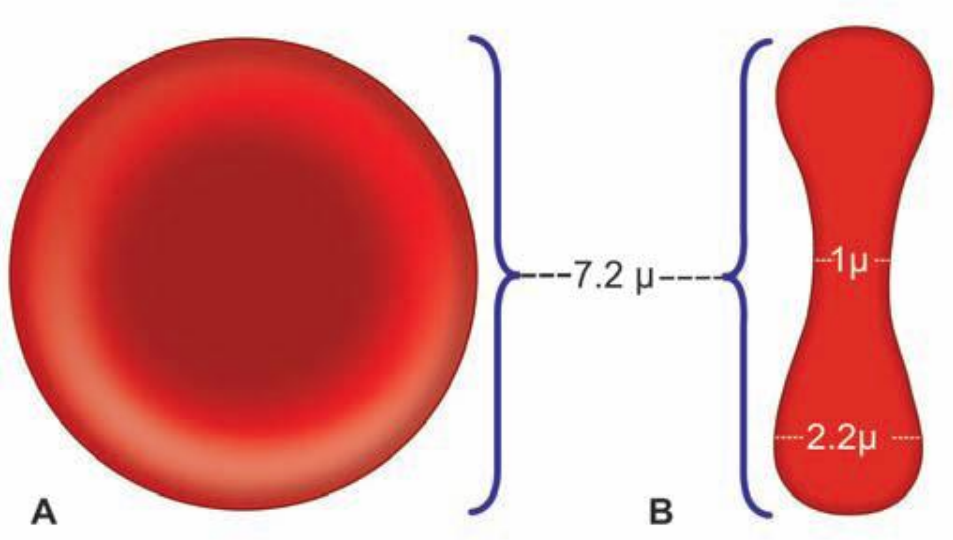
Formed Elements

- Red blood cells (erythrocytes)
- White blood cells (leukocytes)
  - Granulocytes
    - Neutrophils
    - Eosinophils
    - Basophils
  - Agranulocytes
    - Lymphocytes
    - Monocytes
- Platelets (thrombocytes)

Introduction

- Red blood cells (RBC) constitute 99 % of blood cells
- They are the smallest cells in the mammalian body
- They function in the transportation of oxygen to cells and tissues and carbon dioxide from cells and tissues to the lungs for exchange with O2





A. Surface view.

B. Sectioned view.

General feature of RBC:

a.Shape :

-man and dog is biconcave

-cat and horse less concave.

-in ruminant its circular.

-in camel its elliptical.

-in avian its oval with nucleus.

b. Nucleus: In all animals the RBC does not contain nucleus except the avian and reptiles.

c.diameter: about 4-8 micron.

d.color: red because of hemoglobin pigment.

e. number : is about 4.5-5.5 million/ml its varies according to:

1. sex 2. Age .3.nutrition 4.Tempreature. 5.high altitude .

f. life span:100-120 day.

g. fate:its exhausted and destroy in spleen.

h. origin: the RBC originate mainly from red bone marrow but also from liver and spleen.

Erythropoiesis

Definition

Erythropoiesis is the process of the origin, development and maturation of erythrocytes.

formation of RBC in certain tissue called hemopoeitic tissues or reticuloendothelial tissues or erythropoietic tissues.

(bone marrow, liver, spleen and lymph nodes), with growing up the bone marrow is the main organ.

STAGES OF ERYTHROPOIESIS

1. Proerythroblast
2. Early normoblast
3. Intermediate normoblast.
4. Late normoblast
5. Reticulocyte
6. Matured erythrocyte.

Important events during erythropoiesis

Proerythroblast → Synthesis of hemoglobin starts.

Early normoblast → Nucleoli disappear.

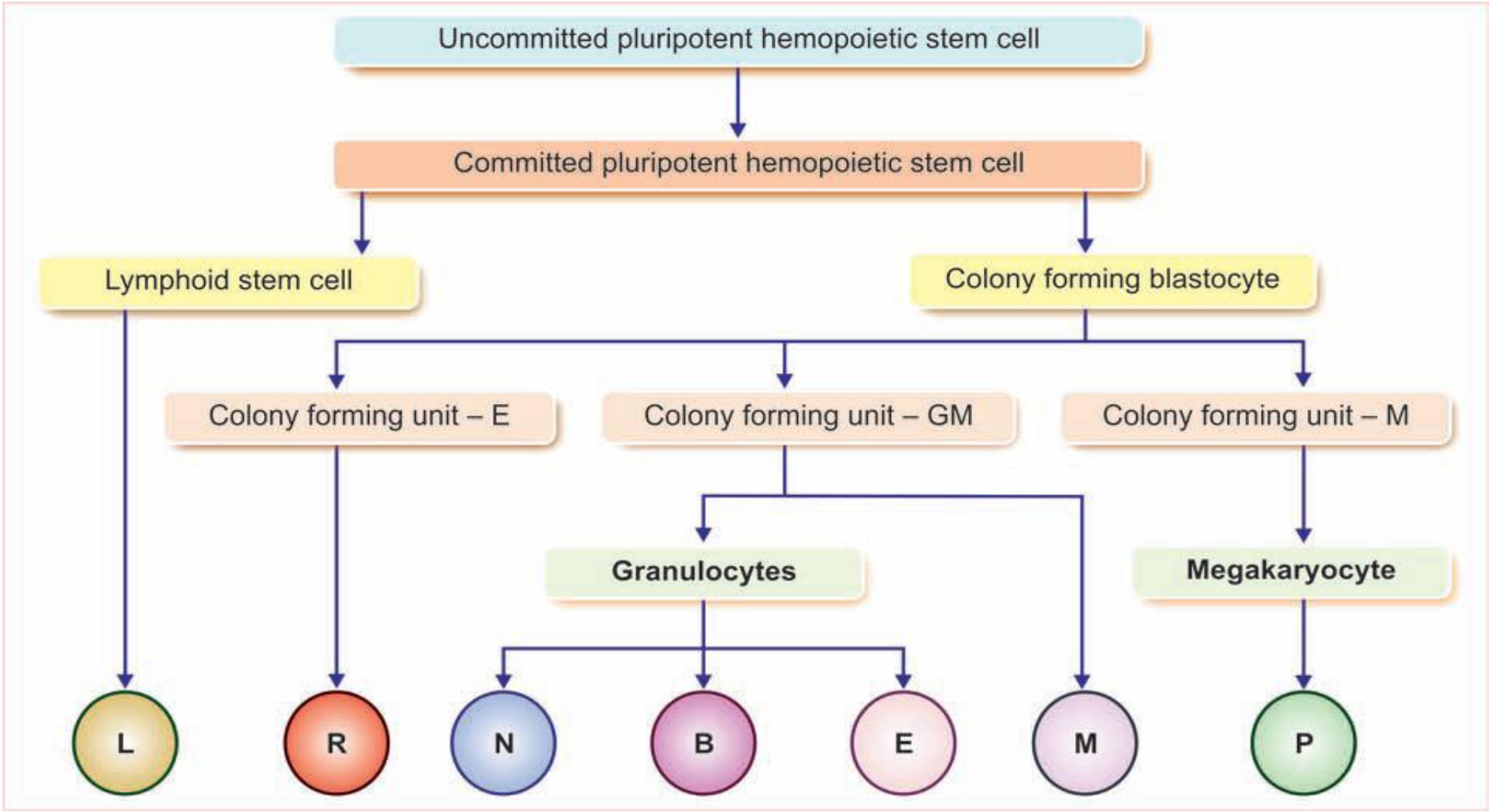
Intermediate normoblast → Hemoglobin starts appearing

Late normoblast → Nucleus disappears

Reticulocyte → Reticulum is formed,cell enters capillary from site of production

Matured RBC → Reticulum disappears ,cell attains biconcavity

PROCESS OF ERYTHROPOIESIS

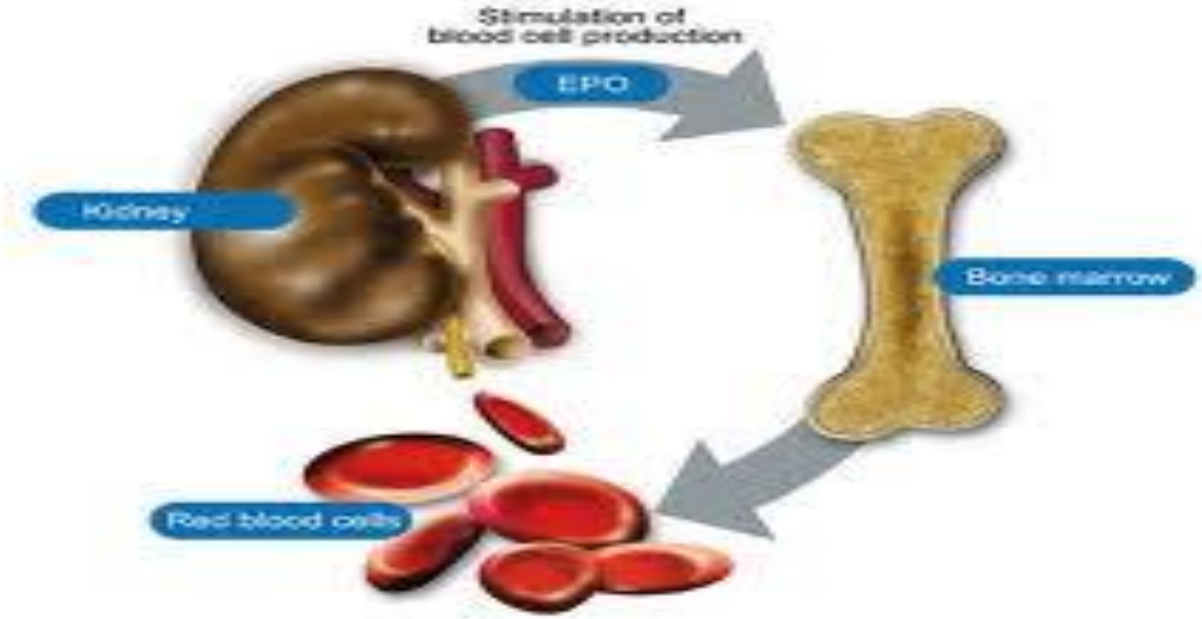


Stem cells. L = Lymphocyte, R = Red blood cell, N = Neutrophil, B = Basophil, E = Eosinophil, M = Monocyte, P = Platelet.

Control of erythropoiesis:

The control of erythropoiesis under the glycoprotein hormone (erythropoietin)synthesized by a special cell in the kidney and release to the blood and reach to the bone marrow to stimulate the formation of megaloblast and erythroblast.

This hormone also increase the Hb synthesis within the RBC after 15 minute.



Production of this hormone and the release is increased by

-hypoxia

-sever exercise

-living in high altitudes.

Hemoglobin (Hb) is the iron containing coloring matter of red blood cell (RBC).
It is a chromoprotein forming 95% of dry weight of RBC and 30% to 34% of wet weight.
Function of hemoglobin is to carry the respiratory gases, oxygen and carbon dioxide. It also acts as a buffer.
Molecular weight of hemoglobin is 68,000.

NORMAL HEMOGLOBIN CONTENT

Average hemoglobin (Hb) content in blood is 14 to 16 g/dL. However, the value varies depending upon the age and sex of the individual.

Age

At birth : 25 g/dL
After 3rd month : 20 g/dL
After 1 year : 17 g/dL
From puberty onwards : 14 to 16 g/dL

At the time of birth, hemoglobin content is very high because of increased number of RBCs .

Sex

In adult males : 15 g/dL
In adult females : 14.5 g/dL

STRUCTURE OF HEMOGLOBIN

Hemoglobin is a conjugated protein. It consists of a protein combined with an iron-containing pigment. The protein part is globin and the iron-containing Pigment is **heme.** Heme also forms a part of the structure of **myoglobin** (oxygen-binding pigment in muscles) and **neuroglobin** (oxygen-binding pigment in brain).

Hemoglobin (Hb):

Properties of Hb:

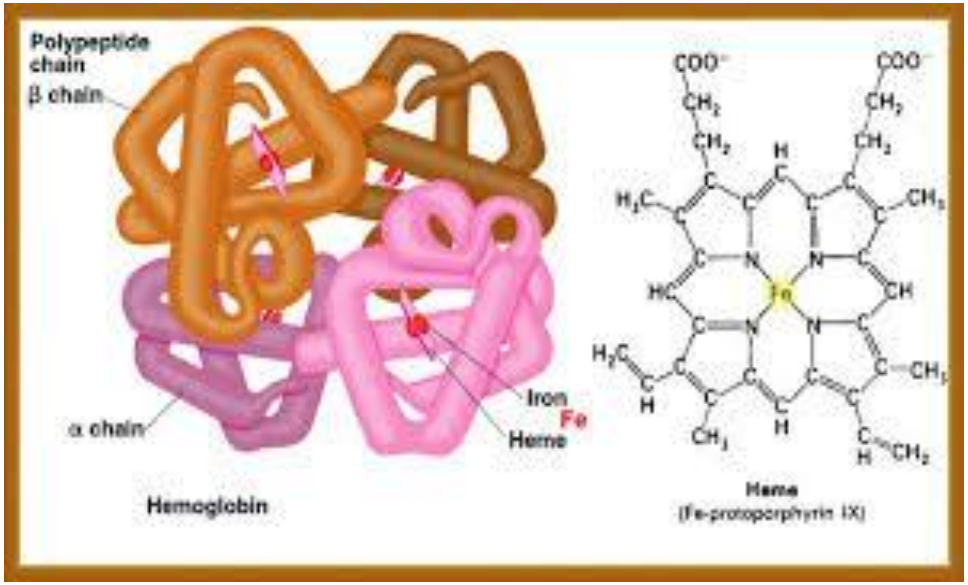
1.It gives the red color of RBC and contain the iron.

2.It is complex contain iron and conjugated protein (globin).

Consist of two portion:

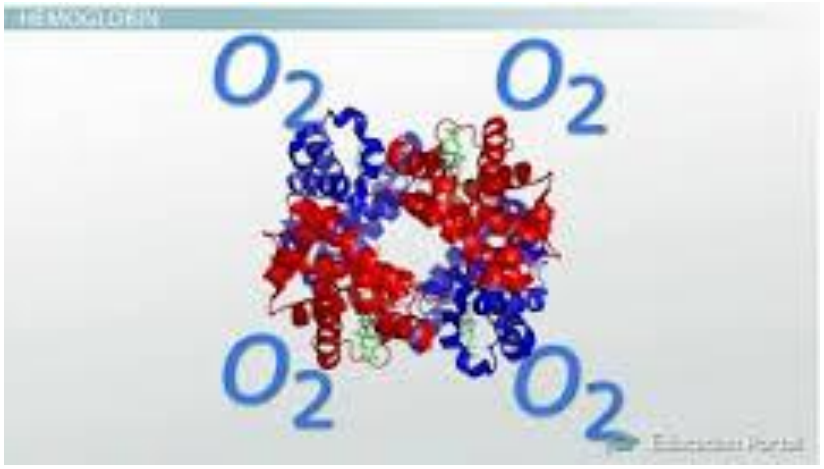
Haem: is the part contain iron.

Globin:is the part contain protein.



3.the normal amount of Hb in human being about 12-16 gram/dl (decileter=100ml)blood.
-in dog is about 12-14gm/100ml of blood.
-in sheep is about(10-12)gm/100ml of blood.
-in cattle is about(11-13)gm/100ml of blood.
- in horse is about (11-14)gm/100ml of blood.

4.the molecular weight of Hb is about 66000-69000 .



Hb synthesis:

The two part of Hb (haem and globin) are synthesis separately during the process of erythropoiesis:

1.haem synthesis: by condensation of glycin and succinyl co-A then combined with iron

Glycin+ succinyl co-A → pyrol

4Pyrol+Fe → Haem

Haem + globin → Hb

iron after its absorption from intestine it transport in plasma in combination with the special protein called transferrin.

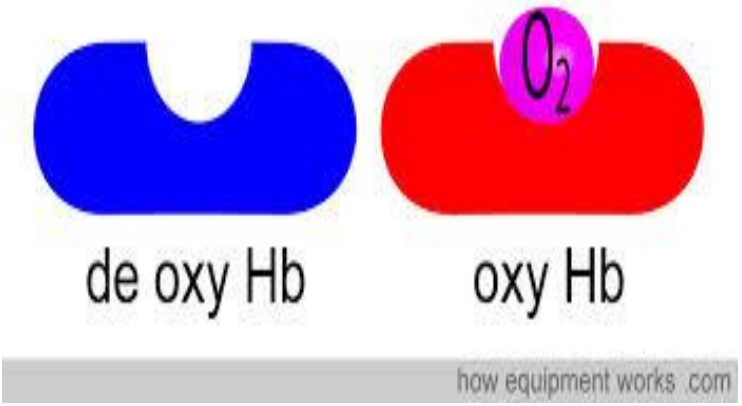
2. globin synthesis: it is synthesis inside the ribosome as any other protein.

Reaction of haemoglobin:

1.Hb bind O2 to form oxy-Hb the O2 attach to the iron Fe in Hb.

the affinity of Hb to O2 is affected by four factor : pH,temperature,co2and 2,3DPG.

Hb+O2 ⟶ oxy-Hb



2.Hb binds to CO2 to form carbamino Hb

Hb+co2 ⟶ carbamino Hb.

3.Hb bind to CO to form carboxy Hb.

Co is a toxic gas and its ability to bind with Hb is 200 times more than O2.

Hb+co → carboxy Hb.

4.Hb bind to some oxidizing agent (nitrate) to form met hemoglobin.

5.Hb is also apart of muscle structure and its called myoglobin which is an O2 pigment and give the red color.

6.Hb bind to H2S to form sulf –Hb.

H2S+Hb ⟶ sulf-Hb.

Catabolism of Hb:

1.old RBC are destroyed in reticuloendothelial system (RES)mainly spleen and release Hb.

2.opinening of prophyrin ring and elimination of iron which occur in RES mainly in liver form two parts

a.ferritin

b.hemosedrin.

3.the iron from these two compound are taking up by a special protein called transferrin as Fe+3 (ferric) to transport in blood and to inter a new Hb synthesis.

4.the globin portion of Hb molecule is split off to form a new Hb.

5.Haem converted to bilivridin form which is greenish in color and reduce to form bilirubin which is yellowish in color.

6. biliviridin and blirubin are excreted by bile.

*** biliviridin: most content of bile in herbivorus.**

***bilirubin form the most content of bile in carnivorous and aminovarus.**

TYPES OF NORMAL HEMOGLOBIN

Hemoglobin is of two types:

1. Adult hemoglobin – HbA
2. Fetal hemoglobin – HbF

Replacement of fetal hemoglobin by adult hemoglobin starts immediately after birth. It is completed at about 10 th to12th week after birth. Both the types of hemoglobin differ from each other structurally and functionally.

In new born animal Hb-A 50% and Hb-F 50%.

Structural Difference

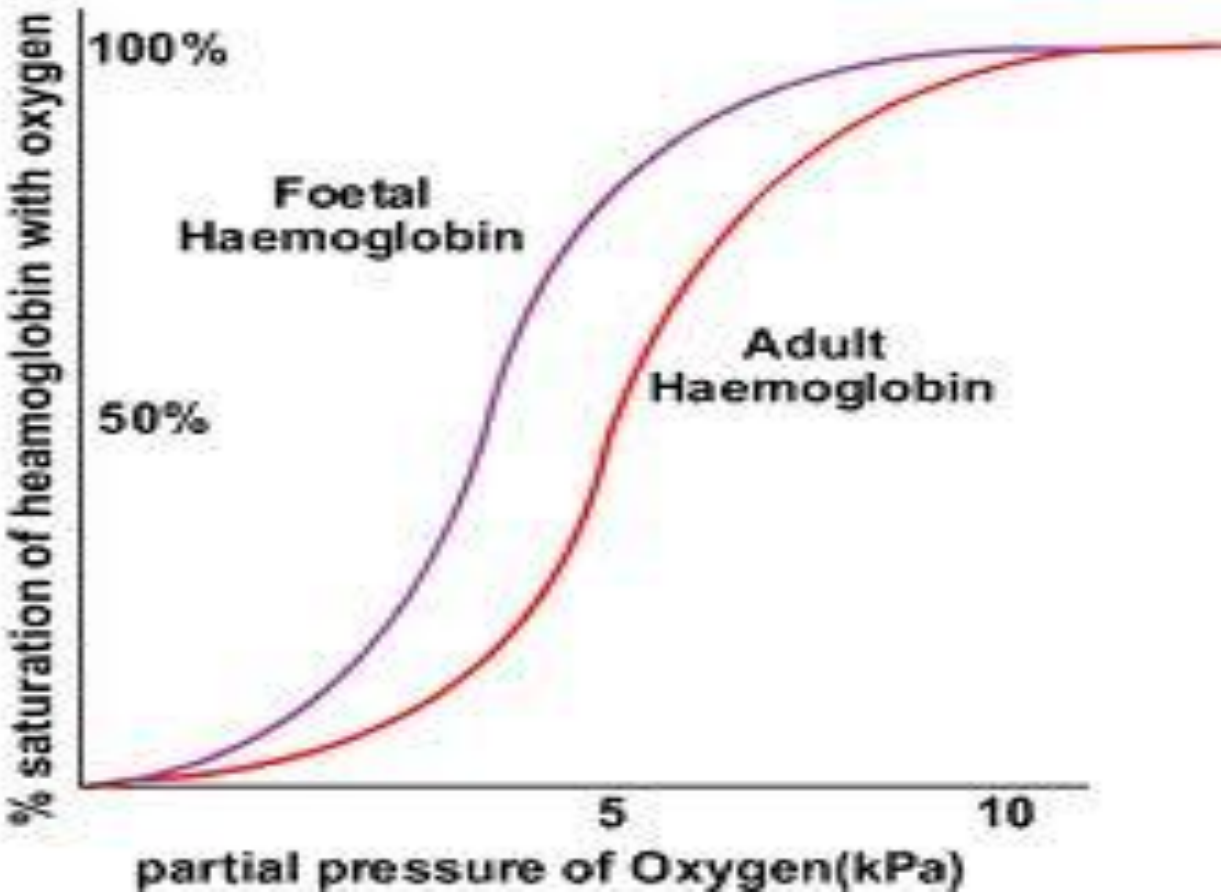
In adult hemoglobin, the globin contains two α-chains and two β-chains. In fetal hemoglobin, there are two α chains and two γ-chains instead of β-chains.

Functional Difference

Functionally, fetal hemoglobin has more affinity for oxygen than that of adult hemoglobin

as in animal growing up the % of Hb-F decrease and Hb-A increase.

The differences between Hb-F and Hb-A is mainly in there ability to carry the O2 the Hb-F has more ability than the Hb-A.


% saturation of heamoglobin with oxygen
100%
50%
Foetal Haemoglobin
Adult Haemoglobin
5
10
partial pressure of Oxygen(kPa)

White blood cell

1.number there are much less than RBC there are normally about 4000-11000 cell/ml the number vary in different animal from time to time according to nutritional state and health.

Leucopenia decrease WBC

Leukocytosis increase WBC

Leukemia increase WBC too much.

2.shape: WBC have no shape.
3.life span: are few hours about 5-7hr.
4.WBC are complete cell because they contain nucleus and all cellular organelles.

5.WBC are classified into 2 type:

a. granulocytes:

1.neutophiles 40-70% in human and non ruminant

25-35% in chicken and ruminant .

2.easinophiles (acidophiles) 2-5%

3.basophiles 0-1%

b. A granulocytes

(poly morphonucleus leukocytes):

1.monocytes 2-5%

2.lymphocytes40-45% in human and non ruminant

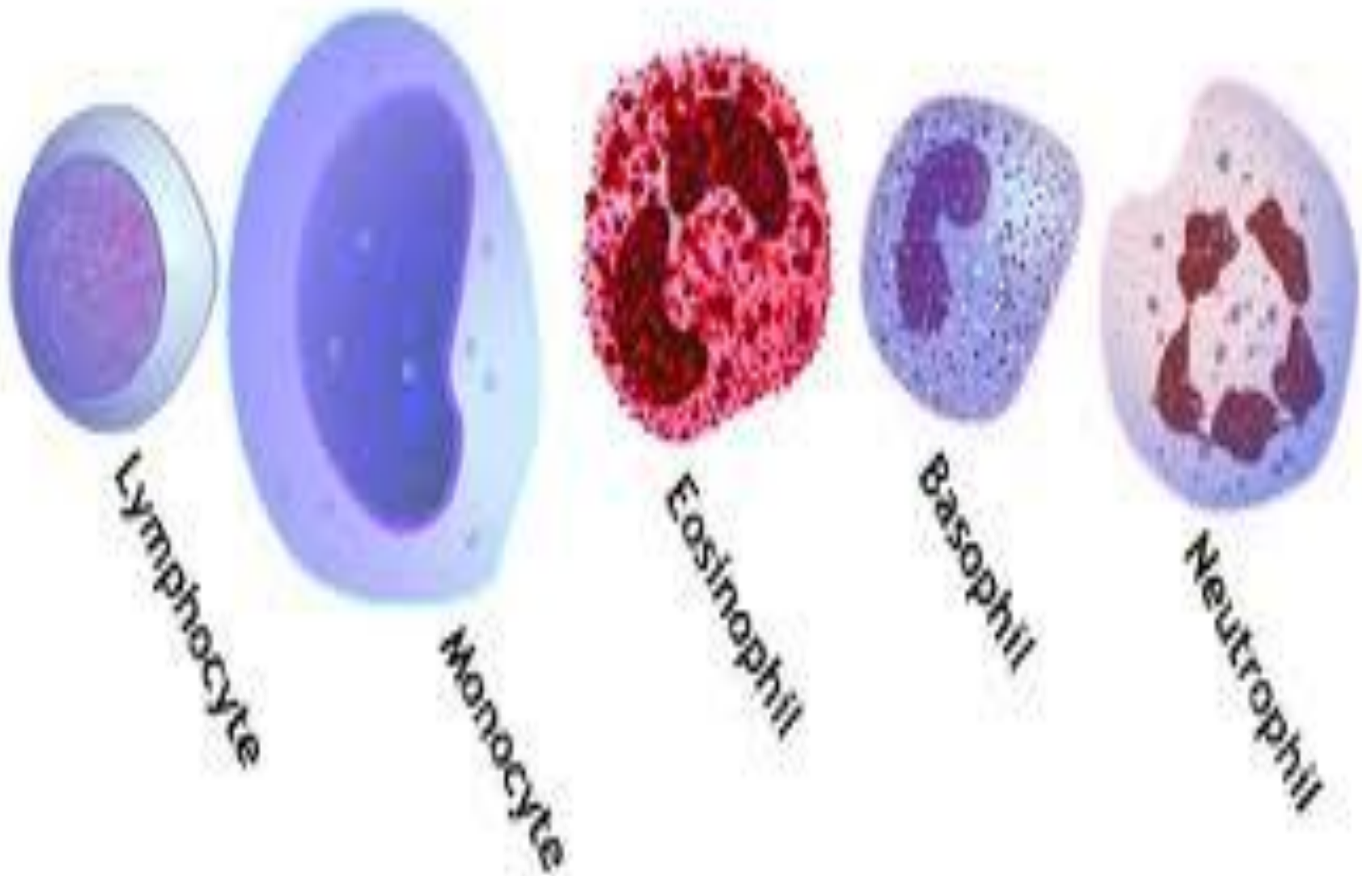
50-70%in ruminant.

-**The granules of granulocyte are cellular lysosomes.**

-all 3 types of granulocyte are originate from the hemopoitic tissue in bone marrow.

-monocyte ; originate from cells in the RES in spleen and bone marrow.

-lymphocytes: originate from RES tissue but its maturation in lymph node, thymus and bursa of febreisious(in chicken) .


Lymphocyte
Monocyte
Eosinophil
Basophil
Neutrophil

White blood cells

neutrophil eosinophil basophil monocyte lymphocyte

Control of WBC synthesis:

by colony stimulating factor CSF that released by WBC themselves.

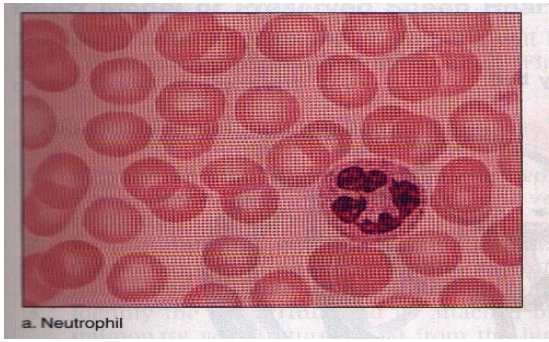
Granulocytes :

1.neutrophiles:

***nucleus: is lobulated about 1-5 lobes the number of lobes increase as the cell became older.**

***activity: it has amoeboid activity called phagocytosis.**

***age: the average life span is about 7 hours.**



*origin:

are synthesis in bone marrow take about 6-10 days,

a large number of them stored in bone marrow and

small number inter the circulation adhere to blood capillary wall all this called neutrophilic reserves.

Releasing:- **Its believed that bacteria produce agents that attract neutrphiles to infected area these agent called *chemotaxis.***

***migration:-** **of neutrophiles from blood vessels to site of infection is by diapedesis.**

***function:-** **in engulfing bacteria by phagocytosis it concerned as the first line of defense in the body .**

2. Basophiles: they found in normal blood about 0-1 %, its size is the same as neutrophils but it nucleus similar to the letter S and form two lobes.

Which secrete **histamine** and **heparin**:-

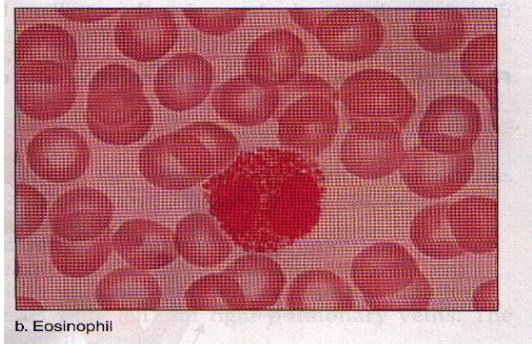
The **histamine** cause vasodilatation of blood vessels .

The **heparin** to prevent clotting of blood.

*number is increase in allergic and inflammation also in chronic disease and this called basophilia.

3.Acidophiles:or Eosionophiles:

There number about 2-5% of total WBC count. It synthesis in bone marrow .



b. Eosinophil

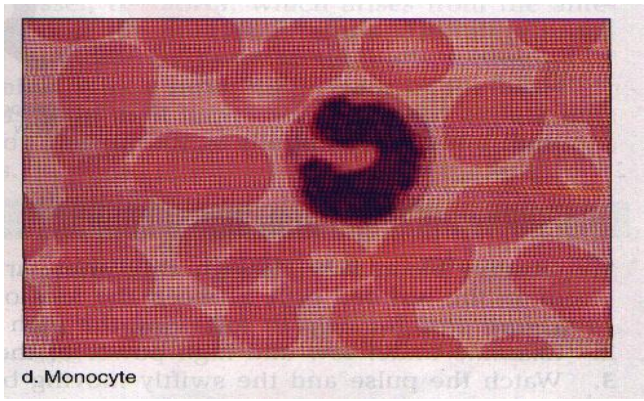
***The nucleus**

Has two lobes normally and cytoplasm contain large granules.Increase in parasitic disease, the increasing in number called acidophillia.

A granulocytes:

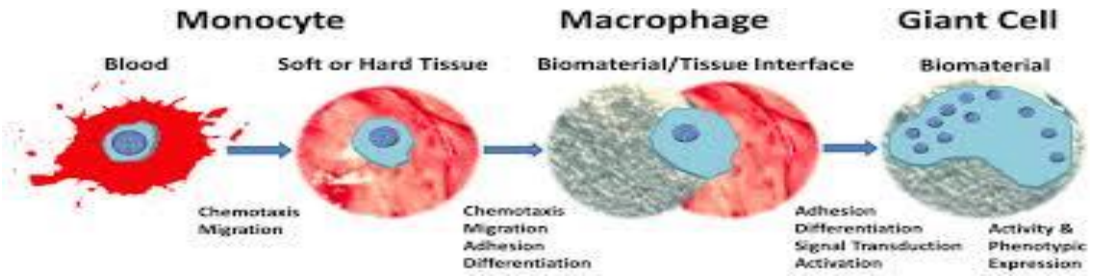
1.Monocyte:

about 2-5%, second line of defense in the body, increase in chronic disease.
***originated from bone marrow and inter circulation after 24 hr they leave the blood to tissue in order to settle there and became tissue macrophage.**
***they called kuffer cell in liver and alveolar cell in lung.**


d. Monocyte

* they are largest leukocyte or WBC in the body.

*3or more macrophage fused together to form (Giant cell) to engulf bacteria.



2. lymphocytes:

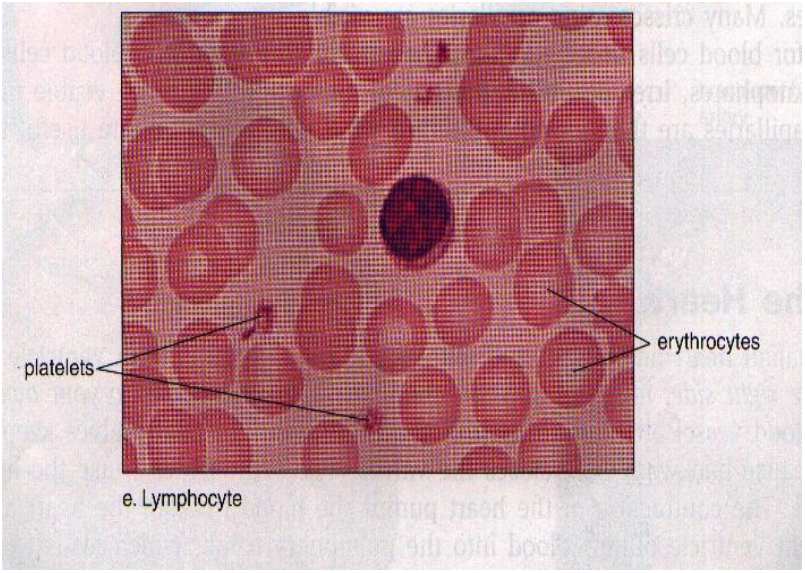
***number 40-45%**

two types:

B-lymphocyte and T-lymphocyte.

B-lymphocyte orginate from bone marrow but maturation in lymph node, liver, spleen in mammals and bursa of ferocious in chicken.

T-lymphocyte originate from bone marrow but maturation in thymus gland.



* the function is formation of antibodies
Hum oral immunity
Cellular immunity
*lymphocyte increase in viral disease , the increasing in number called lymphocytosis.