HUMAN ANATOMY AND PHYSIOLOGY-I

HAEMOPOIESIS

Haemopoiesis or hematopoiesis is the process of origin, development and maturation of all the blood cells.

- Erythropoiesis is the process of the origin, development and maturation of erythrocytes.
- Leucopoiesis is the process of the origin, development and maturation of leucocytes.
- Thrombopoiesis is the process of the origin, development and maturation of platelets.

Site of hemopoiesis:

In the first two months of gestation, the yolk sac is the main site of haem**o**poiesis

From third month of gestation,liver and spleen become the main site of blood formation

At birth haemopoiesis occurs in the bone marrow

In young children,active haemopoietic bone marrow is found in both axial skeleton and bones of extremities

In adults bone marrow is confined to axial skeleton and proximal ends of bones

SITE OF ERYTHROPOIESIS:

The red blood cells are derived from pluripotent stem cells

STAGES:

1.Pronormoblast:

It is the earliest recognizable cell of erythroid series seen in the red bone marrow

2.Early normoblast:

The pronormobalst progrsses into the early normoblast

Intermediate normoblast:

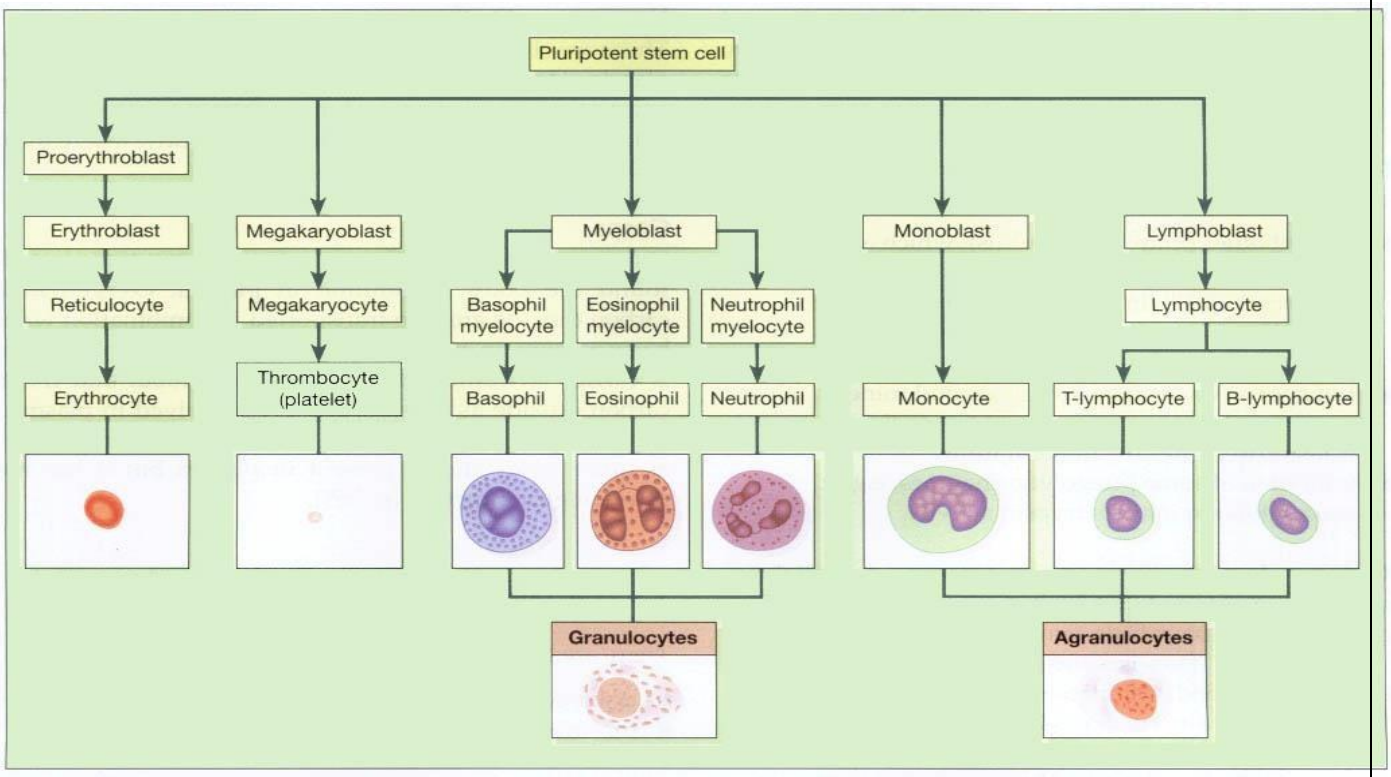
It is the next maturation stage in erythroid series.haemoglobin appears in this stage

3.Late normoblast:

It is the last nucleated cell of erythroid series

4.Reticulocyte:

It is the last stage in formation of erythrocytes and it is called as young red cells



HAEMOGLOBIN:

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** (oxygenbinding pigment in muscles) and **neuroglobin** (oxygenbinding pigment in brain).

„ IRON

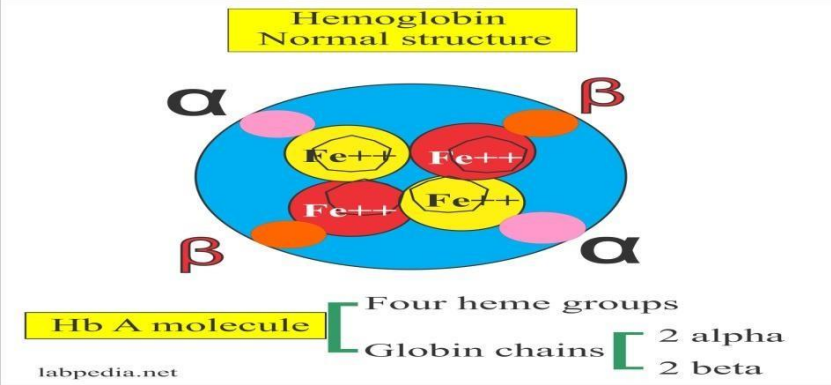
Normally, it is present in ferrous (Fe2+) form. It is in unstable or loose form. In some abnormal conditions, the iron is converted into ferric (Fe3+) state, which is a stable form.

„ PORPHYRIN

The pigment part of heme is called porphyrin. It is formed by four pyrrole rings (tetrapyrrole) called, I, II, III and IV. The **pyrrole rings** are attached to one another by methane (CH4) bridges. The iron is attached to ‘N’ of each pyrrole ring and ‘N’ of globin molecule.

„ GLOBIN

Globin contains four polypeptide chains. Among the four polypeptide chains, two are chains and two are α-chains



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

FUNCTIONS OF HEMOGLOBIN

„ TRANSPORT OF RESPIRATORY GASES

Main function of hemoglobin is the transport of respiratory gases:

1. Oxygen from the lungs to tissues.
2. Carbon dioxide from tissues to lungs.

1. Transport of Oxygen

When oxygen binds with hemoglobin, a physical process called **oxygenation** occurs, resulting in the formation of oxyhemoglobin. The iron remains in ferrous state in this compound. Oxyhemoglobin is an unstable compound and the combination is reversible, i.e. when more oxygen is available, it combines with hemoglobin and whenever oxygen is required, hemoglobin can release oxygen readily . When oxygen is released from oxyhemoglobin, it is called reduced hemoglobin or ferrohemoglobin.

2. Transport of Carbon Dioxide: When carbon dioxide binds with hemoglobin, carbhemoglobin is formed. It is also an unstable compound

and the combination is reversible, i.e. the carbon dioxide can be released from this compound.

The affinity of hemoglobin for carbon dioxide is 20 times more than that for oxygen

SYNTHESIS OF HEMOGLOBIN

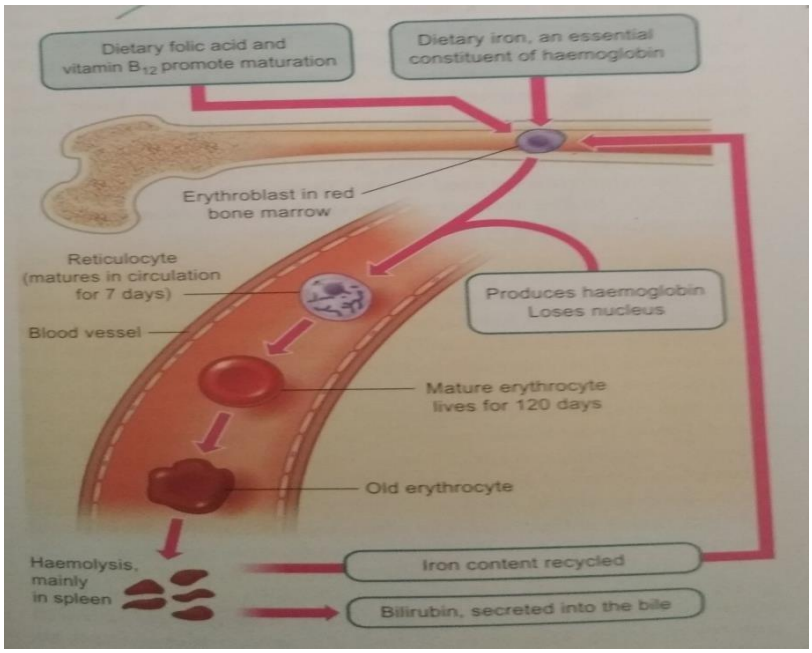
Synthesis of hemoglobin actually starts in proerythroblastic stage . However, hemoglobin appears

in the intermediate normoblastic stage only. Production of hemoglobin is continued until the stage of reticulocyte. Heme portion of hemoglobin is synthesized in mitochondria. And the protein part, globin is synthesized in ribosomes.

TYPES OF NORMAL HEMOGLOBIN

Hemoglobin is of two types:

1. Adult hemoglobin – HbA,HbA_2
2. Fetal hemoglobin – HbF



ANAEMIA:

Anemia is the blood disorder, characterized by the

reduction in:

1. Red blood cell (RBC) count
2. Hemoglobin content
3. Packed cell volume (PVC).

DEFINITION:

It is a not a single disease but a group of disorders in which heamoglobin concentration of blood is below the normal range for the age and sex of the subjects.

Anaemia:

Hb level is less than

Adult male:<13 gm/dl

Adult female:<11.5 gm/dl

New born:<15 gm/dl

3 month of age:<9.5 gm/dl

RBC level is less than 4million/mm^3

CLASSIFICATION

1.Deficiency anaemia:

Perinicious anaemia due to deficiency of vitamin B12 and folic acid (iron deficiency anaemia or megaloblastic anaemia)

Protein and vit c also cause anaemia

2.blood loss anaemia:

It occurs mainly during accidents a)acute post haemorrhagic b) chronic post haemorrhagic anaemia

3.haemolytic anaemia:

It is uncommon and occurs due to increase in destruction of RBC

4.Aplastic anaemia:

It occurs due to failure of bone marrow to produce anaemia

5.*Sickle cell anemia*

Sickle cell anemia is an inherited blood disorder, characterized by sickleshaped red blood cells. It is also called **hemoglobin SS disease** or **sickle cell disease.** It is common in people of African origin. Sickle cell anemia is due to the abnormal hemoglobin called hemoglobin S (sickle cell hemoglobin). In this, αchains are normal and βchains are abnormal. The molecules of hemoglobin S polymerize into long chains and precipitate inside the cells. Because of this, the RBCs attain sickle (crescent) shape and become more fragile leading to hemolysis . Sickle cell anemia occurs when a person inherits two abnormal genes (one from each parent). In children, hemolyzed sickle cells aggregate and block the blood vessels, leading to

infarction (stoppage of blood supply). The infarction is common in small bones. The infarctedsmall bones in hand and foot results in varying length in the digits. This condition is known as **hand and foot syndrome.** Jaundice also occurs in these children.

6.Thalassemia

Thalassemia is an inherited disorder, characterized by abnormal hemoglobin. It is also known as **Cooley's anemia** or **Mediterranean anemia.** It is more common in Thailand and to some extentin Mediterranean countries.

Thalassemia is of two types

i. α thalassemia

ii. β thalassemia.

α-Thalassemia

α-thalassemia occurs in fetal life or infancy. In this αchain are less, absent or abnormal. In adults, βchains are in excess and in children, γchains are in excess. This leads to defective erythropoiesis and hemolysis. The infants may be stillborn or may die immediately after birth.

β-Thalassemia

In βthalassemia, βchains are less in number, absent or abnormal with an excess of αchains. Theαchains precipitate causing defective erythropoiesis and hemolysis.

HUMAN ANATOMY AND PHYSIOLOGY - I

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.

Haematology-branch of science concerned with study of blood,blood forming tissues and disoreders associated with blood

PROPERTIES OF BLOOD

1. *Color:* Blood is red in color. Arterial blood is scarletred because it contains more oxygen and venous

blood is purple red because of more carbondioxie

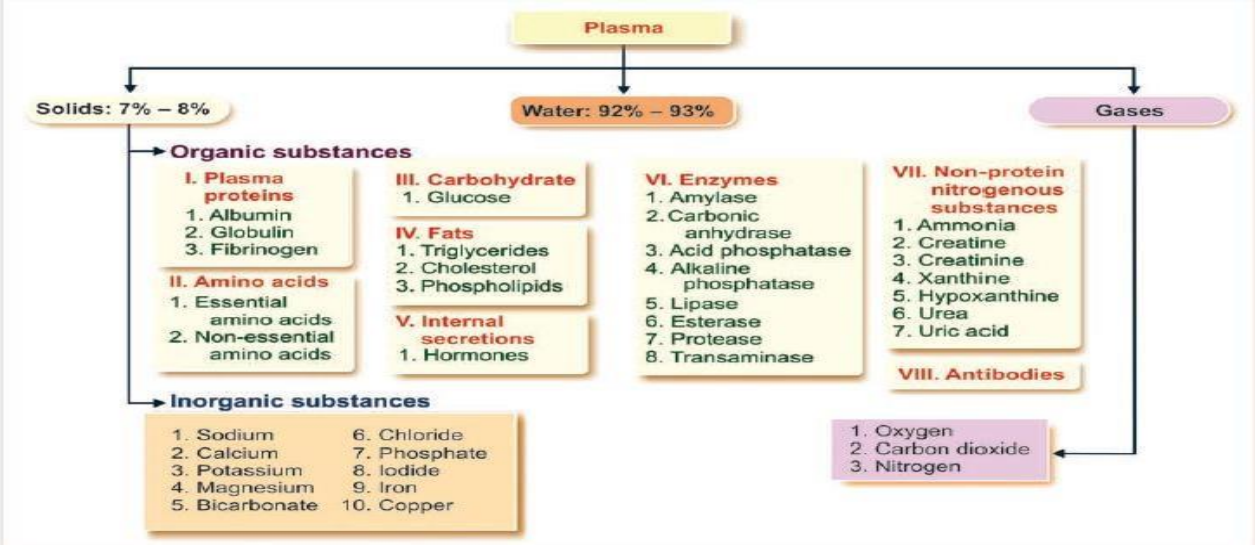
2. *Volume:* Average volume of blood in a normal adult is 5 L. In a newborn baby, the volume is 450 ml. It increases during growth and reaches 5 L at the time of puberty. In females, it is slightly less and is about 4.5 L. It is about 8% of the body weight in a normal young healthy adult, weighing about 70 kg.

3. *Reaction and pH:* Blood is slightly alkaline and its pH in normal conditions is 7.4.

4. *Viscosity:* Blood is five times more viscous than water. It is mainly due to red blood cells and plasma proteins

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.

FUNCTIONS OF BLOOD

„ 1. NUTRITIVE FUNCTION

Nutritive substances like glucose, amino acids, lipids and vitamins derived from digested food are absorbed from gastrointestinal tract and carried by blood to different parts of the body for growth and production of energy.

„

2. RESPIRATORY FUNCTION

Transport of respiratory gases is done by the blood. It carries oxygen from alveoli of lungs to different tissues and carbon dioxide from tissues to alveoli.

„ 3. EXCRETORY FUNCTION

Waste products formed in the tissues during various metabolic activities are removed by blood and carried to the excretory organs like kidney, skin, liver, etc. for excretion.

„ 4. TRANSPORT OF HORMONES AND ENZYMES

Hormones which are secreted by ductless (endocrine) glands are released directly into the blood. The blood transports these hormones to their target organs/tissues. Blood also transports enzymes.

„ 5. REGULATION OF WATER BALANCE

Water content of the blood is freely interchangeable with interstitial fluid. This helps in the regulation of water content of the body.

„ 6. REGULATION OF ACID-BASE BALANCE

Plasma proteins and hemoglobin act as buffers and help in the regulation of acid-base balance

„ 7. REGULATION OF BODY TEMPERATURE

Because of the high specific heat of blood, it is responsible for maintaining the thermoregulatory mechanism in the body, i.e. the balance between heat loss and heat gain in the body.

„ 8. STORAGE FUNCTION

Water and some important substances like proteins, glucose, sodium and potassium are constantly required by the tissues. Blood serves as a readymade source for these substances. And, these substances are taken from blood during the conditions like starvation, fluid loss, electrolyte loss, etc.

„ 9. DEFENSIVE FUNCTION

Blood plays an important role in the defense of the body. The white blood cells are responsible for this

function. Neutrophils and monocytes engulf the bacteria by phagocytosis. Lymphocytes are involved in

development of immunity. Eosinophils are responsible for detoxification, disintegration and removal of foreign proteins

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

Plasma proteins are:

1. Serum albumin
2. Serum globulin
3. Fibrinogen.

FUNCTIONS OF PLASMA PROTEINS

Plasma proteins are very essential for the body. Following are the functions of plasma proteins:

„ 1. ROLE IN COAGULATION OF BLOOD

Fibrinogen is essential for the coagulation of blood

2. ROLE IN DEFENSE MECHANISM OF BODY

Gamma globulins play an important role in the defense mechanism of the body by acting as antibodies (immune substances). These proteins are also called immunoglobulins. Antibodies react with antigens of various microorganisms, which cause diseases like diphtheria, typhoid, streptococcal infections, mumps, influenza, measles, hepatitis, rubella, polio myelitis, etc.

„ 3. ROLE IN TRANSPORT MECHANISM

Plasma proteins are essential for the transport of various substances in the blood. Albumin, alpha globulin and beta globulin are responsible for the transport of the hormones, enzymes, etc. The alpha and beta globulins play an important role in the transport of metals in the blood.

„ 4. ROLE IN MAINTENANCE OF OSMOTIC PRESSURE IN BLOOD

At the capillary level, most of the substances are exchanged between the blood and the tissues. However, because of their large size, the plasma proteins cannot pass through the capillary membrane easily and remain in the blood. In the blood, these proteins exert the colloidal osmotic (oncotic) pressure. Osmotic pressure exerted by the plasma proteins is about 25 mm Hg. Since the concentration of albumin is more than the other plasma proteins, it exerts maximum pressure. Globulin is the next and fibrinogen exerts least pressure.

5.ROLE IN REGULATION OF ACID-BASE BALANCE

Plasma proteins, particularly the albumin, play an important role in regulating the acidbase balance in the blood. This is because of the virtue of their buffering action . Plasma proteins are responsible for 15% of the buffering capacity of blood.

„ 6. ROLE IN VISCOSITY OF BLOOD

Plasma proteins provide viscosity to the blood, which is important to maintain the blood pressure. Albumin provides maximum viscosity than the other plasma proteins.

7. ROLE AS RESERVE PROTEINS

During fasting, inadequate food intake or inadequate protein intake, the plasma proteins are utilized by the body tissues as the last source of energy. Plasma proteins are split into amino acids by the tissue macrophages. Amino acids are taken back by blood and distributed throughout the body to form cellular protein molecules. Because of this, the plasma proteins are called the reserve proteins.

RED BLOOD CELLS:

Red blood cells (RBCs) are the **non-nucleated** formed elements in the blood. Red blood cells are also known as erythrocytes (erythros = red). Red color of the red blood cell is due to the presence of the coloring pigment called hemoglobin.

NORMAL SHAPE

Normally, the RBCs are disk shaped and biconcave (dumbbell shaped).

NORMAL SIZE

Diameter : 7.2 μ (6.9 to 7.4 μ).

Thickness : At the periphery it is thicker with 2.2 μ and at the center it is thinner with 1 μ (Fig. 9.1). This difference in thickness is because of the biconcave shape.

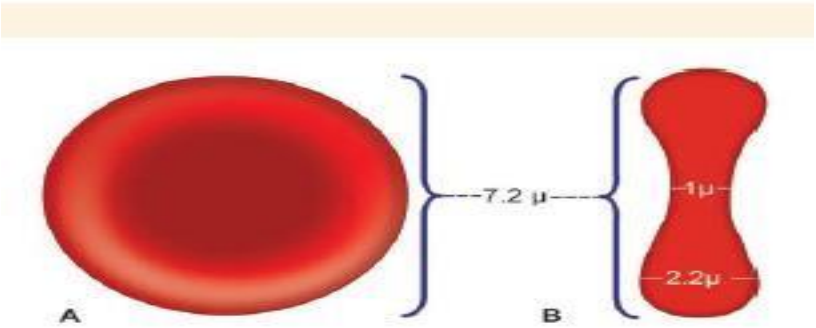


FIGURE 9.1: Dimensions of RBC.
A. Surface view, B. Sectioned view.

NORMAL VALUE

RBC count ranges between 4 and 5.5 million/cu mm of blood. In adult males, it is 5 million/cu mm and in adult females, it is 4.5 million/cu mm.

PATHOLOGICAL VARIATIONS

Pathological Polycythemia

Pathological polycythemia is the abnormal increase in the RBC count. Red cell count increasesabove 7 million/ cu mm of the blood.

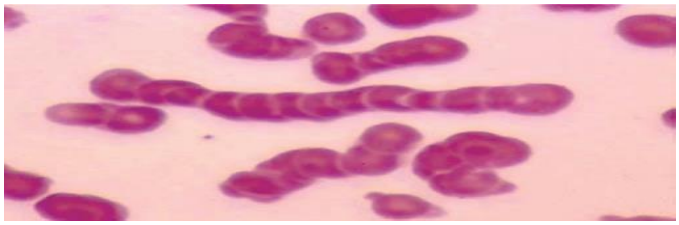
Anemia

Abnormal decrease in RBC count is called anemia

PROPERTIES OF RED BLOOD CELLS

„ ROULEAUX FORMATION

When blood is taken out of the blood vessel, the RBCs pile up one above another like the pile of coins. This property of the RBCs is called rouleaux (pleural = rouleau) formation . It is accelerated by plasma proteins globulin and fibrinogen.



SPECIFIC GRAVITY

Specific gravity of RBC is 1.092 to 1.101.

PACKED CELL VOLUME

Packed cell volume (PCV) is the proportion of blood occupied by RBCs expressed in percentage. It is also called hematocrit value. It is 45% of the blood and the plasma volume is 55%