

- Hematology is defined as the study of the blood, the term (hemo or hemato) is derived from the Greek word for blood.
- Hematology is defined as the **study of** normal and pathologic aspects of blood and **blood cells.**

## Blood

- Is highly specialized tissue, which along with the circulatory sys.
- The blood is fluid of life about (7-8%) of human B.w, is highly specialized circulating tissue, and is adapted to meet the needs of the body tissues and organ systems.

## The main function of blood is

- Transport of O<sub>2</sub>, CO<sub>2</sub>, nutrients, and waste products, hormones.
- protection, plays roles in inflammation , phagocytosis, antibody & complements and platelet factors
- Regulation, act as buffer, water balance, acid- base balance & internal communication.
- Regulation and equalizing of internal body temperatures

The ancient presumed that blood carries a mysterious (vital force) and Roman gladiators drank it to fortify themselves for battle.

From ancient Egypt to 19<sup>th</sup> century, physicians drained bad blood from their patients to treat everything from gout to headaches.

Little information was known about blood until the first microscopes revealed the blood cell.

## SELECTED SCIENTIFIC DEVELOPMENTS RELEVANT TO HEMATOLOGY

- 1628 Blood circulation described by William Harvey (1578-1657) in England
- 1674 First description of red blood cells, by Antonj van Leeuwenhoek (1623-1723) in Holland
- 1772 Plasma clotting factors described by William Henson (1739-1774)
- 1773 First descriptions of white blood cells, by William Henson in England
- 1830 Compound microscope developed
- 1843 First hematology monograph published, in France by Gabriel Andral (1797-1876)
- 1845 Leukemia described as a distinct disease by Rudolf Virchow (1821-1902) in Germany and John Bennett (1812-1875) in Scotland
- 1851 Hemoglobin discovered by Otto Funke in Germany; first blood cell counts published, by Karl Vierordt in Germany
- 1858 Fibrinogen isolated by Denis de Commercy in France and Olaf Hammarsten in Uppsala
- 1865 Red blood cell function described by Felix Hoppe-Seyler (1825-1895) in Germany
- 1869 Bone marrow identified as source of blood cells by Ernst Neumann (1834-1918) in Germany and Giulio Bizzozero (1846-1901) in Italy
- 1870 Leukemia identified as a disease of the bone marrow by Neumann
- 1879 Paul Ehrlich (1854-1915) in Germany develops white blood cell differential count and tri-acid staining technique
- 1886 Phagocytosis described by Ilya Metchnikov (1845-1916), a Russian
- 1890 Anticoagulants based on calcium removal described by Arthus and Pages in Switzerland
- 1900 ABO blood groups discovered by Karl Landsteiner (1868-1943) in Austria

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- 1902 May-Grünwald stain and Wright stain (1906) introduced for blood smears
- 1905 Common coagulation pathway proposed by Paul Morawitz (1879-1936) in Germany
- 1906 Platelets accurately characterized by James Wright (1869-1938) in Boston
- 1910 Sickle-cell anemia presented as a disease by James Herrick in Chicago
- 1925 Thalassemia described by Thomas Cooley in Detroit
- 1926 Studies on lymphocytes and cell-mediated immunity by James Murphy in New York
- 1927 Sternal puncture technique utilized by Mikhail Arinkin (1876-1948) in Russia; makes possible routine bone marrow examination
- 1929 Closed-tube hematocrit introduced by Maxwell Wintrobe in the United States
- 1931-1949 Red cell metabolism and enzymes detailed by Otto Warburg (1883-1970), Gustav Embden (1874-1933), and Otto Meyerhof (1884-1951) in Germany
- 1936 Prothrombin assays introduced; expand understanding of coagulation mechanism
- 1950 Ferrokinetic studies used to study iron turnover
- 1957 Introduction of automated cell counters to the clinical laboratory
- 1961 Hematopoietic stem cell demonstrated by transplantation and irradiation techniques; platelet aggregation with ADP studied in Sweden
- 1969 T and B lymphocytes characterized
- 1975 Kohler and Milstein describe the production of monoclonal antibodies by cells in tissue culture

- Blood is a connective tissue composed of two portions: Liquid portion is called plasma about (55% of the whole blood) and the solid portion is called cellular components about (45%).

- **Plasma** (55%) is liquid portion of the blood, consists of a large number of organic & inorganic substances (solutes (9%)) dissolved in water (solvent (91%)).
  - **Water**; The most important part of plasma, represent about 91% of plasma and about 9% represent other solutes.

### **The main function of water**

\_\_\_ is act as polar solvent for blood cells and other components of blood

\_\_\_ is act as temperature regulation of body, by two way 1- radiation 2- evaporation of water from the skin.

**Different solutes** (9%) include mostly

p. protein, salts, ions (  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{+2}$ ,  $\text{Mg}^+$ ,  $\text{Zn}^+$ ,  $\text{Cl}^-$  and  $\text{HCO}_3^-$  plays an important role in acid-base balance of the body), gasses, hormones, nutrients, wastes (uric acid, urea & creatinine), and enzymes.

A- **Plasma protein** (7%), formed mainly in the liver, and classified according to (or function, structure) their solubility's in the water.

**Albumins** (soluble in water) are smallest & most abundant p. protein.

- - Which contribute to viscosity, osmotic pressure, & blood volume.
- - helps buffer blood
- - transports many solutes by binding to them, like drugs, penicillin, pigments, fatty acids, bile salts and hormones.

**Globulins** (not soluble in water)

Some involved in clotting.

Some are enzymes.

Globulins divided into 3 types ( $\alpha$ ,  $\beta$ ,  $\gamma$ ) according to their speed in electrophoretic medium.

- **alpha globulins** ( $\alpha_1$  and  $\alpha_2$ )(e.g., the proteins that transport thyroxine and retinol [vitamin A])
- **beta globulins** (e.g., the iron-transporting protein **transferrin**). **Fibrinogen** is soluble precursor to fibrin. That forms the framework of blood clot. **LDL** and **plasminogen**

– **Gamma globulins.**

- Gamma globulins are the least negatively-charged serum proteins.
- Most antibodies are gamma globulins. Therefore gamma globulins become more abundant following infections or immunizations.

**Functions of plasma proteins**

- Carrier proteins; many plasma proteins act as carriers for many compounds (called carrier proteins).
- Regulation of the movement of water between the intravascular and extravascular fluid component (osmotic pressure of the albumins maintains the balance between them).
- Coagulation (plugging any breaks in the circulatory system) carried out by action same plasma proteins.
- Immunoglobulins (antibody produced by certain lymphocytes against to pathogens)

**Table 2.1** Components of the Blood

Liquid phase: plasma
Water
Electrolytes (e.g., Na <sup>+</sup> , Ca <sup>2+</sup> , HCO <sub>3</sub> <sup>-</sup> , Cl <sup>-</sup> )
Proteins
Miscellaneous: sugars, fats, vitamins, hormones
Solid phase: formed elements
Erythrocytes
Leukocytes
Granulocytes
Neutrophils
Eosinophils
Basophils
Lymphocytes
Monocytes
Platelets

**Table 2.2** Electrolyte Composition of Blood (mEq/L)

Cations	Plasma	Anions	
Na <sup>+</sup>	142	HCO <sub>3</sub> <sup>-</sup>	27
K <sup>+</sup>	5	Cl <sup>-</sup>	103
Ca <sup>2+</sup>	5	Protein	16
Mg <sup>2+</sup>	3	Miscellaneous	9
Total	155		155
Erythrocytes			
K <sup>+</sup>	125	HCO <sub>3</sub> <sup>-</sup>	20
Na <sup>+</sup>	30	Cl <sup>-</sup>	74
Mg <sup>2+</sup>	12	Miscellaneous	73
Total	167		167

Table 2.4

Summary of the Major Plasma Proteins

Plasma Protein	Plasma Concentration (g/L)	Molecular Weight (daltons)	Functions
Albumin	40.0	69,000	Regulation and maintenance of plasma volume and distribution of extracellular fluid. Also functions as a carrier protein.
<i>α<sub>1</sub>-Globulins</i>			
α <sub>1</sub> -Antitrypsin	3.0	45,000	Anticoagulant effect
HDLs (high-density lipoproteins)	0.5	200,000	Lipid transport
<i>α<sub>2</sub>-Globulins</i>			
Ceruloplasmin	0.4	160,000	Copper transport
Haptoglobins	1.2	95,000	Types of glycoproteins that bind free hemoglobin to conserve iron.
α <sub>2</sub> -Macroglobulin	3.0	800,000	Anticoagulant effect
VLDLs (very low-density lipoproteins)	1.0	10,000,000	Lipid transport
<i>β-Globulins</i>			
Transferrin	3.0	90,000	Iron transport
Hemopexin	1.0	80,000	Binds ferriheme
C <sub>3</sub> (β <sub>1C</sub> -globulin)	1.2	220,000	Component of complement pathway
C <sub>4</sub> (β <sub>1E</sub> -globulin)	0.4	240,000	Component of complement pathway
Plasminogen	0.7	140,000	Fibrinolysis
Fibrinogen	3.0	350,000	Fibrin formation
LDLs (low-density lipoproteins)	1.0	2,300,000	Lipid transport
<i>γ-Globulins</i>			
Immunoglobulins	2.5	170,000	Each Ig group has different antibody functions. They move mainly as γ-globulins on zone electrophoresis, but some migrate as β-globulins or as α <sub>2</sub> -globulins.
IgA	0.03	180,000	
IgD	Trace	200,000	
IgE	10.0	150,000	
IgG	1.0	900,000	

Cellular component (about 45% of blood) are include

a- Red blood cells or erythrocytes (95%)

These corpuscle lack a nucleus and organelles, they contain hemoglobin & distribute oxygen. RBC marked by proteins that define different blood groups.

\_\_\_ Biconcave disc thin center, thick edges (2.0 μm thick and 7.5 μm diameter)

\_\_\_ High surface area / volume ratio

\_\_\_ Flexible, easily deforms to fit through narrow capillaries

b- Leukocytes (WBC) 3% of blood cells

Are true cell, larger than RBC, about 8 μm in diameter, the main function in protection of body as part of immune system, attack & destroy bacteria & pathogens and remove dead cells and tissues.

Most WBC has pseudopodia; they squeeze out of capillaries into tissue spaces. They are classified according to their structure and affinity for various dyes.

- **Granulocyte**

- Neutrophils, Band cell or PMNs about (60-70%). Are multi lobed nuclei and abundant cytoplasmic granules, they have little affinity for either dye or called microphage outside blood vessels.
- Eosinophils (1-4%). The granules take up red dye eosins. Attack parasites and phagocyte antigen-antibody complexes.
- Basophils (0.1%). The granules have affinity for blue dye. They secrete anticoagulant and vasodilator substances as histamines and serotonin.
- **Monocyte** (2-8%).

- They are long lived cell &
- largest of the circulating WBC, with a diameter of 17-24  $\mu\text{m}$ ,
- they have large C or S shaped nucleus,
- Pale cytoplasm and a number of granules, which is called macrophage outside blood vessels.

## **Lymphocytes**

- Second most common type of WBC (20-35%)
- Small cells / large round dense stained nucleus occupy the cells.

1- B Lymphocytes (10-15%) produce Antibody, act as humoral immunity (B= bursa of fabricius in bird)

2- T Lymphocytes (75-80%)

- cytotoxic T ( $T_c$ ) act as cell-mediated immunity
- Helper T cells ( $T_H$ ), activate B cell and T cells (T= matured in thymus)

3- Natural killer cells (10%)

Are large lymphocytes present, cytoplasm contain a number of reddish-purple granules

- **Platelets 1 % (  $250 \times 10^3$  platelet/ $\mu\text{m}$  )**

Are fragment of cytoplasm produced from megakaryocytes, round or oval in shape and have very invaginated surface area and have short life span 1-2 weeks.

## **Platelet functions are**

\_\_\_ Secrete vasoconstrictors

\_\_\_ Promote homeostasis

\_\_\_ Stimulate formation of clot dissolving enzymes to remove clots, because of clots are not permanent, after repair the clots is removed by platelets action