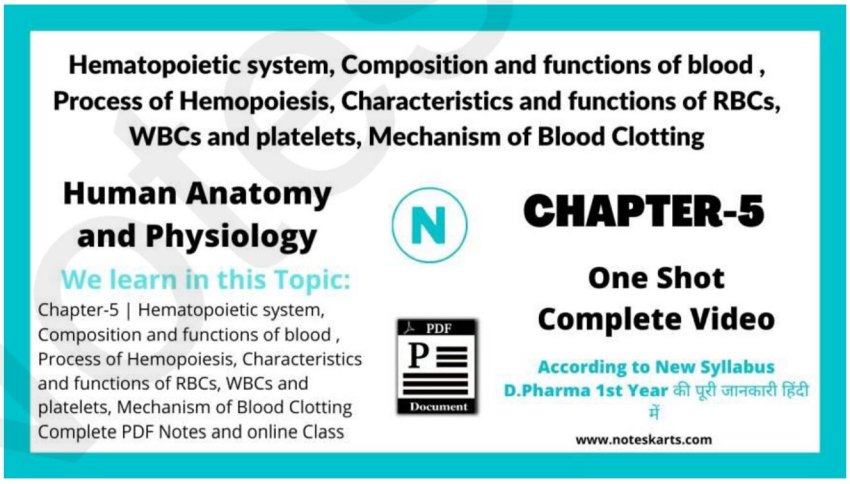
# Chapter-5
# Human Anatomy & Physiology

## D.Pharma 1st Year Notes

## Chapter- 5

## Haemopoietic system

- Composition and functions of blood
- Process of Hemopoiesis
- Characteristics and functions of RBCs, WBCs and platelets
- Mechanism of Blood Clotting.

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# Hematopoietic System

## Introduction:-

**Hematopoietic System** is consists of the blood and blood components forming elements (tissue, organ) which include the bone marrow, thymus, lymph nodes etc. in this chapter we will discussed about blood and their composition and their role in our body.

Hematopoietic System regulates in transportation of nutrients materials and gaseous exchange and it is also acts as connecting link between the one organ to another organs.

Haemopoetic system also participates in the defense mechanism by producing the different types of immune regulating materials (antibodies), and prevents the microbial growth during any infection or manifestation.

- **Consisting materials—**
- **Haemopoetic organ— Bone marrow, lymph nodes, Thymus, Spleen, Haemopoetic glands.**
- **Haemopoetic material—**
- **Connecting link— Arteries and veins**
- **Fluid material— Blood, lymph**

## Composition and functions of bloods

### Blood:-

- Blood is a special type of fluid connective tissue which consisting of clear straw colored watery non- living fluid matrix (Plasma) and living blood cells (formed elements).
- Blood is the most commonly used body fluid for circulating any materials from one organ to another organ.
- Blood constitutes about 8 percent of the total body mass and it has a slightly alkaline PH ranging from 7-7.5. The color of blood varies with its oxygen content, when saturated with oxygen it is bright red, when unsaturated with oxygen it is dark red.
- The blood volume is 5-6 liters in adult male and 4-5 liters in adult female.

**Composition of blood:**

- **Blood plasma:** Plasma proteins, inorganic salts, nutrients, principally from digested foods, waste materials, hormones, gases.
- **Formed elements:** RBCs, WBCs, Platelets.

**Blood Plasma**

- Plasma is the straw colored fluid constituting nearly 55 percent of the blood. 90-92 percent of plasma is water and proteins contribute 6-8 percent of it.
- Blood cells and plasma can be separated by centrifugation or by gravity when blood is allowed to stand.
- The cells are heavier than plasma and sink to the bottom of any sample.

**Plasma proteins—**

1. Albumins—These are most abundant plasma proteins about 60 percent of total and their main function is to maintain normal plasma osmotic pressure.
2. Globulins— Globulins primarily are involved in defense mechanism of the body and play an important role in immunity.
3. Fibrinogen— These proteins are responsible for the coagulation of the blood.

**SERUM—**Serum is plasma from which clotting factors have been removed.

**Function of blood:**

- Blood performs a number of functions, all concerned in one way or another with transporting substances, regulating blood levels of particular substances, or protecting the body.

**Transport:**

- Transporting the oxygen and carbon dioxide from the lungs to other parts of organ.
- Transports the nutrients and wastes material from metabolic sites to eliminating sites.
- Transports hormones from the endocrine organs to their target organs.

**Regulation:**

- It regulates the fluid volume by releasing the inorganic salts ($Na^{+}$, $Ca^{2+}$, $K^{+}$, $HCO^{3-}$ etc.) and maintain the normal PH in body tissue.
- Maintain body temperature by absorbing and distributing heat throughout the body and to the skin surface to encourage heat loss.

**Protection—**

- Prevent blood loss, when a blood vessel is damaged, platelets and plasma proteins initiate clot formation, halting blood loss.
- Prevent the infection by producing the antibodies and leukocytes cell, which help defend the body against foreign invaders such as bacteria and viruses.

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**RBC: (Red Blood Cell)**

- RBC stands for red blood cell.
- RBCs are also known as erythrocytes and are responsible for transporting oxygen from the lungs to all parts of the body.
- They contain a protein called hemoglobin, which carries oxygen.
- The amount of oxygen delivered to the body's tissues depends on the number of RBCs and how well they function.

**Characteristics of RBC—**

- Erythrocytes or Red Blood Cells are the most abundant of all the cells in blood. These are devoid of nucleus in most of the mammals.
- Healthy adult man has on an average 4.5-5.5 millions of RBC/$mm^3$ of blood. They are about 7.5µm in diameter and shape like biconcave discs with depressed center. They have a red colored, iron containing complex protein called hemoglobin, hence the color and name of these cells. A healthy individual has 12-16gm of hemoglobin every 100ml of blood.
- RBCs are formed in the red bone marrow in the adults (development of red blood cells is called erythropoiesis) and have an average life span of 120 days after which they are destroyed in the spleen (graveyard of RBCs).

**Functions of RBC—**

- RBC helps in the transportation of the gaseous from lungs to tissue and tissue to lungs in the form of oxy-hemoglobin (oxygen binds to the hemoglobin) and carbamino-hemoglobin (carbon dioxide binds to the hemoglobin) respectively.
- RBCs contain the antigens (A, B and RH factor) on the surface and helps in the blood groups determination.

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**WBC (White blood cells)**

- WBC stands for white blood cell, which is a part of the body's immune system.
- White blood cells, also known as leukocytes, help the body fight infection and other diseases by circulating in the blood and mounting inflammatory and cellular responses to injury or pathogens.
- When you get sick, your body makes more white blood cells to fight the bacteria, viruses, or other foreign substances causing your illness, which increases your white blood count.

**Characteristics of WBC—**

- White blood cells are also known are leukocytes, these cells have an important function in defense and immunity, they are colorless due to lack of heomoglobin.
- Leucocytes are the largest blood cell but they account for only about 1% of the blood volume. They contain nuclei and some have contains granules in their cytoplasm.
- The average number of WBCs present in the human blood about 6000-8000 leucocytes $mm^{-3}$.

Leucocytes are generally short lived. We have divided into two main categories—

1. **Granulocytes (Polymorphonuclear leucocytes)** —All granulocytes have multilobed nuclei in their cytoplasm. Their names represent the dyes they take up when stained in the laboratory. Eosinophils take up the red acid dye (eosin), basophils take up alkaline methylene blue and neutrophils are purple because they take up both dyes. Granulocytes are divided into three parts—

    a. Neutrophils— These are active scavengers of the body and protect the infection and remove the debris and dead cells from damaged tissue by engulfing or phagocytosis. Neutrophils are the most abundant cell 60-65 percent.

    b. Basophils— Basophils are closely related with allergic reactions. It also secretes the histamine, serotonin, heparin etc, and is involved in inflammatory reactions. Basophils are least in number about 0.5-1 percent.

c. Eosinophils— Eosinophils number about 2-3 percent, resist infections and are also associated with allergic reactions.

2. **Agranulocytes**— They have a large nucleus and no cytoplasmic granules. It is also divide into two parts—

   a. Monocytes— These are largest of the white blood cells. The number of monocytes about 6-8 percent. It prevent the infection by engulfing or phagocytosis the microbes.

   b. Lymphocytes— Lymphocytes are of two major types-

      **B-lymphocytes, T- lymphocytes** are responsible for immune response of the body. The number of lymphocytes about 20- 25 percent.

**Functions of WBC—**

- WBCs play an important role in the defensive mechanism and protects our body from the invading organisms or foreign bodies.

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## Platelets

### Characteristics of Platelets—

- Platelets are also called thrombocytes, are very small discs 2-4µm in diameter cell fragment derived from the cytoplasm of megakaryocytes in red bone marrow.
- Platelets cytoplasm is packed with granules containing a variety of substances that promote blood clotting, which cause hemostasis.
- Blood normally contain the 150000-350000 platelets $mm^{-3}$
- The life span of platelets is between 8 and 11 days and those not used in hemostasis are destroyed by macrophages, mainly in the spleen.
- Some of platelets are stored within the spleen rather than in the circulation, this is an emergency store that can be released as required to control excessive bleeding.

### Functions of Platelets—

- Platelets are the responsible for blood coagulation/blood cloating by the formation of fibrin net.
- Platelets is useful for the repair of the endothelium and other structure of the ruptured blood vessels.
- By the property of agglutination, platelets encircle the foreign bodies and destroy them.

## Hemopoiesis

The process by which the formed elements of blood develop is called **hemopoiesis** or *hematopoiesis.* Before birth, hemopoiesis first occurs in the yolk sac of an embryo and later in the liver, spleen, thymus, and lymph nodes of a fetus. Red bone marrow becomes the primary site of hemopoiesis in the last 3 months before birth, and continues as the source of blood cells after birth and throughout life.

### Process of Hemopoiesis—

- Erythrocyte production begins when the myeloid stem cells (Haemopoetic stem cell) transforms into proerythroblast.
- After maturation on proerythroblast in turn give rise to basophilic erythroblasts that produce huge number of ribosomes.

- Basophilic erythroblasts synthesis huge amount of haemoglobin and iron and transforms into a poly chromatic erythroblast and finally matures into orthochromatic erythrocyte.
- After the maturation or processing of orthochromatic erythroblast, its nucleus degenerates and is pinched off , allowing the cell to collapse inward and eventually assume the biconcave shape and finally convert into reticulocyte.
- Fully mature reticulocyte converts into erythrocyte within two days.
- The entire process from Haemopoetic stem cell to reticulocyte takes about 15 days. Reticulocytes account for 1-2 percent of all erythrocytes in the blood of healthy people.

**Regulation of the haemopoiesis**—

- Red cell numbers remain fairly constant, because the bone marrow produces erythrocytes at the rate at which they are destroyed. This is due to a homeostatic negative feedback mechanism.
- The hormone that regulates red blood cell production is *erythropoietin*, produced mainly by the kidney.
- The primary stimulus to increased erythropoiesis is *hypoxia*, i.e. deficient oxygen supply to body cells.
- Hypoxia can result from anaemia, low blood volume, poor blood flow, reduced oxygen content of inspired air (as at altitude) or lung disease.
- Each of these leads to erythropoietin production in an attempt to restore oxygen supplies to the tissues.

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## Blood Clotting

Blood clotting is a mechanism by which the blood loss restricted during the injury or trauma by the formation of fibrins mesh or blood clot (dark reddish brown color scum). During this process platelets play a vital role because it contains the clotting factors. Blood clot prevents the microbial activity at the infected area.

Blood clotting helps in the haemostatic mechanism of the blood by the formation of the fibrin mesh. Haemostatic mechanism divided into three steps during any injury or trauma.

- Vasoconstriction—
- Platelet plug formation—
- Blood clotting or coagulation.

## Factor of blood clotting:

In our all (except tissue factor) normally circulate in blood in inactive form. Although vitamin K is not directly involved in coagulation but responsible for synthesis in many coagulating factors.

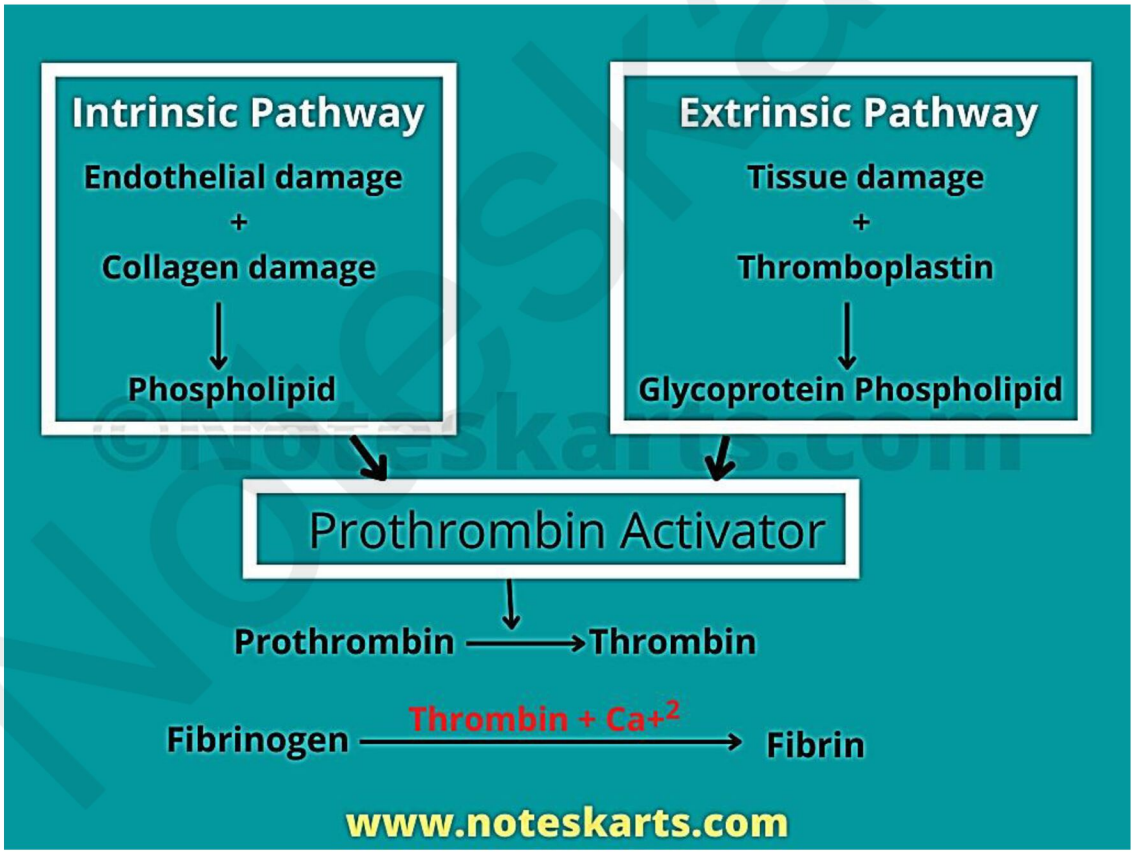
In our body various clotting factors are responsible for blood clot and it works on many steps

## Clotting factors

| S.No | Clotting factors | Sources |
|---|---|---|
| I | Fibrinogen. | Liver |
| II | Prothrombin. | Liver |
| III | Tissue factor (thromboplastin) | Damaged tissue cells |
| IV | Calcium ion ($Ca^{+2}$ ) | Bone, plasma,supplement |
| V | Proaccelerin or labile factor or AcG | Liver, platelets |
| VII | Proconvertin or stable factor or SPCA | Liver |

| | | |
|---|---|---|
| **VIII** | Antihaemophilic factor-A (AHF-A) | Liver |
| **IX** | Christmas factor, PTC, AHF-B. | Liver, lung capillaries |
| **X** | Stuart factor, Prower factor, thrombokinase | Liver |
| **XI** | PTA, AHF-C | Liver |
| **XII** | Hageman factor, AHF-D | Liver |
| **XIII** | Fibrin stabilizing factor (FSF) | Liver, bone marrow. |

**Mechanism of blood clotting—**



**Blood Groups:**

- There are 4 main blood groups (types of blood) – A, B, AB and O.
- Your blood group is determined by the genes you inherit from your parents.

**Types of blood groups**

**ABO Grouping**

**ABO Blood group—**

In ABO system two types of antigens are present in the surface of RBCs (antigen A and antigen B) and two types of antibody are present in the plasma (antibody A and antibody B).

Blood group system are discovered by the Karl landsteiner in 1901.

Determination of ABO blood groups depends upon the immunological reactions between the antigen and antibody.

Based on the presence or absence of antigen A and antigen B, blood is divided into four groups given in the table.

| Blood Group | Antigens on RBCs | Antibodies in Plasma | Donor's Group |
|---|---|---|---|
| A | A | B | A,O |
| B | B | A | B,O |
| AB | A,B | × | AB,A,B,O |
| O | × | A,B | O |

**RH (Rhesus) Grouping—**

**Rh factor-** Rh factor is an antigen, present on the RBCs. This antigen was discovered by Landsteiner and Wiener. It was first discovered in the Rhesus monkey and hence the name Rh factor.

The person whose contains the Rh antigen, then their blood group is define as Rh positive blood group and whose person not contains the Rh antigen, then their blood group is define as Rh negative blood group.

Among Indian population 85% of people are Rh positive and 15% of people Rh negative.

**Importance of Blood Group**

- By the blood group determination we find out suitable donor and suitable recepient and remove the agglutinations problem with any other groups of blood.
- By the the group determination we conclude that-

**A-$O^-$** is the universal donor blood group because it does not contains any antigen **(A and B)** and Rh factors on the RBCs surface.

**B- $AB^+$** is the universal acceptor blood group because it does not contains any antibody (A and B) and Rh factor in the plasma of blood.

In the blood transfusion blood group play an important role and prevent the severe diseases like Agglutinations, jaundice, Cardiac shock, kidney arrest etc.

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**Deficiency disease of blood and blood groups**

I. **Anemia-** Anemia is the blood disorder characterized by the reduction in RBCs and hemoglobin content. It is induce due to the excess loss of blood from the body, decrease production of RBCs or Increased destruction of RBCs.

- Common symptom include- discolor in skin(pale yellow), leg cramps, dizziness, easy fatique and loss of energy etc. It is many types-

    1. Hemorrhagic anemia.
    2. Hemolytic anemia.
    3. Aplastic anemia.
    4. Nutrition deficiency anemia.

II. **Hemophilia -** It is an inherited(x-linked congenital) bleeding disorder arises due to lack of plasma coagulation factors (VIII-type A and IX-type B) . In hemophilic condition patient looses their blood clotting ability so the excessive blood loss appear in the body.

III. **Polycythemia vera -** It is also a blood disorder in which the body produce more amount of blood cell. It is arises both by the physiological activity (exercise, hypoxia) as well as pathological activity (cancer of Bone marrow).

IV. **Sickle cell disease -** It is a type of autosomal recessive disorder. It is caused by the mutation in the hemoglobin β- gene found on chromosome 11. This result in a defective hemoglobin formation and RBCs become stiff and assume sickle shape. Due to their abnormal shape it is not utilised by the body and easily distructed by spleen.

V. **Leukemia-** Leukemia is a cancer of blood forming cells in the bone marrow. It is arising from a single lymphoid stem cell with impaired maturation and accumulation of the malignant cells in the bone marrow.

VI. **Thalassemia-** Thalassemia is an inherited blood disorder in which the body produces an abnormal form of hemoglobin which results in excessive destruction of red blood cells and further leads to anemia. Thalassemia is of two types-

1. Alpha (α) thalassemia.
2. Beta(β) thalassemia.

VII. **Erythroblastosis Foetalis-**

- It is a mismatching blood group disorder observed between the Rh -ve blood of a pregnant mother with Rh +ve blood of the foetus.
- Rh antigens of the foetus do not get exposed to the Rh-ve blood of the mother in the first pregnancy as the two bloods are well separated by the placenta.
- However, during the delivery of the first child, there is a possibility of exposure of the maternal blood to small amounts of the Rh+ve blood from the foetus. In such cases, the mother starts preparing antibodies against Rh antigen in her blood.
- In case of her subsequent pregnancies, the Rh antibodies from the mother (Rh-ve) can leak into the blood of the foetus (Rh+ve) and destroy the foetal RBCs.
- This could be fatal to the foetus or could cause severe anaemia and jaundice to the baby.
- This condition is called erythroblastosis foetalis.
- This can be avoided by administering anti-Rh antibodies to the mother immediately after the delivery of the first child.

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