Al-Mustaqbal University

College of Engineering and Technologies

Biomedical Engineering Department

Systemic Physiology II

Lecture: 1

Blood Physiology

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The blood:-

-Blood is specialized connective tissue consisting of cellular elements suspended in plasma.

-The cells make up approximately 45% of the total blood volume.

-The blood is one of the largest organs of the body, which a volume of about 5 liters& a weight of 5.5 kg an average 70 kg man.

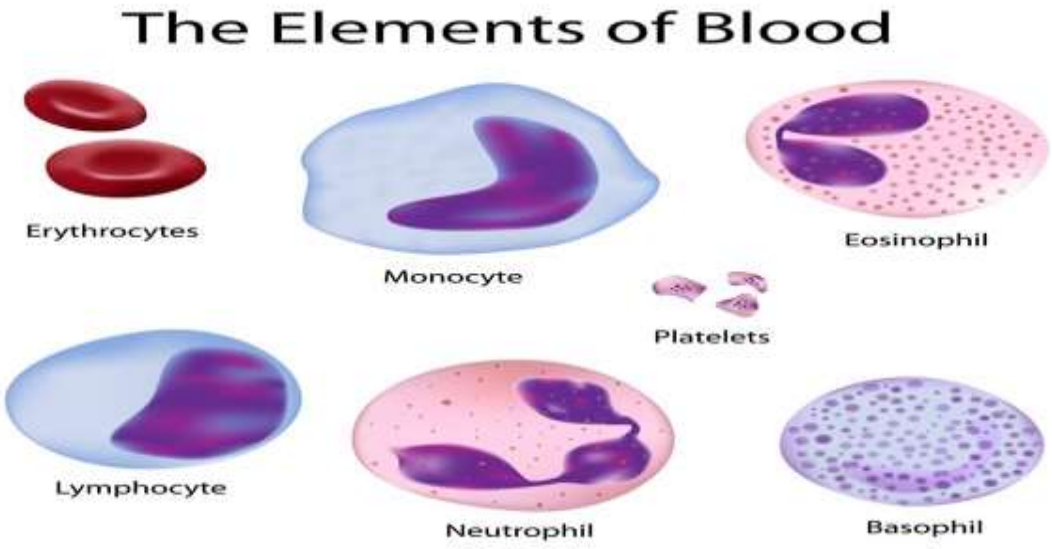
-Normal peripheral blood is composed of three types of cell, red blood cells, white blood cells & platelets, suspended in a pale yellow fluid called plasma.

(1) The cellular elements:-

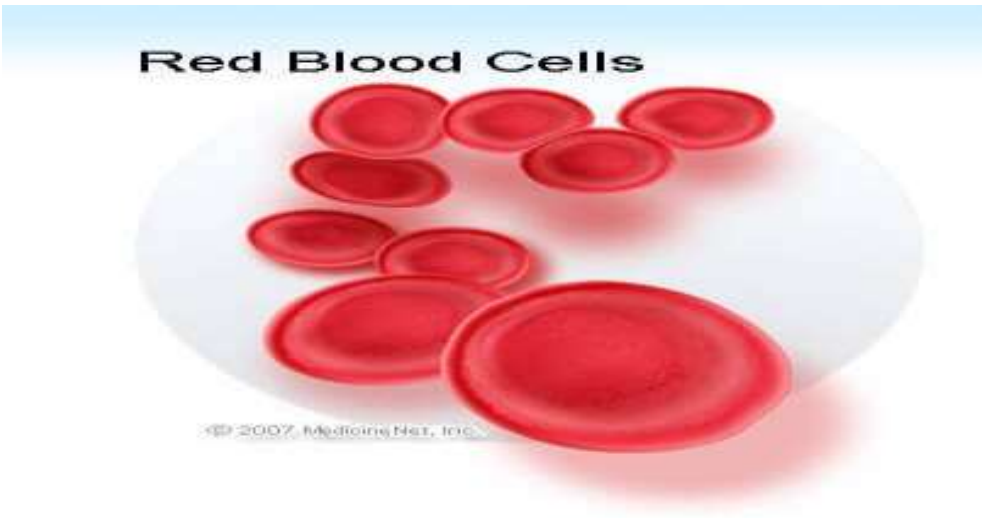
A- Red blood cells (erythrocytes)

B- White blood cells (leucocytes)

C- Platelets.



(A) Red blood cells (RBCs) :-



-Mature RBCs, or erythrocytes, are the most numerous of the blood cells: about$5x10^{12}$normally are present in each liter of blood.

-RBCs are biconcave discs approximately 7.5 micron in diameter and 2 micron thick, but their extreme pliability allow them to squeeze through capillaries less than 5-micron diameter.

-Red blood cells survive in the circulation for about 120 days before being sequestered in the spleen & consumed by the phagocytic cells of the reticuloendothelial system.

-Less than 1% of RBCs are the newly formed reticulocytes, which take 1-2 days to develop into mature red cells.

-The red cell membrane is freely permeable to water & anions (chloride & bicarbonate) transverse the membrane in less than second, & is relatively impermeable to cations.

-The major function of red cells is to transport hemoglobin, which in turn carries oxygen from the lungs to the tissues & transport CO_2 from tissues back to the lungs.

-Red blood cells contain a large quantity of carbonic anhydrase, which catalyzes the reaction between CO_2& water, increasing the rate of this reaction many thousand fold.

-The rapidity of this reaction make it possible for the water in blood to react with large quantities of CO_2& thereby transport it from the tissues to the lungs in the form of the bicarbonate ion (HCO_3^-).

-The percentage of the total blood volume comprised of red blood cells is called the hematocrit, & this is normally about 40% in women & about 45% in men.

(B):-White blood cells (leukocytes) :-

-The leucocytes are the mobile units of the body's protective system.

-They are formed partially in the bone marrow (the granulocytes & monocytes, & a few lymphocytes) & partially in the lymph tissue (lymphocytes & plasma cells), but after formation they are transported in the blood to the different parts of the body where they are to be used.

-The number of white blood cells in the blood is normally only 1/600 the number of red blood cells.

-Leucocytes are of two main types :-

(1) Granular leucocytes.

(2) A granular leucocytes.

(1):- Granular leucocytes :-

-Are the most numerous. Always contain specific granules, & they are characterized by the presence of many lobed nucleus for this reasons they are referred to as Polymorphonuclear leucocytes.

There are three types of granular leucocytes :-

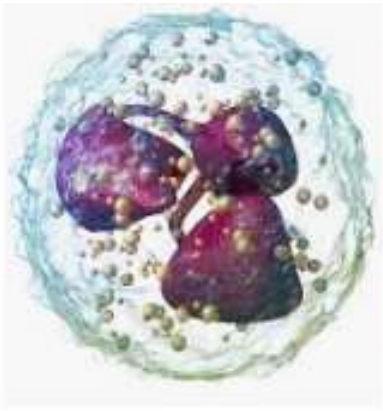
(a):-Neutrophils (b):-Eosinophils (c):-Basophils.

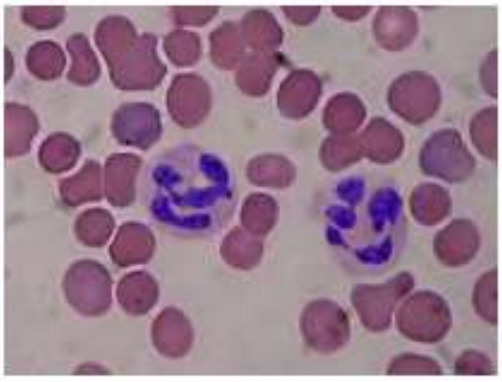
(a):-Neutrophils :-

-They are the most numerous of the leukocytes in human blood, which constitute 50-70% of the total white blood cells.

-The neutrophil nucleus is highly polymorphous Which usually consist of from **3 to 5** irregular ovoid lobes connected by a thin chromatin strand.

-Neutrophil cytoplasm contains numerous fine neutrophil granules, which are special types of lysosomes that contains principally hydrolytic enzymes.





-Neutrophils constitute the first line of defense against invading organism so the main function of neutrophils is bacterial killing by phagocytosis.

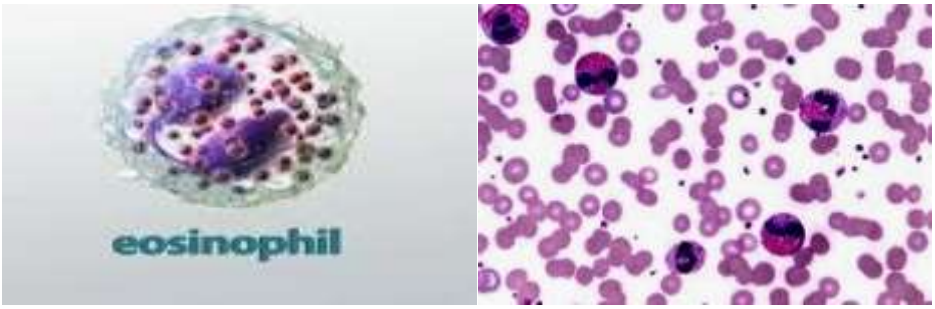
-Neutrophils are highly mobile, highly phagocytic, & are attracted out of the blood into tissue areas where tissue destruction is occurring by a process called chemotaxis, which means attraction by the destruction products from the damaged tissues.

(b):-Eosinophil :-

-They normally constitute about 1 to 4 percent of the total white blood cells.

-The nucleus is usually **bilobed**.

-This name is derived from the staining Characteristic of the large cytoplasmic granules of uniform sized which stain strongly with the acidic dye eosin.



-Eosinophils are produced in large numbers in persons with parasitic infections.

-The parasites are usually too large to be phagocytized, but the eosinophils attach themselves to the surface & release lethal substances that can kill many of the parasites.

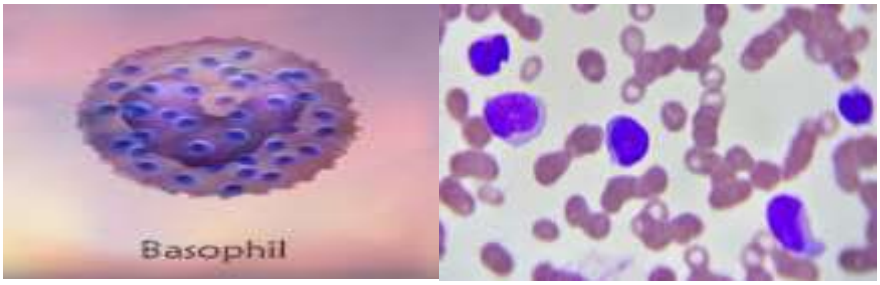
-Large numbers of eosinophils also appear in the blood in allergic conditions & may help detoxify toxins that are released by allergic reactions.

(c) <u>Basophils :-</u>

-These cells are difficult to find in human blood, since they constitute only about 0.5 to 1 percent of the total number of leucocytes.

-The nucleus often is irregular in outline & partially constricted into two lobes **(S shape like).**

-The cytoplasmic granules are round & variable in size, which stain with basic dyes.



-The basophils are very similar to mast cells located immediately outside many of the capillaries in the body.

-Basophils & mast cells are important for allergic reaction.

-Also, basophils & mast cells liberate heparin into the blood, a substance that can prevent blood coagulation. As well as histamine.

-Basophils differ from neutrophils in that they are no phagocytic.

(2) – A granular leucocytes :-

- This cells have cytoplasm that appears homogenous & nuclei that are spherical to reniform in shape.

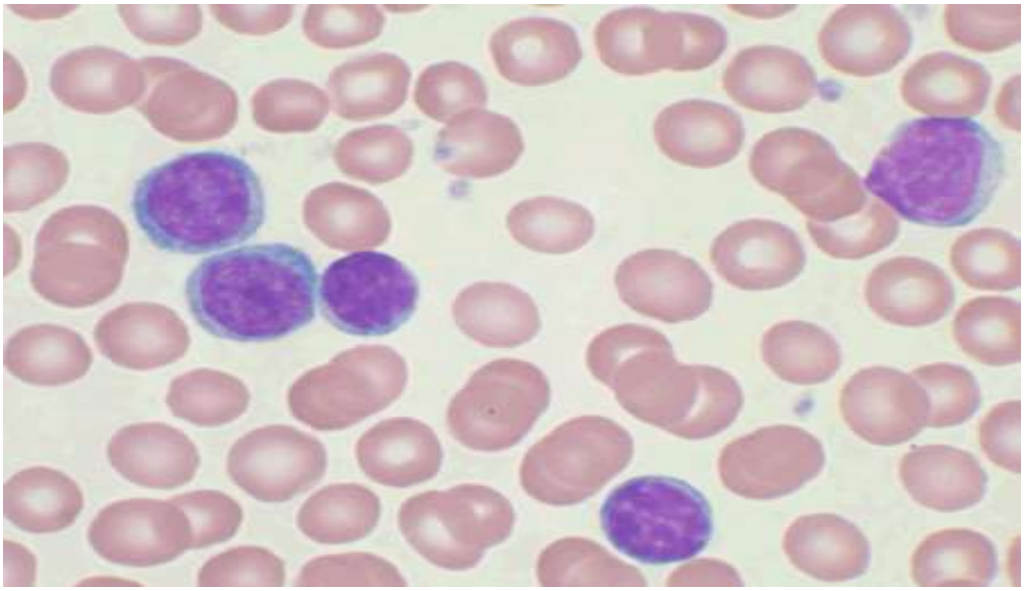
There are two types of a granular leucocytes :-

(a):- Lymphocytes:-

-Lymphocytes are the second most common white cell in the peripheral blood, with arrange of 20 to 40 percent of circulating white blood cells.

-Typically, lymphocytes are much smaller than monocytes (10-12 micron in diameter).

-The majority of the lymphocytes are small in size, spherical cells, with small amount of cytoplasm surrounding dense, round nucleus.



-Most of lymphocytes are formed in lymph nodes, thymus & spleen.

-Lymphocytes are divided into two major populations, which play distinct roles in specific immunity .

-One of the population is responsible for forming the activated lymphocytes that provide cell - mediated immunity, which called T lymphocyte.

-The other population is for forming the antibodies that provide humoral immunity, which is called B-lymphocytes.

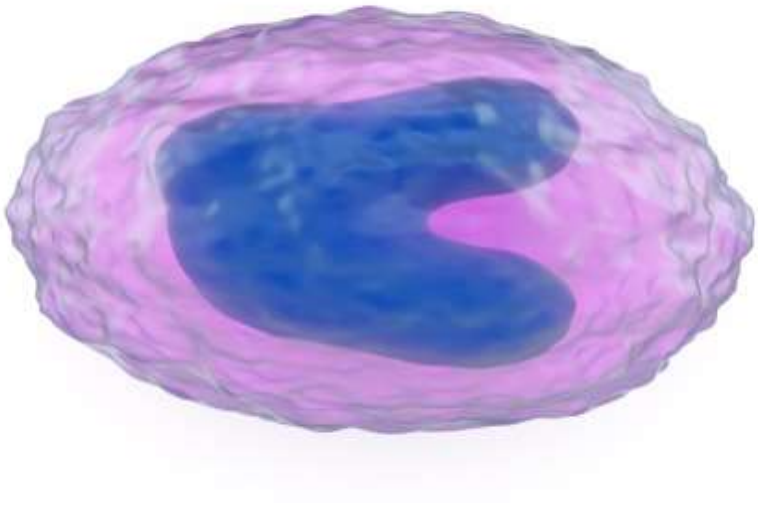
-In the blood 70 – 80% of small lymphocytes are T cells & 15 – 20% are B cells.

(b):-Monocytes:-

-Monocytes are phagocytic leucocytes that play a major role in defense against pathogenic organism & foreign cells.

-The monocytes is larger than neutrophils, & have abundant cytoplasm in relation to the nucleus.

-The nuclei of monocytes frequently are kidney shaped.



-Monocytes enter the circulation from the bone marrow but after about 24 hours, they enter the tissues to become tissue macrophage.

-The tissue macrophage system has generally been called the reticuloendothelial system.

-The macrophages migrate in response to chemotaxis stimuli & engulf & kill bacteria by phagocytosis.

(3) – Platelets:-

-Blood platelets are small protoplasmic disks, which are non-nucleated, granulated bodies, constitute about 300,000m^3 of circulating blood.

-The primary role of the blood platelet is in the arrest of blood loss. Adequate number of Functionally normal platelets are essential for optimal hemostasis.

Blood functions

(1):-Transport of nutrients from digestive tract to tissues.

(2):-Transport of metabolites (eg . lactic acid from muscle to liver) .

(3):-Transport of excretory products from tissues to excretory organs (urea in liver to kidney).

(4):-Transport of gases (O_2&CO_2) between respiratory organs & tissues.

(5):-Transport of hormones & vitamins.

(6):-Transport of heat from deeper organs to surface.

(7):-Coagulation, serves to protect against blood loss.

(8):-Forms antibodies which helps to resisting the various specific infections.