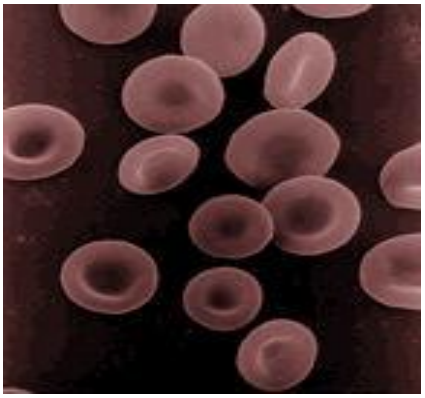
# B.N. Bandodkar College of Science, Thane
# Zoology – Paper II
# Haematology
# Erythrocytes- Red Blood Corpuscles
# By Dr N.N. Patil

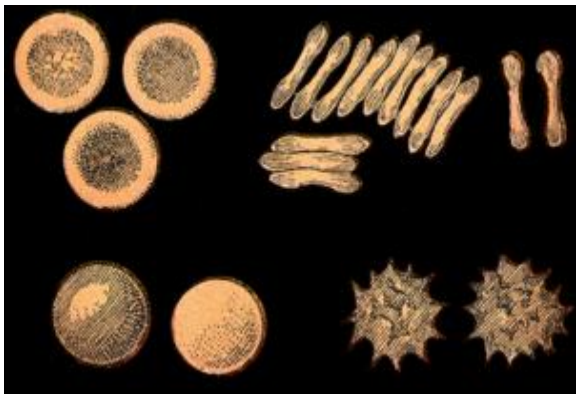
The mature humans red blood cells are circular , biconcave discs that lack a cell nucleus and most organelles. The edges of cells are rounded and thicker than the centre. Cells are depressed in the center and when viewed from the side they look like a dumb bell.

Each cell is composed of a colourless envelope( cell membrane) enclosing semiliquid material , composed of 65% water and 35 % solids out of which 33% is haemoglobin. Inside the corpuscle there is a framework mainly composed of proteins, phospholipids, cholesterols and fats. The meshes of the framework are filled up with haemoglobin.

The mature red cell is soft, flexible and can readily squeeze through narrow tiny blood capillaries .

The distinctive biconcave shape helps RBC in squeezing through tiny capillaries.





These cells have nuclei during early phases of erythropoiesis, but extrude them ( nuclei) during development as they mature.

Absence of nucleus is of great benefit to the cell.

It give red cells their biconcave shape and provide more space for hemoglobin.I

It also allows considerable alteration in cell volume without increasing tension on the cell membrane. Concave part can easily moves in and out as volume decreases or increases.

It allows easy folding of the cell when it passes through the narrow capillaries.

Because of biconcave shape haemoglobin remains distributed in thin film which allows quick saturation and desaturation with respiratory gases.

In mammals, erythrocytes also lose all other cellular organelles such as their mitochondria, golgi apparatus and endoplasmic reticulum. Because of the lack of nuclei and organelles, mature red blood cells do not contain DNA and cannot synthesize any RNA, and **consequently cannot divide and have limited repair capabilities.**

A diameter of RBC when in body varies from 5.5 µm to 8.8 µm and a thickness is about 2. 2 µm .These cells have a volume of about 90 cubic µ with a surface of about 120 $\mu m^2$,

**RBCs help in transportation of respiratory gases with the help of haemoglobin.**

**Haemoglobin, is a complex metalloprotein containing heme groups whose iron atoms temporarily bind to oxygen molecules ($O_2$) in the lungs and release them throughout the body.**

**Oxygen can easily diffuse through the red blood cell's cell membrane**.

**Hemoglobin in the erythrocytes also carries some of the waste product carbon dioxide back from the tissues; (but most waste carbon dioxide, however, is transported back to the pulmonary capillaries of the lungs as bicarbonate ($HCO_3^-$) dissolved in the blood plasma)**

**The colour of erythrocytes is due to the heme group of hemoglobin**

**The Red cell membrane** is composed of proteins, phosphatides and lipids .The inner and outer layer is made up of proteins and middle layer of lipids. The permeability of this membrane is highly selective. The cations like Na, K are not allowed to pass but anions like Cl, HCO and crystalloids like urea are allowed to pass.

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In large blood vessels, red blood cells sometimes occur as a stack, flat side next to flat side. This is known as ***rouleaux*** formation, and it occurs more often if the levels of certain serum proteins are elevated, as for instance during inflammation.

About 2.4 million new erythrocytes are produced per second. The cells develop in the bone marrow through a process named erythropoiesis, developing from committed stem cells and mature in about 7 days. When matured, these cells live in blood circulation for about 100 to 120 days.

## Normal Red cell count and variation of Red Cell Count under various conditions

The normal RBC count in Women is about 4 to 5 million erythrocytes per cubic millimeter of blood and men about 5 to 6 million per cubic millimeter.

In Infants the count is 6 to 7 million per cubic millimeter and in foetus 7.8 million per cubic millimeter. In the first ten days of postnatal life large number of RBCs are destroyed.

Total RBC count shows variations under various conditions.

1. **Diurnal variation –** About 5% variation in RBC count occurs Within 24 hrs. The count is lowest during sleep, then gradually rises and becomes maximum in the evening.
2. **Muscular exercise –** Exercise rises the count temporarily. During exercise more oxygen is required which is provided by increased cell count.
3. **Altitude –** At higher altitude cell count rises, whereas at lower altitude count falls.
4. **High external temperature –** increases the cell count
5. **Low Oxygen Tension –** Any condition which lowers the oxygen tension of arterial blood increases the red cell count.
6. **Injection of adrenaline** increases the cell count.
7. **Excitement** increases the cell count as during excitement adrenaline is secreted by body.

## LEUKOCYTES (white cells)

Leukocytes, or white cells, are responsible for **the defense of the organism**. In the blood, they are much less numerous than red cells. The density of the leukocytes in the blood is 5000-7000 /$mm^3$. Leukocytes divide in two categories: **granulocytes** and **lymphoid cells** or agranulocytes. The term granulocyte is due to the presence of granules in the cytoplasm of these cells. In the different types of granulocytes, the granules are different

and help us to distinguish them. In fact, these granules have a different affinity towards neutral, acid or basic stains and give the cytoplasm different colors. So, granulocytes distinguish themselves in neutrophil, eosinophil (or acidophil) and basophil. The lymphoid cells, instead, distinguish themselves in lymphocytes and monocytes. As we will see later, even the shape of the nucleus helps us in the recognition of the leukocytes.

Each type of leukocyte is present in the blood in different proportions:

neutrophil 50 - 70 %
eosinophil 2 - 4 %
basophil 0,5 - 1 %
lymphocyte 20 - 40 %
monocyte 3 - 8 %

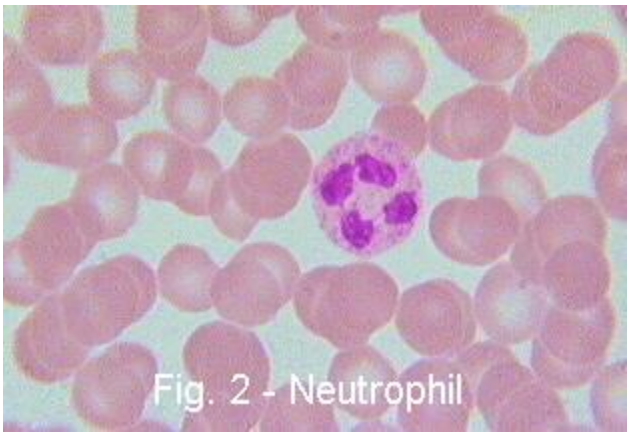
Fig. 2 - Neutrophil

**Neutrophils** are very active in phagocyting bacteria and are present in large amount in the pus of wounds. Unfortunately, these cells are not able to renew the lysosomes used in digesting microbes and dead after having phagocyted a few of them.

**Eosinophils** attack parasites and phagocyte antigen-antibody complexes.

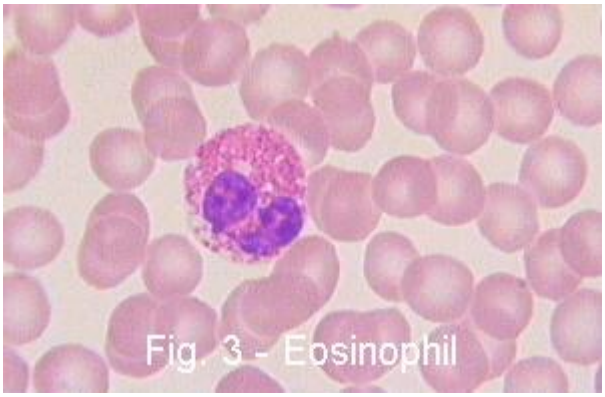
Fig. 3 - Eosinophil

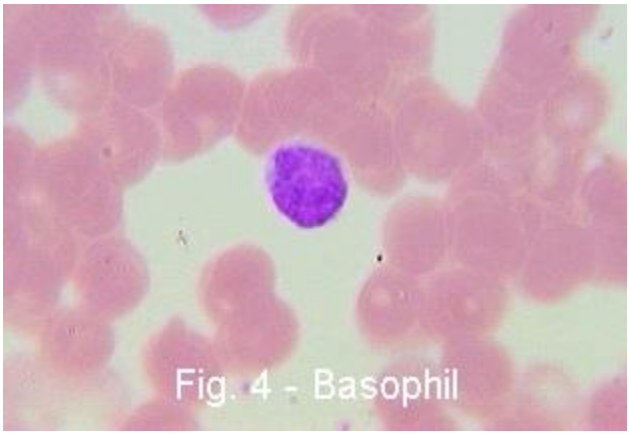

Fig. 4 - Basophil

**Basophil** secrete anti-coagulant and vasodilatory substances as histamines and serotonin. Even if they have a phagocytory capability, their main function is secreting substances which mediate the hypersensitivity reaction.

**Lymphocytes** are cells which, besides being present in the blood, populate the lymphoid tissues and organs too, as well as the lymph circulating in the lymphatic vessel. The lymphoid organs include thymus, bone marrow (in birds bursa), spleen, lymphoid nodules, palatine tonsils, Peyer's patches and lymphoid tissue of respiratory and gastrointestinal tracts.

Most lymphocytes circulating in the blood is in a resting state. They look like little cells with a compact round nucleus which occupies nearly all the cellular volume. As a consequence, the cytoplasm is very reduced. The lymphocytes of the lymphoid tissues and organs can be activated in a different amount following antigenic stimulation. In the blood, lymphocytes are 20-40 % of all leukocytes and are slight larger than red blood cells.

The lymphocytes are the main constituents of the immune system which is a defense against the attack of pathogenic micro-organisms such as viruses, bacteria, fungi and protista. Lymphocytes yield **antibodies** and arrange them on their membrane. An antibody is a molecule able to bind itself to molecules of a complementary shape called **antigens**, and recognize them. As for all proteins, even the antibodies are coded by genes. On the basis of a recombination mechanism of some of these genes, every lymphocyte produces antibodies of a specific shape.

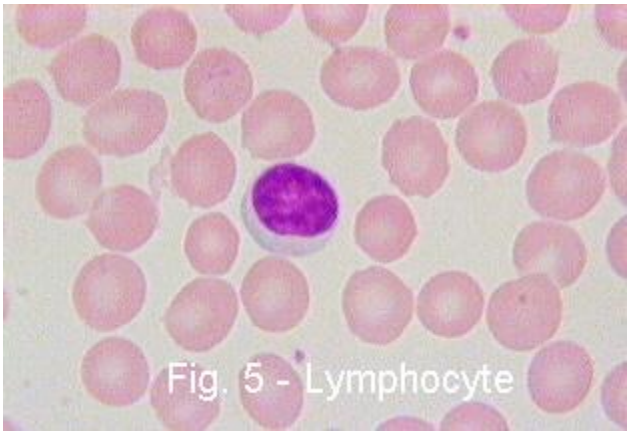

Fig. 5 - Lymphocyte

Monocytes are the precursors of macrophages. They are larger blood cells, which after attaining maturity in the bone marrow, enter the blood circulation where they stay for 24-36 hours. Then they migrate into the connective tissue, where they become macrophages and move within the tissues. In the presence of an inflammation site, monocytes quickly migrate from the blood vessel and start an intense phagocytory activity. The role of these cells is not solely in phagocytosis because they have also have an intense secretory activity. They produce substances which have defensive functions such as lysozime, interferons and other substances which modulate the functionality of other cells. Macrophages cooperate in the immune defense. They expose molecules of digested bodies on the membrane and present them to more specialized cells, such as B and Th lymphocytes.

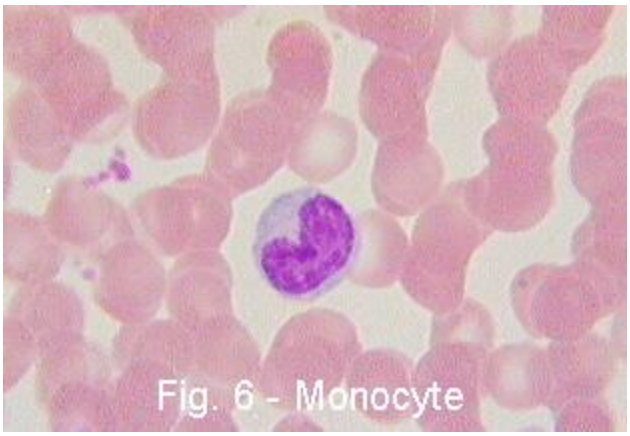

Fig. 6 - Monocyte

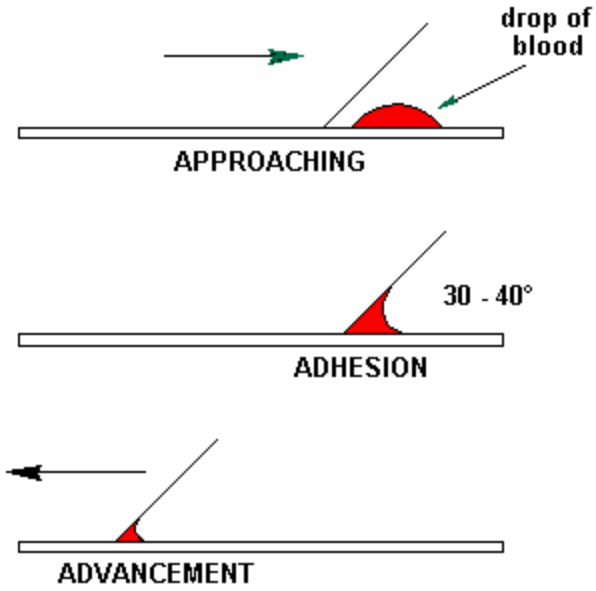


Fig. 7 - How to prepare a blood smear

# Plasma (Blood Plasma)

**Blood Plasma** is one of the many components (including different types of cells) which, together, form the fluid known as blood.

The structure of **Blood Plasma** is summarised as follows:
Normal blood plasma is 90-92 % water.
This is the straw-coloured fluid in which the blood cells are suspended, and consists of:

- Dissolved substances including electrolytes such as sodium, chlorine, potassiun, manganese, and calcium ions;
- Blood plasma proteins (albumin, globulin, fibrinogen);
- Hormones.

The functions of **Blood Plasma** include:

- The medium in which the blood cells are transported around the body (by the blood vessels) and are able to operate effectively.
- Helps to maintain optimum body temperature throughout the organism.
- Helps to control the pH of the blood and the body tissues, maintaining this within a range at which the cells can thrive.
- Helps to maintain an ideal balance of electrolytes in the blood and tissues of the body.

For more information about other components (or "constituents") of blood, see the page about:
The Structure and Functions of Blood. This may interest students of massage, reflexology, beauty therapies, or other health or clinical courses.

## 1. Functions of Blood

1. **Transports:**
   - Dissolved gases (e.g. oxygen, carbon dioxide);
   - Waste products of metabolism (e.g. water, urea);
   - Hormones;
   - Enzymes;
   - Nutrients (such as glucose, amino acids, micro-nutrients (vitamins & minerals), fatty acids, glycerol);
   - Plasma proteins (associated with defence, such as blood-clotting and anti-bodies);
   - Blood cells (incl. white blood cells 'leucocytes', and red blood cells 'erythrocytes').

2. **Maintains Body Temperature**

3. **Controls pH**

   The pH of blood must remain in the range 6.8 to 7.4, otherwise it begins to damage cells.

4. **Removes toxins from the body**

   The kidneys filter all of the blood in the body (approx. 8 pints), 36 times every 24 hours. Toxins removed from the blood by the kidneys leave the body in the urine. (Toxins also leave the body in the form of sweat.)

5. **Regulation of Body Fluid Electrolytes**

   Excess salt is removed from the body in urine, which may contain around 10g salt per day
   (such as in the cases of people on western diets containing more salt than the body requires).

## 2. Composition of Blood

Blood consists of many components (constituents).
These include:

55% Plasma

45% Components, i.e. 'Blood Cells'.

Of these, 99% are erythrocytes (red blood cells) and 1% are leucocytes (white blood cells) and thrombocytes (blood platelets).

This is summarised in the following diagram, and described in further detail below.