Blood Physiology

Blood

- The total blood volume makes up about 6-8 percent of the body's weight.
- Accordingly, a 70-kilogram person will have 5 to 6 litres of blood.
- Circulating blood volume will be lesser than total blood volume, because some amount of blood will be deposited in organs like liver.

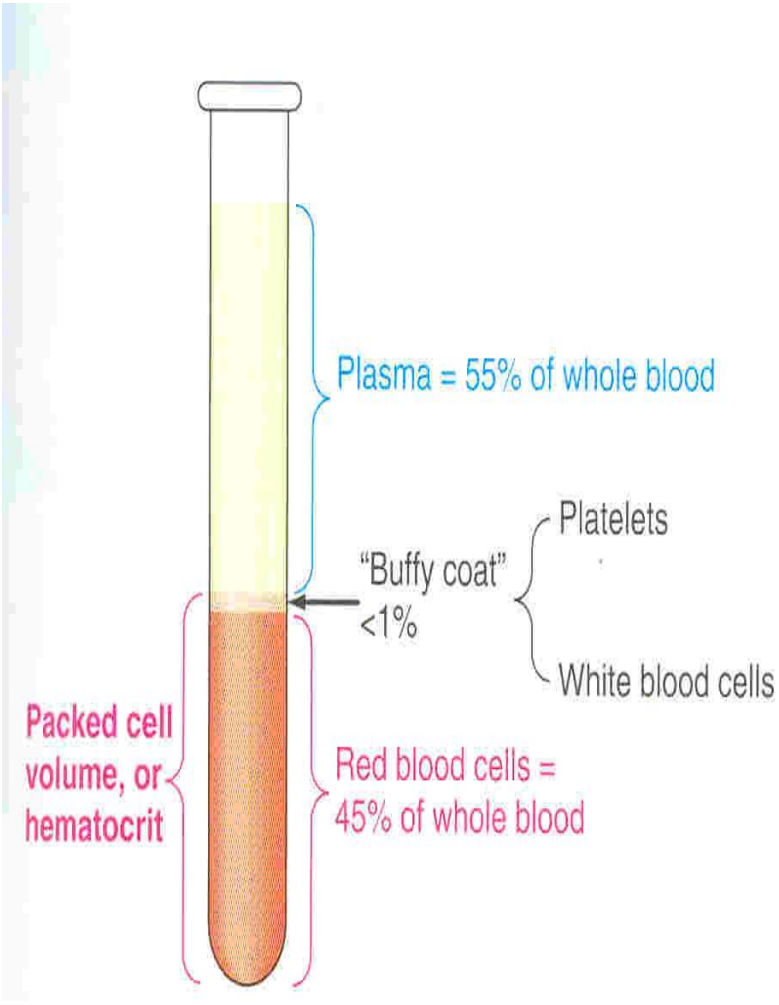
FUNCTIONS OF BLOOD

1. **Transport**
   - **O2, CO2, nutrient, hormones, waste product**
2. **Homoeostasis**
   - **Regulation of body temperature, pH**
3. **Protecting against infections**
   - **White Blood Cells, Antibodies**
4. **Blood clotting prevent blood loss**

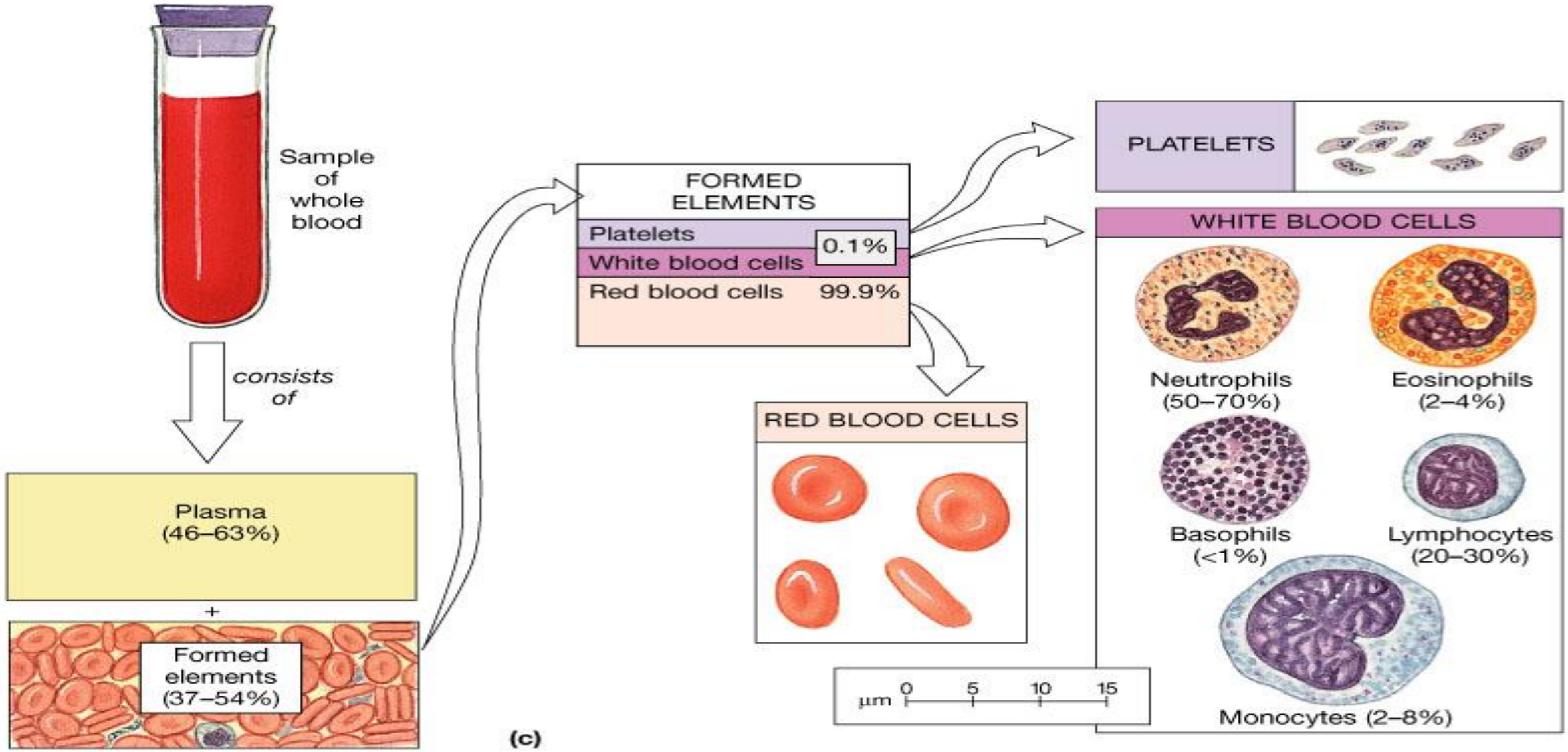
BLOOD COMPOSITION

1. **Cellular components**
   - **Red Blood Cells (Erythrocytes)**
   - **White Blood Cells (Leucocytes)**
   - **Platelets (Thrombocytes)**
2. **Plasma**
   - **98% water, ions, plasma proteins (Albumin, globulin, Fibrinogen)**
   - **Same ionic composition as interstitial fluid**

Blood Composition

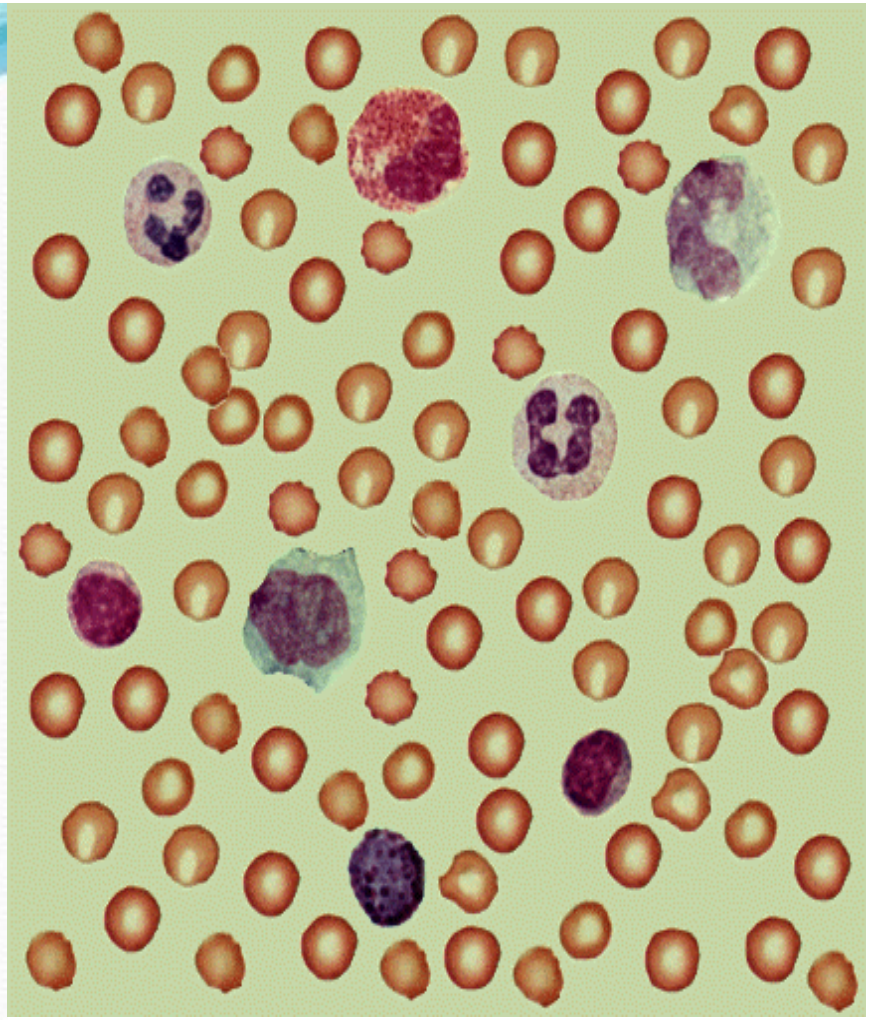


Blood Composition



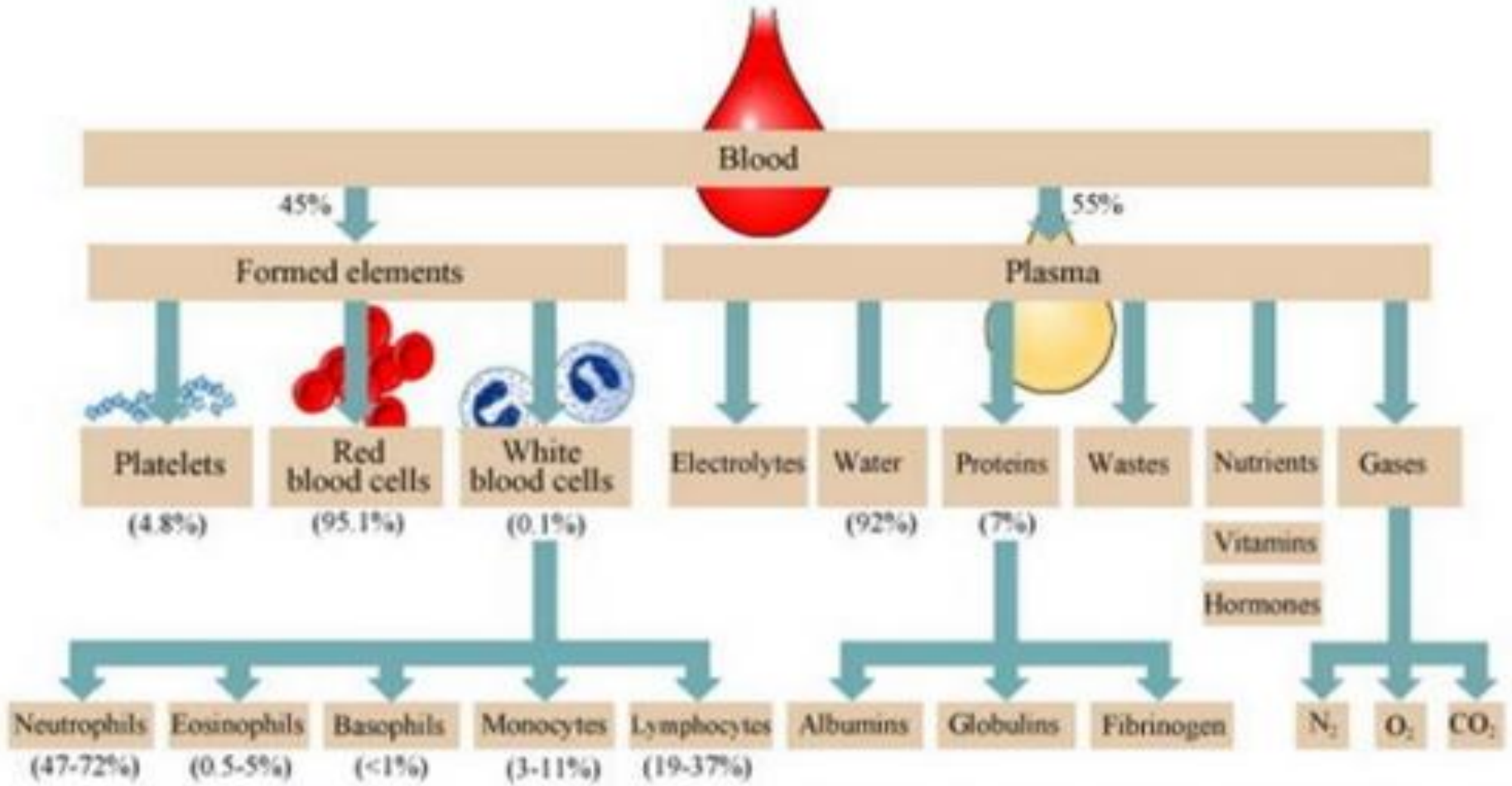
Blood

- Formed elements include
  - Erythrocytes (red blood cells);
  - Leukocytes (white blood cells);
  - Thrombocytes (platelets)



Blood Film

Blood Composition

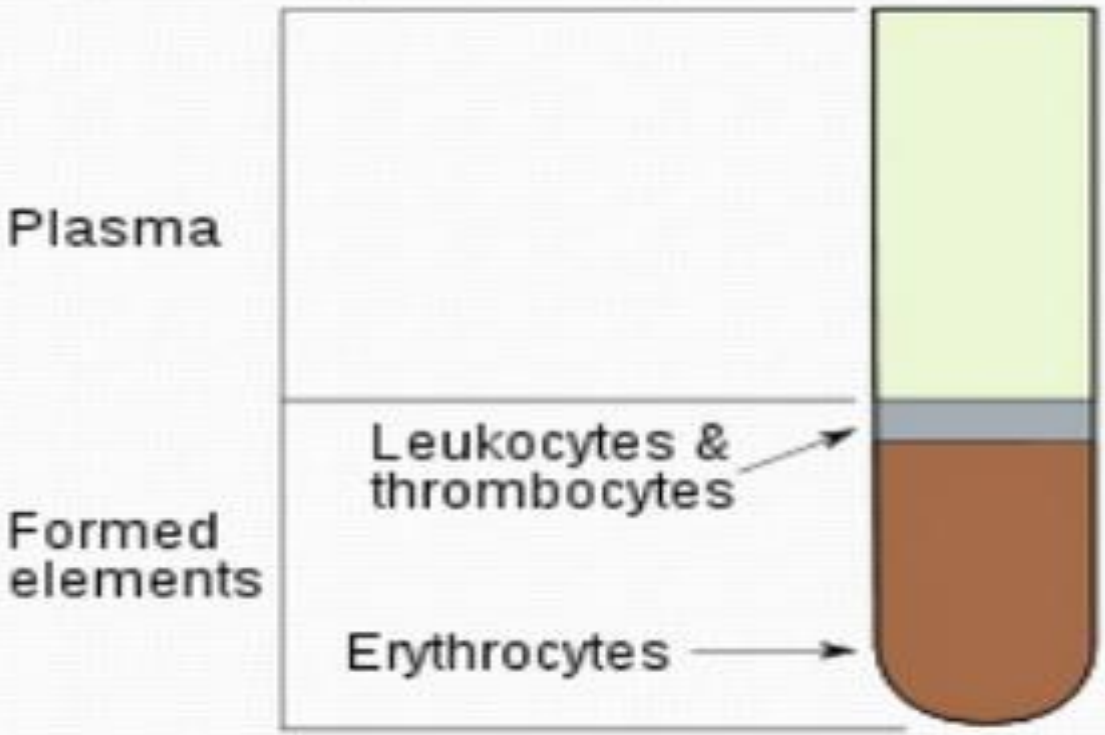


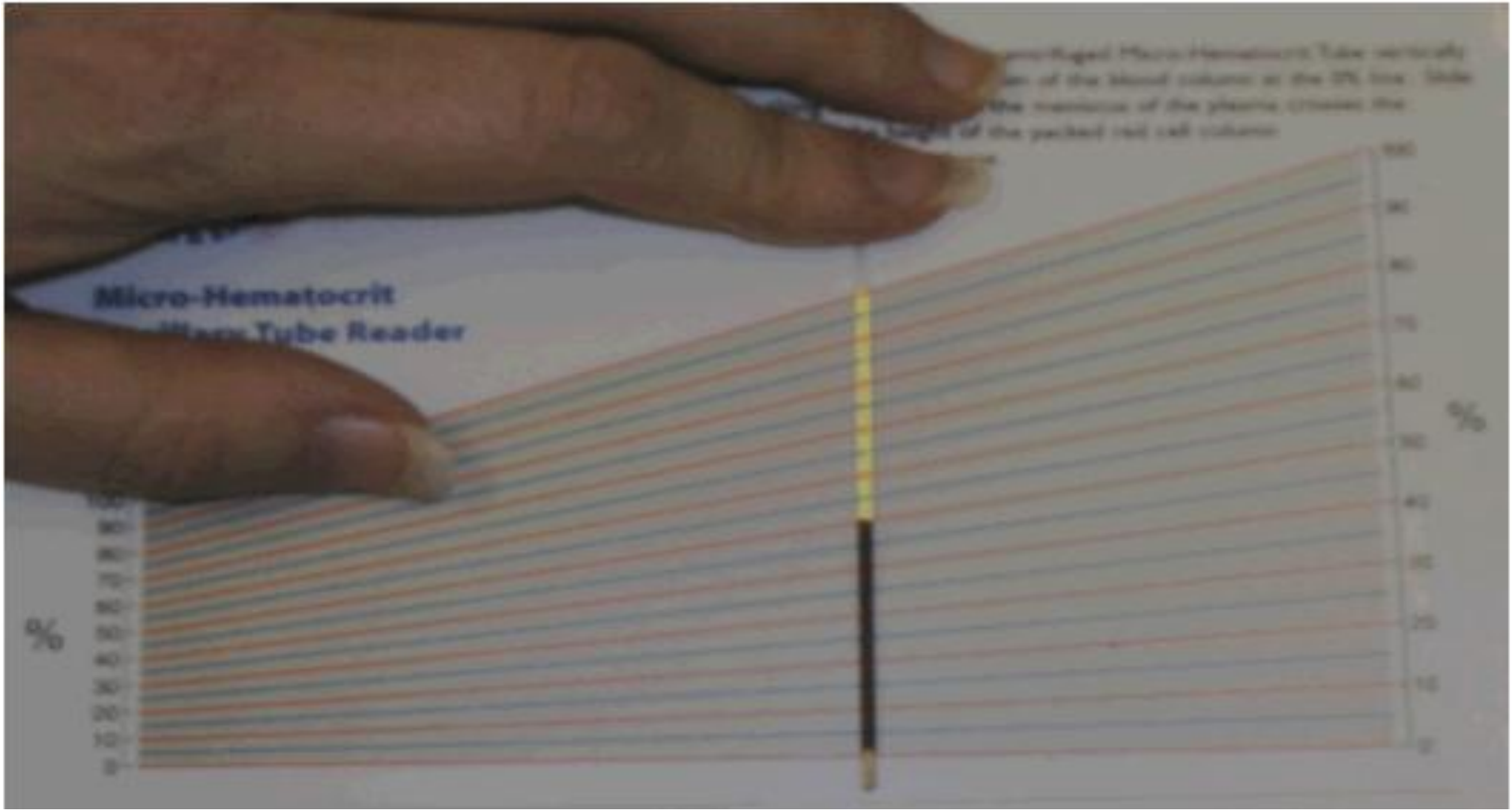
Hematocrit

The hematocrit , also known as packed cell volume (PCV) or erythrocyte volume fraction (EVF), is the volume percentage (%) of red blood cells in the blood. It is normally about

40-48% for men and

36-42% for women




Micro-Hematocrit
Tube Reader
%
%

Blood plasma

- **The organic components of plasma include :**
  - **proteins**
  - **lipids**
  - **carbohydrates**

Plasma proteins and their role

- Plasma proteins include :
- Albumin (65-85 g/l) -
  - Transportation
  - Regulation of oncotic pressure
  - Regulation of pH
- Globulin (28 g/l) -
  - α
  - β } - Transportation
  - γ - Defense
- Fibrinogen (3 g/l) - Blood clotting (haemostasis)

Serum

- **When fibrinogen is removed from plasma as a result of coagulation, such plasma without fibrinogen is called serum.**

Osmosis

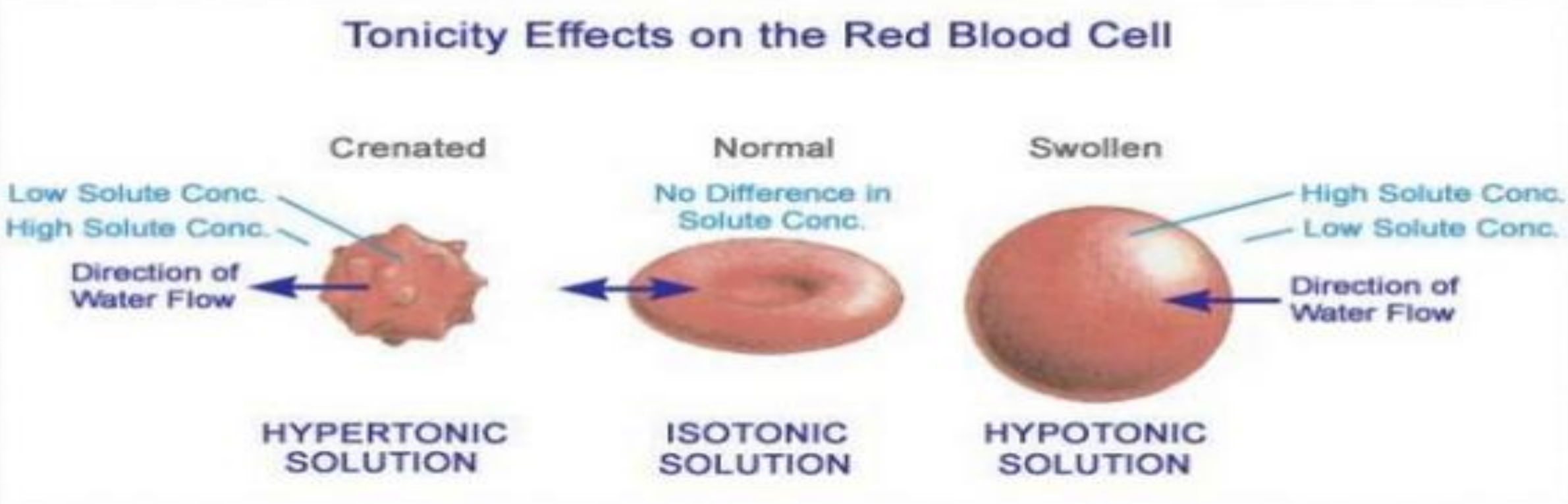
- **Osmosis**

-movement of water from higher concentration to lower concentration.

(or)

-movement of dissolved substances from lower concentration to higher concentration.

Osmotic pressure



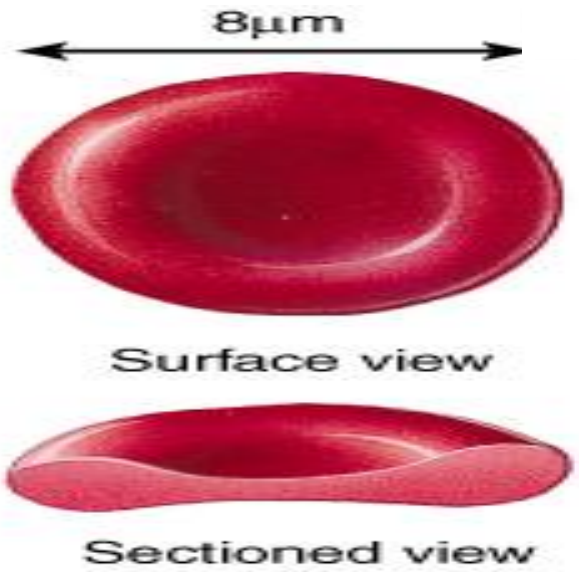
Viscosity

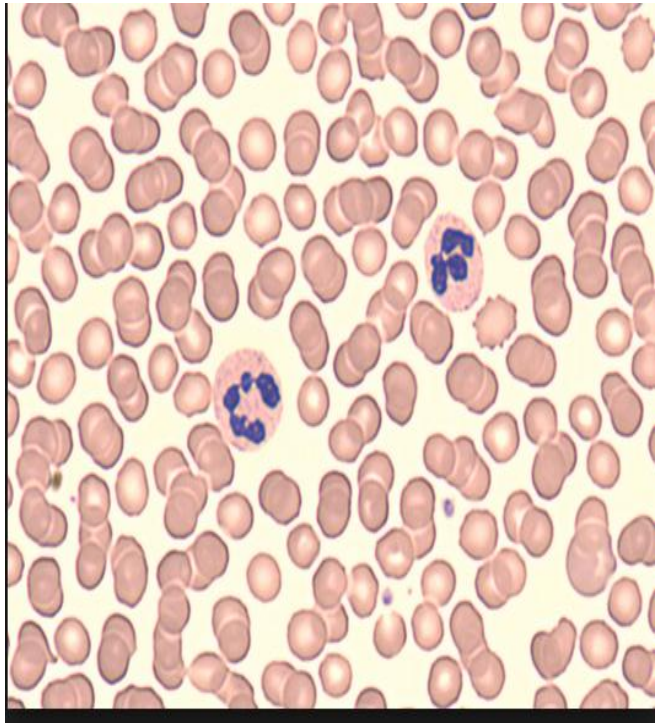
- Blood viscosity can be described as the thickness and stickiness of blood.
- It is a measure of the resistance of blood to flow.
- The viscocity of blood is 5 times more than that of water

  (based on time taken for the flow of both in a tube)
- It depends on :
  - RBCs
  - Plasma proteins

Erythrocytes

- Red blood cells, or erythrocytes, are the most abundant type of blood cell.
- Approximately 2.4 million new erythrocytes are produced per second.
- Approximately a quarter of the cells in the human body are red blood cells.





Erythrocytes -Structure

- In humans, mature red blood cells are oval biconcave disks and they are flexible.
- A typical human erythrocyte has a disk diameter of approximately 6.2–8.2 µm
- They lack a cell nucleus and most organelles, in order to accommodate maximum space for haemoglobin.

RBC Count

- **Normal range :**
- **In male : $4.0\text{-}5.0 \times 10^{12}/L$**
- **In female : $3.5\text{-}4.5 \times 10^{12}/L$**

Production of RBC

- Early few weeks of embryo nucleated RBCs are formed in yolk sac.
- Middle trimester mainly in liver & spleen & lymph nodes.
- Last months RBCs are formed in bone marrow of all bones
- Bone marrow of flat bone continue to produce RBC into adult life
- Shaft of long bone stop to produce RBC at puberty while epiphysis continued

Regulation of RBC production

- Erythropoiesis is stimulated by erythropoietin hormone produced by the kidney in response to hypoxia (low oxygen in the blood)
- Hypoxia caused by:
  - Low RBC count (Anaemia)
  - Hemorrhage
  - Prolong heart failure
  - Lung disease

Erythropenia

- If the erythrocyte count is less than normal, such state is called erythropenia.
- A deficiency in number of RBCs or reduced haemoglobin levels in RBCs is known as anaemia.
- Erythropenia may be because of :
  - Problems in production
  - Excessive destruction (haemolysis)
  - Blood loss

Haemoglobin - Structure

- **Content :**
  It is composed of the protein globin (a polypeptide), and the pigment heme.
- **Structure :**
  The haemoglobin has the ability to combine with oxygen is due to the four iron atoms associated with each heme group within the molecule.

Haemoglobin

- **Physiological role :**

The main function of erythrocytes is carried out by means of haemoglobin.

Normal range of haemoglobin :

In men - 135-180 g/L

In women - 120-140 g/L

Compounds of haemoglobin

- **Physiological associations of haemoglobin :**
- **Oxyhemoglobin :**

- Oxygen combines weakly with the haemoglobin molecule. Such association is called oxyhemoglobin . It is formed in lungs.

- **Deoxyhemoglobin :**

- When the oxygen is released to the tissues of the body, the haemoglobin is called reduced haemoglobin or deoxyhemoglobin.

- **Carbhemoglobin :**

- In tissues Hb combines with carbon dioxide and form carbhemoglobin.

Sahli Haemometer

Description

One of the original techniques for measuring haemoglobin. The Sahli haemometer method utilizes the conversion of haemoglobin into acid haematin which has a brown colour in solution.

the Haemoglobin (Hb) is converted to acid haematin by addition of 0.1 N hydrochloric acid and resulting brown colour is compared with standard brown glass reference blocks of a Sahli's haemoglobinmeter.

Method of Use

: □ By using a Pasteur pipette ,add 0.1N HCl in the graduated tube to the mark 10. □ Draw blood upto the 20 µl mark in the Sahli Hb pipette and add it to the acid in the tube. Rinse the pipette well, mix the reaction mixture and allow the tube to stand for atleast 10 min. □ Dilute the solution with distilled water by adding few drops at a time until the colour matches with the standard glass reference blocks. □ The matching should be done only against natural light. The level of the fluid is noted at its lower meniscus and reading corresponding to this level on the scale is recorded in g/dl

Sahli Haemometer

Leucocytes (WBC)

- White blood cells have nuclei
- They make up approximately 1% of the total blood volume in a healthy adult.
- They live for about three to four days in the average human body.
- Normal count of WBC :
  - $4\text{-}9 \times 10^9/L$

Leucocytes-functions

- The major function of leucocytes is :
- Protective function.
- It provides immunity and thus defends the body.

Leucocytosis

- Increased amount of leucocytes in blood.
- It may be :

Physiological

- Food intake
- Exercises
- Emotion
- Stress

Pathological

- Inflammation
- Cancer

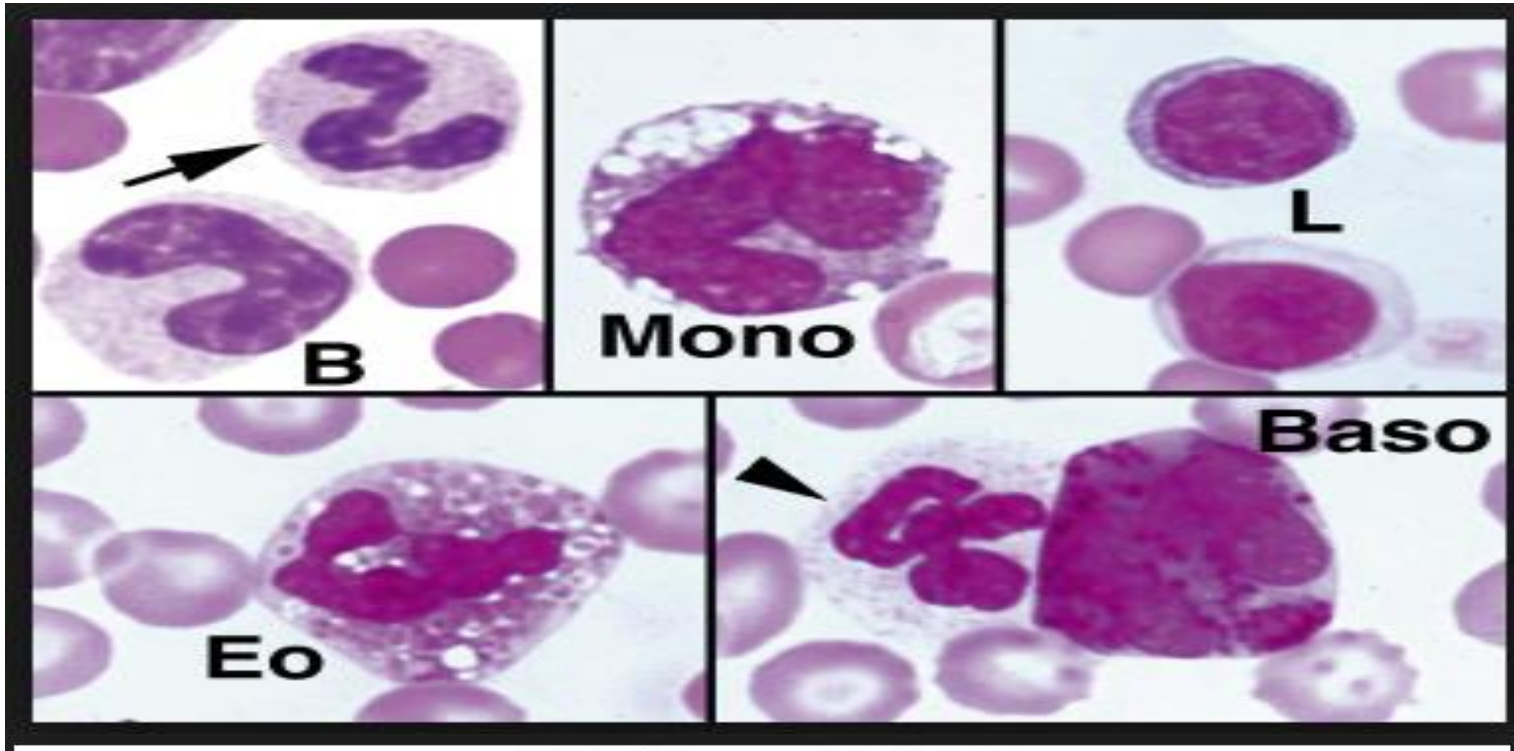
Leucopenia

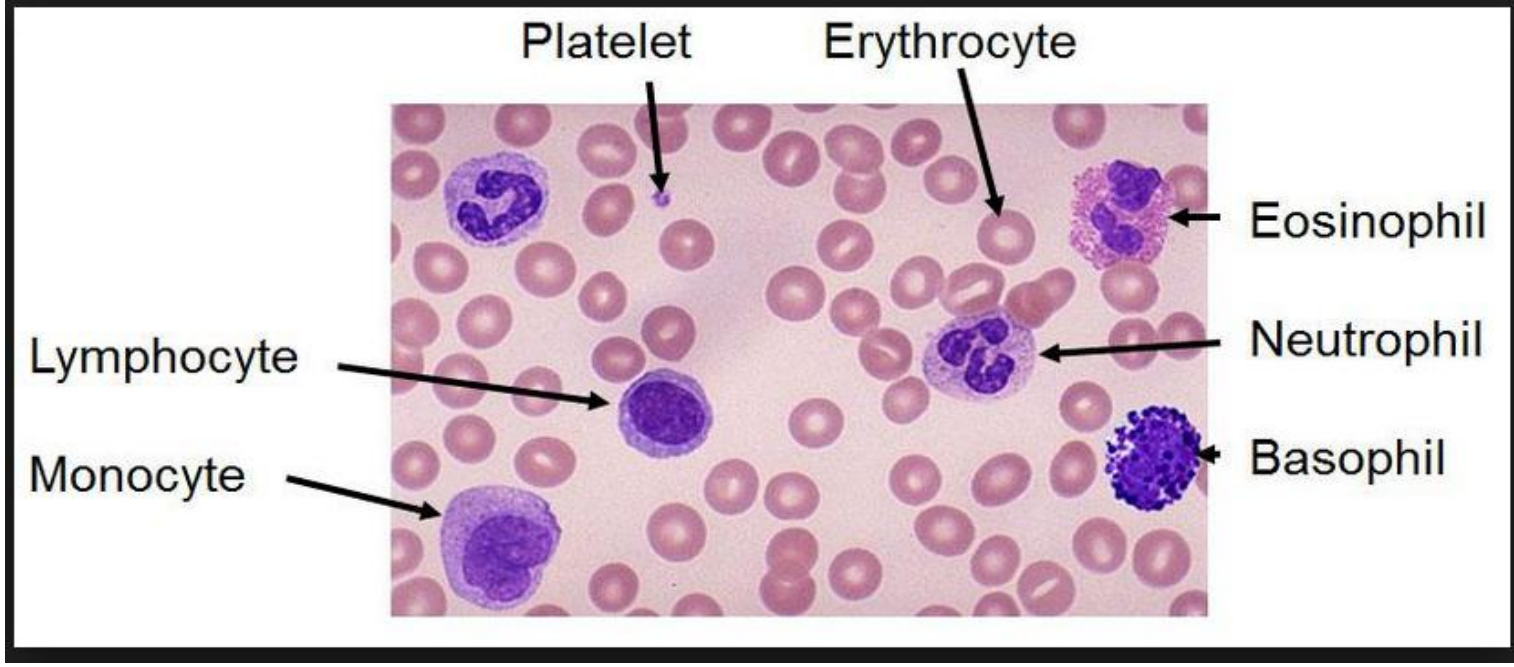
- Abnormally low concentration of leucocytes in blood.
- Only pathological :
  - Severe viral infections
  - Autoimmune disease
  - Chemotherapy
  - Radiation injury

Types of leucocytes

- Leucocytes are of 2 types :

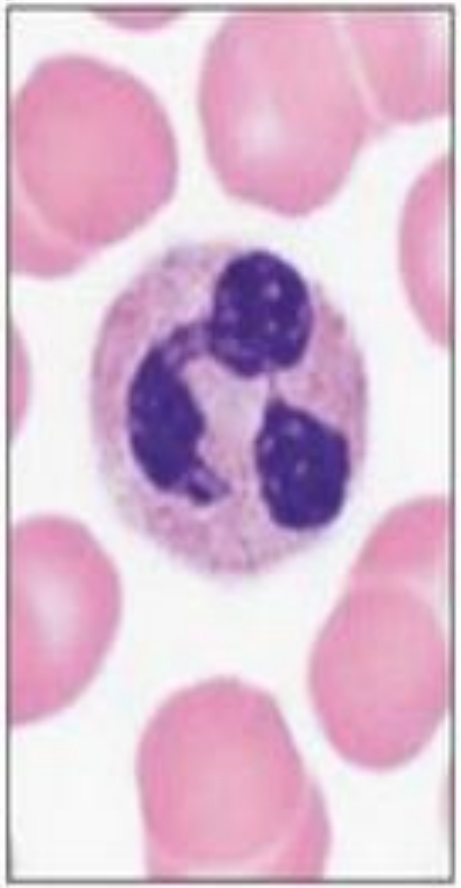
- Granulocytes :
  - Neutrophil
  - Basophil
  - Eosinophil
- Agranulocytes :
  - Monocyte
  - Lymphocyte



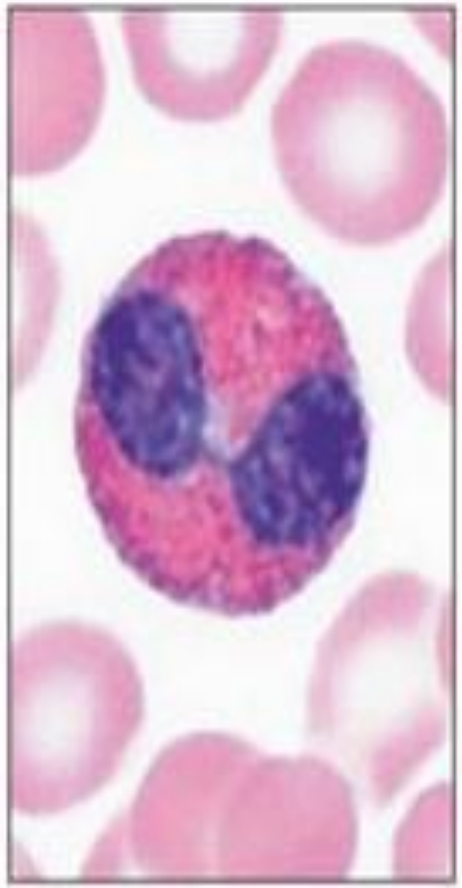


Granulocytes

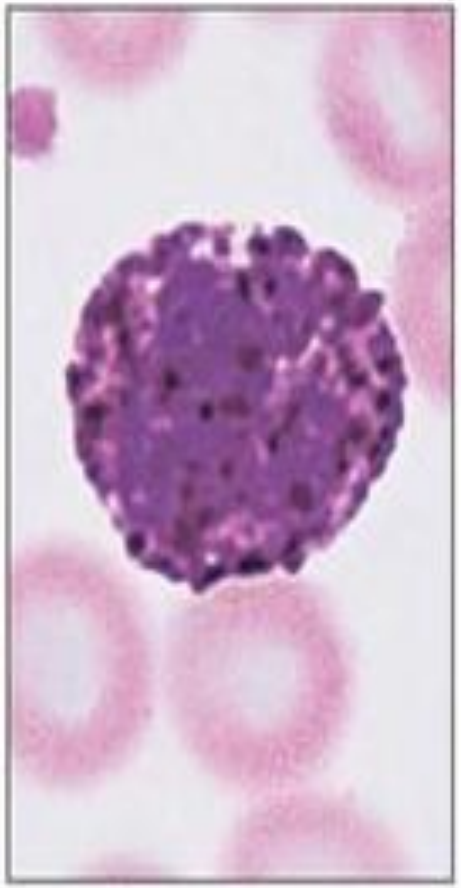
Agranulocytes



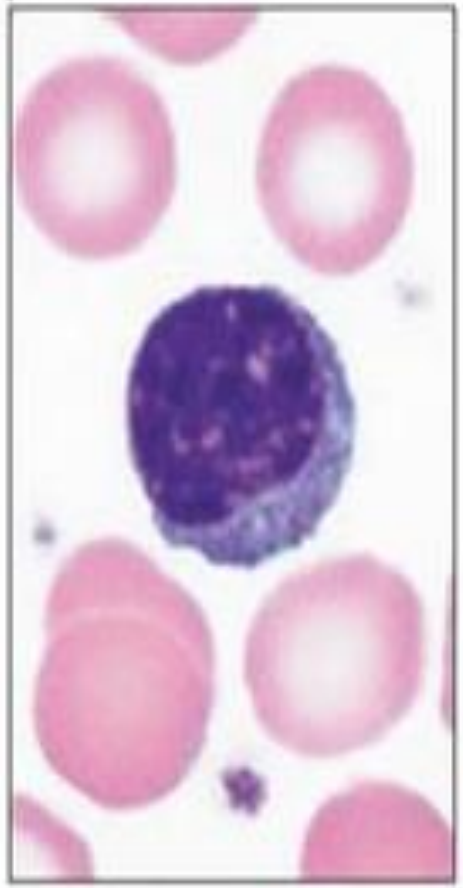
(a) **Neutrophil:** Multilobed nucleus, pale red and blue cytoplasmic granules



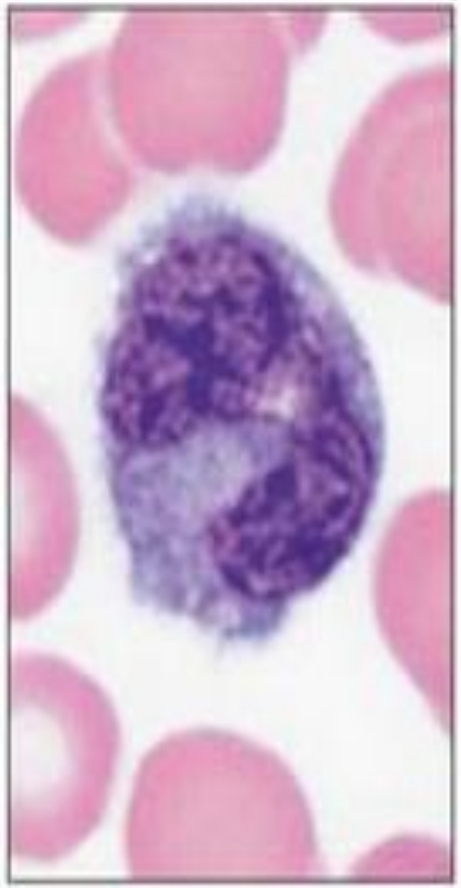
(b) **Eosinophil:** Bilobed nucleus, red cytoplasmic granules



(c) **Basophil:** Bilobed nucleus, purplish-black cytoplasmic granules



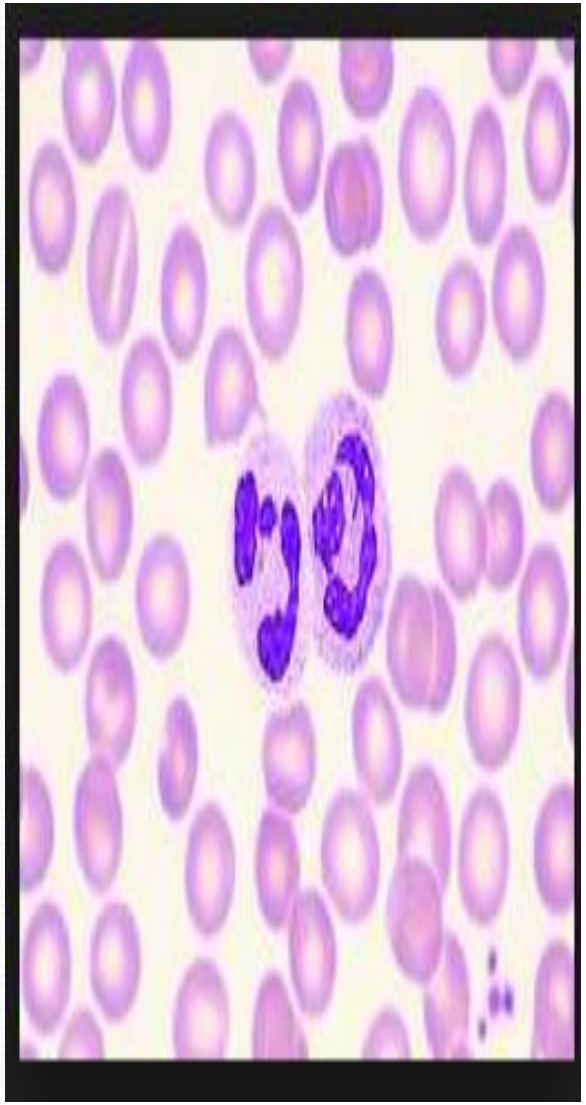
(d) **Lymphocyte (small):** Large spherical nucleus, thin rim of pale blue cytoplasm



(e) **Monocyte:** Kidney-shaped nucleus, abundant pale blue cytoplasm

Neutrophils

- Phagocytosis -cellular ingestion of bacteria with enzymes proteases, peroxidases, cationic proteins
- Microphagocyte – upto 15 or 20 only.

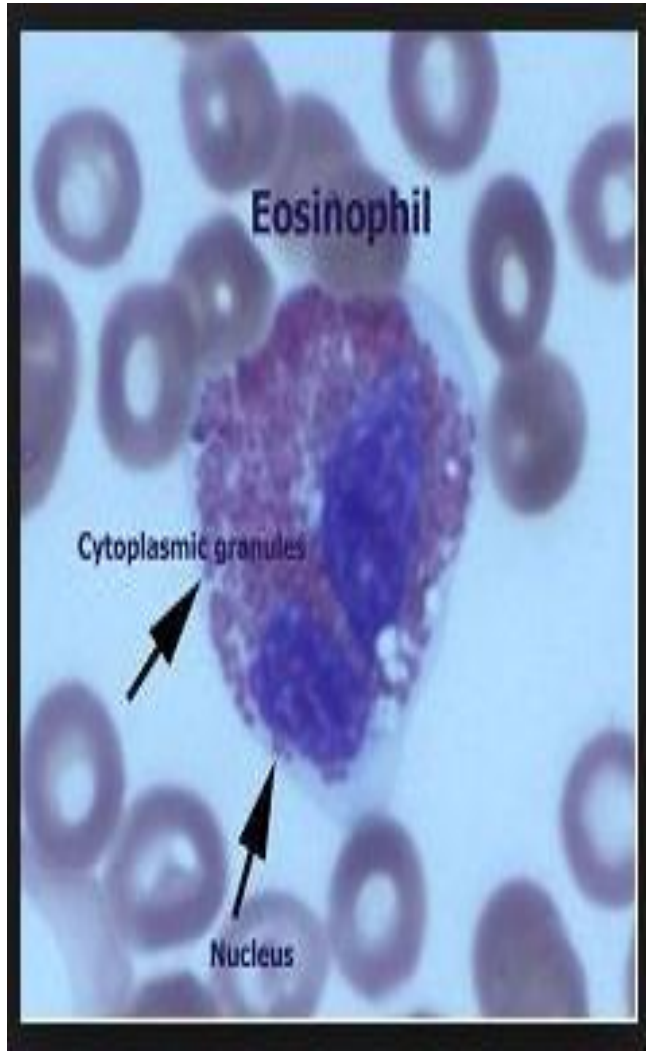


Basophils (0.01-0.1 x 10^9/L)

- Basophils contain :
- Histamine – for vasodilation
- Heparin – anticoagulant
- Has IgE and thus participates in allergic reaction along with mast cells in tissues
- Promotes functions of other leucocytes

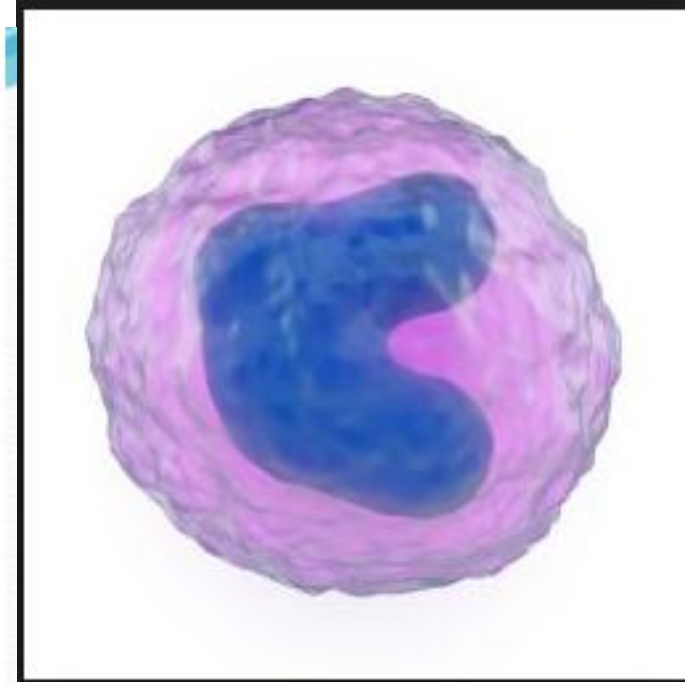
Eosinophils (0.04-0.4 x 10^9/L)

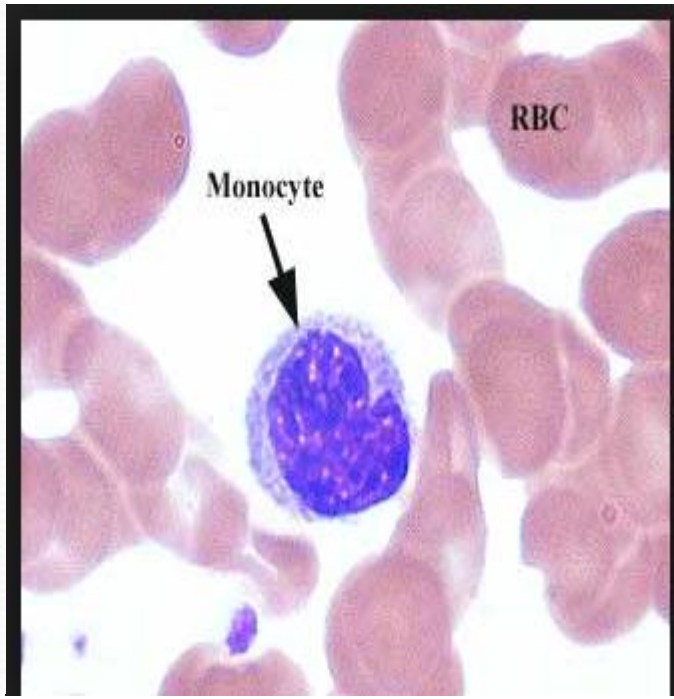
- Eosinophils- Functions :
- They migrate to the site of infection.
- Weak phagocytes.
- Antiparasitic (kills parasites including worms).
- Contains histaminase – and so it reduces allergic reaction.
- Eosinophilia – increased level of eosinophils in the blood.



Monocytes (0.2–0.8 x 10^9/L)

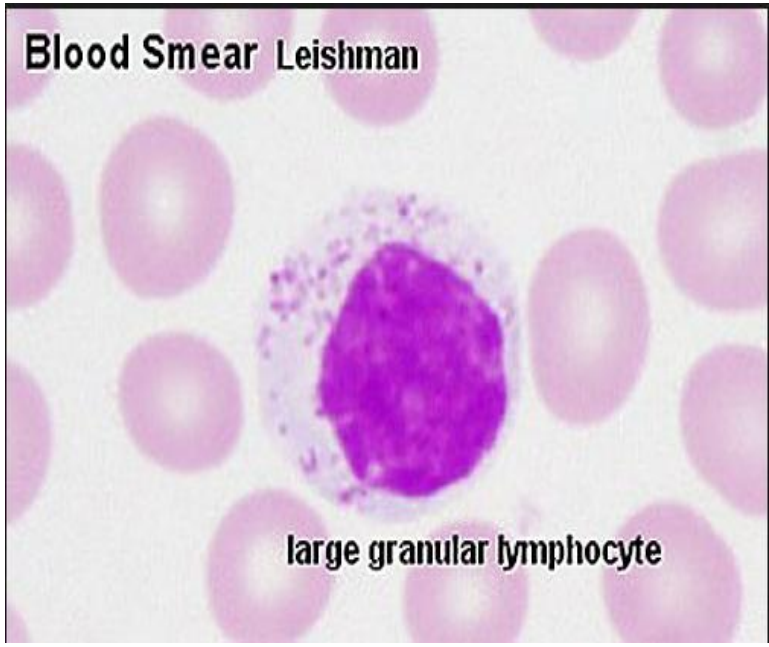
- Monocytes - Functions :
- They differentiate into macrophages which can phagocytose upto 100 bacteria.
- Antigen – presentation function.





Lymphocytes (1.5–3.5 x 10^9/L)

- Provides immunity.
- Two types : B – lymphocytes and T- lymphocytes.
- B – lymphocytes provide humoral immunity.
- T – lymphocytes provides cell-mediated immunity.
- B – cells differentiate into plasma cells which further produces 5 classes of antibodies that provides immunity
- T- cytotoxic cells aims to eliminate :
  - Virus-infected cells
  - Cancer cells

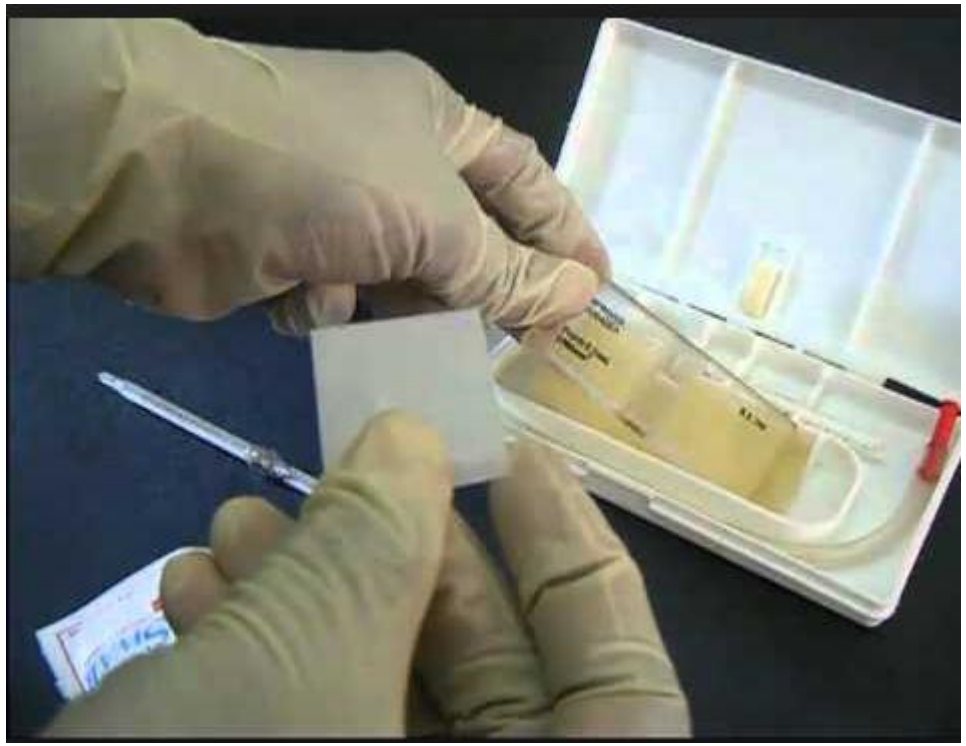


Diagnostic importance

- ↑Neutrophils – inflammation
- ↑Eosinophils – allergy, parasitic infections
- ↓ Eozinophils – stress
- ↑ Lymphocytes – cancer (leukemias – cancerous production of lymphoid cells)

The hemocytometer (counting chamber)

The hemocytometer is a specimen slide which is used to determine the concentration of cells in a liquid sample. It is frequently used to determine the concentration of blood cells (hence the name "hemo-") but also the concentration of sperm cells in a sample.



Agglutination of RBCs

- The clumping of RBCs due to binding of antibody with the corresponding antigen is called haemagglutination.
- Example :

  Anti -A binds A antigen and anti-B binds B antigen
- It has two common uses :
  - Blood typing and
  - The quantification of virus dilutions.

Agglutination

- Agglutinogens (antigens) are proteins that exist on the surface of every red blood cell.
- This agglutinogen , which is present on the surface of RBCs, will stimulate the production of agglutinin (antibody) in the plasma in case of incompatible blood transfusion.
- Helps in determining the blood type of a person.

ABO blood group system

- **According to the ABO blood typing system there are four different kinds of blood types: O, A, B, AB.**
- **I(O) - α,β (40%);**
- **II(A) - β (39%);**
- **III(B) - α (10-15%);**
- **IY(AB) - (5%).**

ABO blood group system

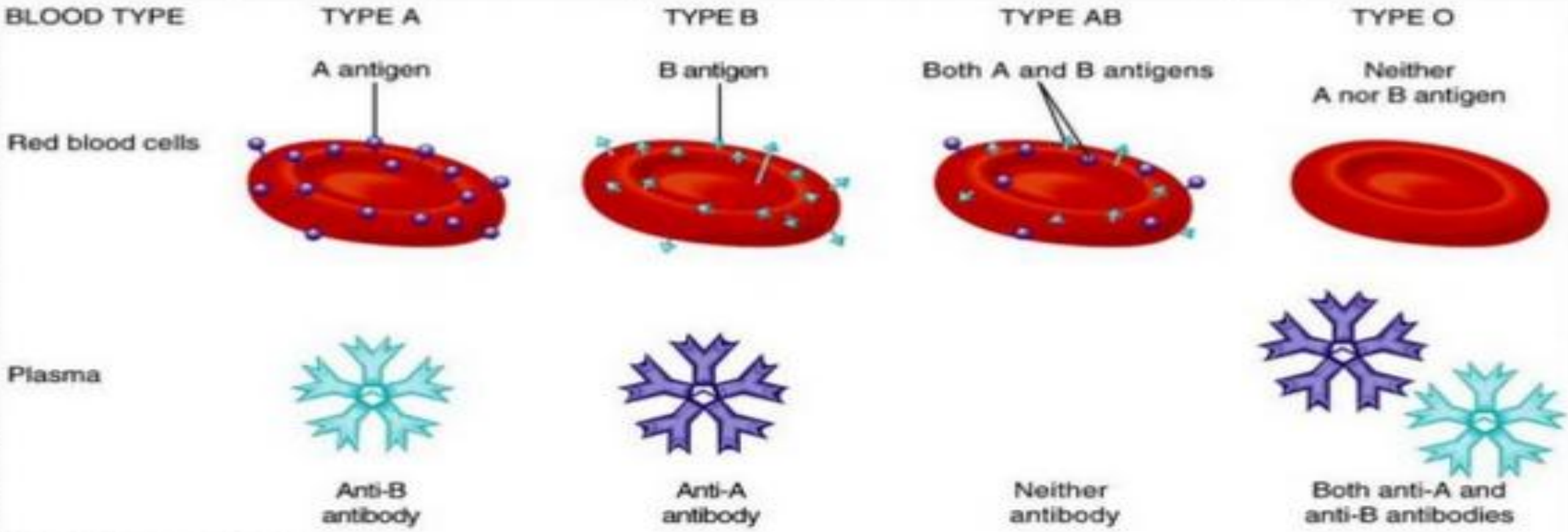


Figure 19.12 Tortora - PAP 12/e

Rhesus (Rh) system

- 85% of the population is - Rh^+
- If Rh-D antigen is present in blood(RBC)
  Rh^+
- If Rh-D antigen is absent in blood(RBC),
  Rh^-
- It is determined by anti-Rh serum.

Rh incompatibility

- **In blood transfusion :**

  Rh^- person cannot receive blood from Rh^+ person, whereas Rh^+ person can receive blood from Rh^- person without any problems.
- **If a Rh^- person receive blood from Rh^+ person for the first time, due to this exposure, there will be formation antibodies(anti-RhD)**
- **So, if a second transfusion is done again with Rh^+ blood, then, the antibodies which are already present causes clumping.**

Rh incompatibility

- **Erythroblastosis fetalis :**

If a Rh^- mother carry a Rh^+ fetus, due to placental barrier the blood doesn't mix. However during delivery some Rh^+ from fetus reaches mother. So,the mother will start producing antibodies against Rh^+ . During consecutive pregnancies, this may cause destruction of RBCs in the fetus causing haemolytic anaemia(erythroblastosis fetalis). So after each pregnancy, the mother will receive anti-RhD (prophylaxis)to prevent this incompatibility.