Medical Biology

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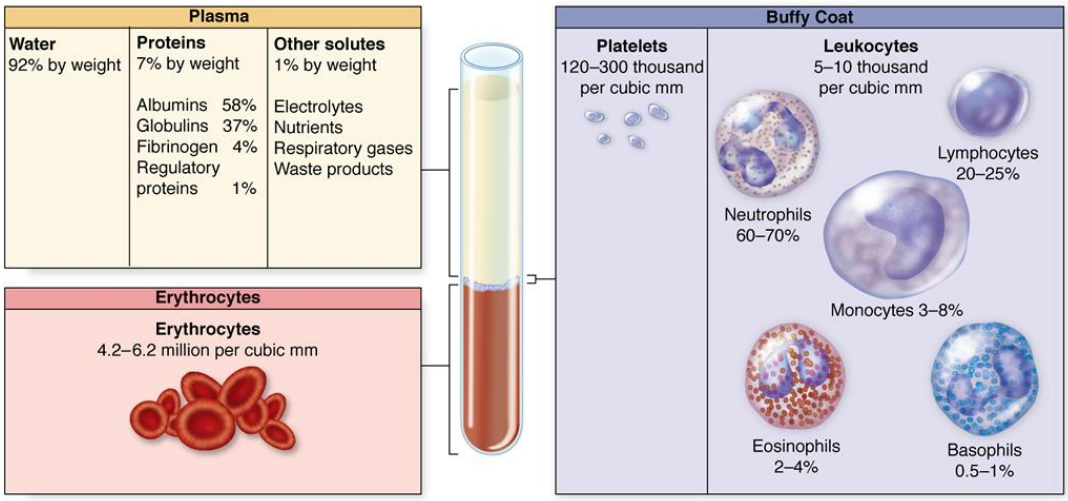
Blood

Blood is a fluid connective tissue consisting of cells suspended in a liquid fibrous matrix. The cells are called formed elements, and the liquid matrix is known as plasma. The formed elements consist of erythrocytes (red blood cells), leukocytes (white blood cells) and platelets. If blood is centrifuged, it divides into 3 portions:
(1) Plasma makes up roughly 55% (upper layer).
(2) Packed RBCs make up roughly 45% (lower layer).
(3) the buffy layer (containing WBCs and platelets) makes up <1% (middle layer).



The % of blood consisting of packed RBCs is known as the haematocrit. Blood's colour ranges from scarlet (oxygen-rich) to dark red (oxygen poor). Its viscosity is 5X that of water, due primarily to the presence of formed elements. Blood pH normally ranges from 7.35-7.45 (slightly alkaline). Blood temperature is typically 100°F. Typical blood volume is 4-5 L for females and 5-6 L for males.

Blood functions:
Blood has 3 main distribution functions:
(1) It carries O2 (from lungs) and nutrients (from GI tract and body stores) to all cells.
(2) It carries wastes from all cells to elimination sites (lungs for CO2; kidneys for nitrogenous wastes).
(3) It carries hormones from endocrine organs to target tissues.
Blood has 3 main regulatory functions:
(1) It regulates body T° by absorbing and distributing heat.
(2) It maintains body pH by virtue of its many buffers.
(3) It maintains adequate fluid volume in the body.
Blood has 2 main protective functions:
(1) It prevents blood loss by initiating clotting mechanisms in response to blood vessel damage.
(2) It prevents infection via WBCs and plasma immune proteins.

Plasma:

It is the straw-colour liquid part of blood. Blood plasma is about 55% of blood volume. 90% of plasma is water. Water acts as a solvent and suspending medium. Solutes dissolved in plasma include plasma proteins, nutrients, electrolytes, respiratory gases, hormones and wastes.

Three major types of plasma proteins are the **albumins, globulins,** and **fibrinogen.** Albumins are the most abundant plasma proteins and contribute most to plasma's osmotic pressure. They also combine with and help transport other organic molecules. The globulins are of three types called alpha, beta, and gamma globulins. Alpha and beta globulins also combine with and help transport substances in the blood such as hormones, cholesterol, and iron. Gamma globulins are also known as antibodies and are produced by plasma cells, not by the liver. Gamma globulins are important in fighting disease- causing pathogens. Fibrinogen is an inactive plasma protein. Once activated, fibrinogen forms a blood clot.

Blood cells:

The blood has 3 major formed elements:

1. Erythrocytes (RBC): function mainly to transport oxygen from the lung to the tissues.
2. Leukocytes (WBC): have a defensive role in destroying infective organisms such as bacteria & viruses as well as assisting in the removal of dead or damaged tissues.
3. Thrombocytes (platelets): are the first line of defense against any damage to blood vessels they adhere to the defect & share in the formation of blood clot.

Erythrocytes:

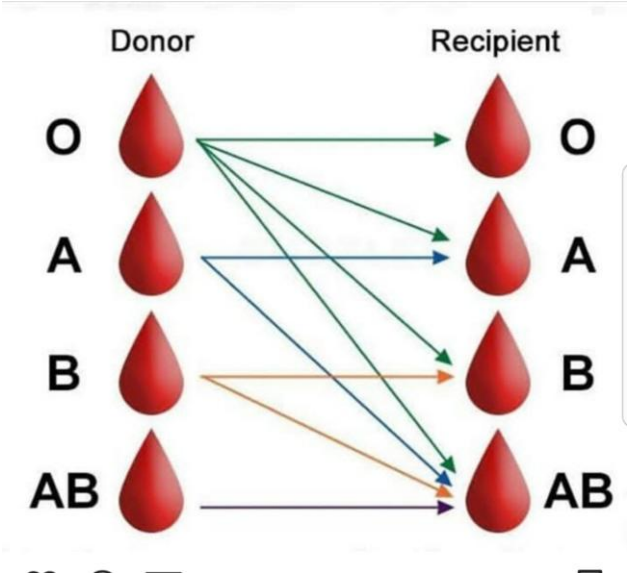
- These are rounded biconcave disks, bright red in color due to the presence of hemoglobin, their biconcave shape will maximize their surface area/ volume ratio so facilitate the gaseous exchange.
- RBCs are about 7.5 µm. in diameter, those RBCs with a diameter more than 9 µm. are called macrocytes, while those with a diameter less then 6µm. are called microcytes.
- RBC count in adult female is about 3.9-5.5 million/microliter, while in adult male it is about 4.1-6 million/microliter. Decrease in the number of RBC in the blood is associated with anemia, while the increase in number is called erythrocytosis or polycythemia.
- Haemoglobin (iron containing protein) is contained in abundance within RBCs. It reversibly binds and releases O2. In lungs, Hb binds O2 and is then oxyhaemoglobin, transport it to body tissue. Blood rich in oxyhaemoglobin are bright red (the arterial blood). In tissues, Hb releases O2 and is then deoxyhaemoglobin or reduced haemoglobin. Haemoglobin carrying CO2 which partly diffuse from the cells and tissues into the blood and carried to the lungs is known as carbaminohaemoglobin which gives venous blood its bluish colour.

- RBCs have no nuclei as they are lost during the process of formation.
- These cells are highly flexible (deformable) so they can pass through the irregular and smallest capillaries.

- RBCs have a short life span of only 100-120 days in circulation, with aging RBCs become less deformable until they cannot pass through the splenic microcirculation and so they will be removed by phagocytosis.
- The extracellular surface of the RBC plasmalemma has specific inherited antigens and thus determine the blood group. The most notable of these are the A and B antigens, which determine the 4 blood groups, A, B, AB, and O.

ABO blood groups system

Blood groups	Antigen present in the surface of RBC	Antibodies present in the plasma
A	Antigens A	b
B	Antigens B	a
AB	Antigens A and B	Neither antibodies a nor b
O	Neither Antigen A nor B	Antibodies a and b

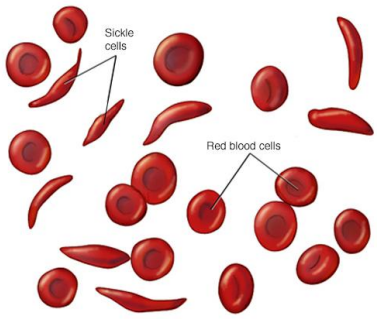


Disorders Involving Red Blood Cells

When there is an insufficient number of red blood cells or the cells do not have enough hemoglobin, the individual suffers from **anemia** and has a tired, run-down feeling. Iron, vitamin B12, and folic acid are necessary to produce red blood cells. ***Iron-deficiency anemia*** is the most common form. It results from inadequate intake of dietary iron, which causes insufficient hemoglobin synthesis. A lack of vitamin B12 causes ***pernicious anemia***, in which stem-cell activity is reduced due to inadequate DNA production. Consequently, fewer red blood cells are produced. ***Folic-acid-deficiency anemia*** also leads to a reduced number of RBCs, particularly during pregnancy. Pregnant women should consult with their health-care provider about the need to increase their intake of folic acid, because a deficiency can led to birth defects in the newborn.

Autoimmune hemolytic anemia causes the immune system to destroy the red blood cells faster than the body can replace them. This results in having too few RBCs. In hemolytic anemia, the rate of red blood cell destruction increases.

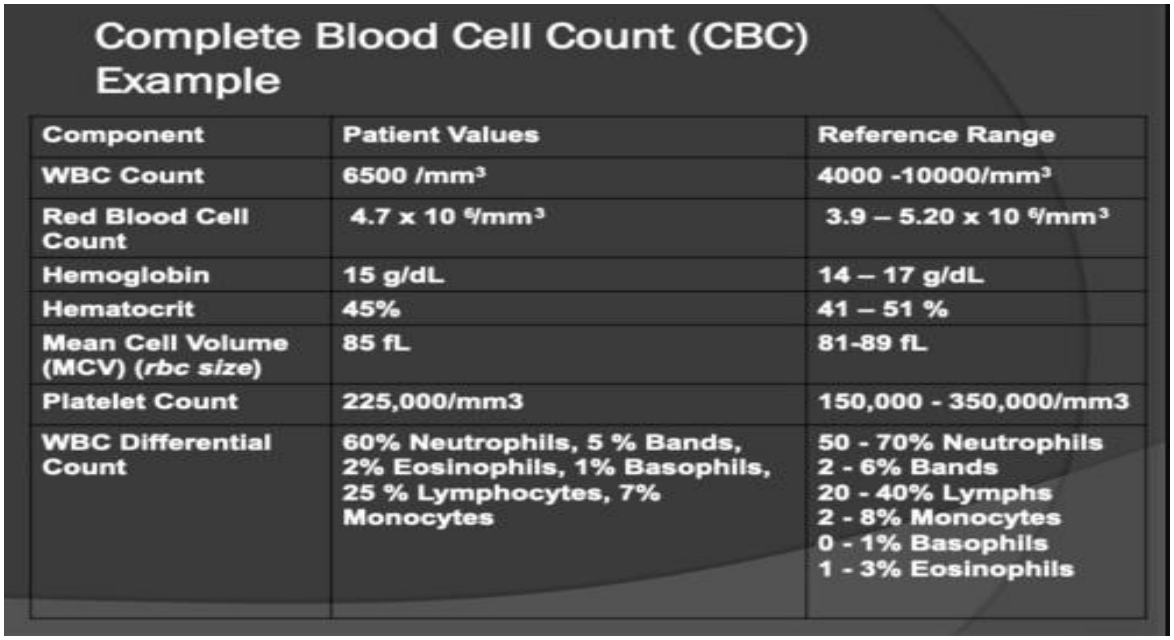
Sickle-cell anemia is a hereditary condition in which the individual has sickle-shaped red blood cells that tend to rupture as they pass through the narrow capillaries. The problem arises because the protein in two of the four chains making up hemoglobin is abnormal. The life expectancy of sickle shaped red blood cells is about 90 days instead of 120 days.



Clinical Notes:

Complete Blood Count (CBC) Test

A complete blood count (CBC) is a test that counts the cells that make up the blood: red blood cells, white blood cells, and platelets.



Complete Blood Cell Count (CBC) Example

Component	Patient Values	Reference Range
WBC Count	6500 /mm³	4000 -10000/mm³
Red Blood Cell Count	4.7 x 10 ⁶/mm³	3.9 – 5.20 x 10 ⁶/mm³
Hemoglobin	15 g/dL	14 – 17 g/dL
Hematocrit	45%	41 – 51 %
Mean Cell Volume (MCV) (*rbc size*)	85 fL	81-89 fL
Platelet Count	225,000/mm3	150,000 - 350,000/mm3
WBC Differential Count	60% Neutrophils, 5 % Bands, 2% Eosinophils, 1% Basophils, 25 % Lymphocytes, 7% Monocytes	50 - 70% Neutrophils 2 - 6% Bands 20 - 40% Lymphs 2 - 8% Monocytes 0 - 1% Basophils 1 - 3% Eosinophils

It is done as a routine checkup or to:

1. Check for anemia.
2. to explain symptoms like weakness, fever, bruising, or feeling tired.
3. See how medications, medical conditions, or treatments like chemotherapy are affecting the blood.

What Does a CBC Measure?

1. White blood cells (**WBCs**).
2. Red blood cells (**RBC**).
3. Hemoglobin (**Hb or Hgb**).
4. Hematocrit (**Hct**). This test tells how much blood is made up of red blood cells. A low score may be a sign that there is not enough iron. A high score could mean dehydration or another condition.
5. Mean corpuscular volume (**MCV**). This is the average size of the red blood cells.
6. Platelets.

Leukocytes:

- Those are spherical cells that circulate in the blood until they migrate to the tissues. So, many functions of WBCs took place when they leave the circulation to enter the tissues.
- The no. of leukocytes (WBC) is much smaller than that of RBCs, in fact in a normal adult there are only between (6000-10,000) WBCs per µL of blood.
- According to the presence or absence of granules in their cytoplasm & according to the shape of the nucleus, the WBCs are classified into two groups:

    1. Granulocytes: (polymorphonuclear leukocytes) because their cytoplasm contains prominent granules. They are Neutrophils, Eosinophils & Basophils.
    2. Agranulocytes: (mononuclear leukocytes) they do not contain specific granules. They are Lymphocytes & Monocytes.

Leukocytes are an important part of the defense mechanism against foreign materials, while they are circulating in the blood, they are spherical non motile cells, they leave the capillary by passing between the endothelial cells and they are normally found in the tissues.