

The blood volume of an adult correlates with his or her body mass and amounts to ca. 4-4.5L in women and 4.5-5L in men of 70kg BW. The functions of blood include:

1. The transport of various molecules (O₂, CO₂, nutrients, metabolites, vitamins, electrolytes, etc.)
2. Regulation of body temperature.
3. Transmission of signals (hormones).
4. Buffering.
5. Immune defense.

The blood consists of a fluid (plasma) and formed elements: Red blood cells (RBCs), White blood cells (WBCs), and platelets (thrombocytes).

The formation of blood cells occurs in the red bone marrow of flat bone in adults and in the spleen and liver of the fetus. Hematopoietic tissues contain pluripotent stem cells which, with the aid of hematopoietic growth factors, develop into myeloid, erythroid and lymphoid precursor cells.

Plasma physiology

Plasma is the fluid portion of the blood in which electrolytes, nutrients, metabolites, vitamins, hormones, gases, and proteins are dissolved.

Plasma proteins are involved in humoral immune defense and maintain oncotic pressure, which helps to keep the blood volume constant. By binding to plasma proteins, compounds insoluble in water can be transported in blood, and many substances (e.g., hem) can be protected from breakdown and renal excretion. The binding of small molecules to plasma protein reduces their osmotic efficacy, many plasma proteins are involved in blood clotting and fibrinolysis.

Serum forms when fibrinogen separates from plasma in the process of blood clotting.

RBCs physiology:

The major functions of erythrocytes are to carry oxygen taken in by the lungs and carbon dioxide produced by cells. RBCs contain a large amount of the protein hemoglobin with which O₂ and CO₂ reversibly combine. Hemoglobin also plays an important role in a buffering to keep the Acid-Base balance.

Erythrocytes have the shape of a biconcave disk, that is, a disk thicker at the edge than in the middle, like a doughnut with a center depression on each side instead of a hole. This shape and their small size (7µm in diameter) impart to them a high surface-to-volume ratio, so that oxygen and carbon dioxide can diffuse rapidly to from the interior cell. The plasma membrane of erythrocytes contains specific polysaccharides and proteins that differ from person to person, and these confer upon the blood its so-called type, or group.

The site of erythrocyte production is the bone marrow, specifically the red bone marrow. With differentiation, the erythrocyte precursors produce hemoglobin but then they ultimately lose their

nuclei and organelles-their machinery for protein synthesis. Young erythrocytes in the bone marrow still contain a few ribosomes. These young erythrocytes called reticulocyte. Normally, only mature erythrocytes, which have lost these ribosomes, leave the bone marrow and enter the general circulation.

The average life span of an erythrocyte is approximately 120 days, which means that almost 1% of the body's erythrocytes are destroyed and must be replaced every day. Erythrocyte destruction normally occurs in the spleen and the liver. Most of the iron released in the process is conserved. The major breakdown product of heme is bilirubin, which gives plasma its color.

The production of erythrocytes requires the usual nutrients needed to synthesize any cell: amino acids, lipids, and carbohydrates. In addition, both iron and certain growth factors, including folic acid and vitamin B₁₂, are essential.

1. **Iron:** is the element to which oxygen binds on a hemoglobin molecule within an erythrocyte, small amounts of iron are lost from the body via the urine, feces, sweat, and cells sloughed from the skin. In addition, women lose a similar amount via menstrual blood. In order to remain in iron balance, the amount of iron lost from the body must be replaced by ingestion of iron-containing foods; particularly rich sources are meat, liver, egg yolk, beans, nuts, and cereals. A significant upset of iron balance can result either in iron deficiency, leading to inadequate hemoglobin production, or in an excess of iron in the body, with serious toxic effects.
2. **Folic acid:** a vitamin found in large amounts in leafy plants, yeast, and liver, is required for synthesis of the nucleotide base thymine. It is, therefore, essential for the formation of DNA and hence for normal cell division. When this vitamin is not present in adequate amounts, impairment of cell division occurs throughout the body but is most striking in rapidly proliferating cells, including erythrocyte precursors. Thus, fewer erythrocytes are produced when folic acid is deficient.
3. **Vitamin B₁₂:** production of normal erythrocyte numbers also requires extremely small quantities of a cobalt-containing molecule, vitamin B₁₂, since this vitamin is required for the action of folic acid. Vitamin B₁₂ is found only on animal products, and strictly vegetarian diets may be deficient in it. The absorption of vitamin B₁₂ from the gastrointestinal tract requires a protein called intrinsic factor, which is secreted by the stomach; lack of this protein also causes vitamin B₁₂ deficiency. Unlike folic acid, vitamin B₁₂ is also needed for myelin formation, so a variety of neurological symptoms may accompany the poor erythrocyte production when vitamin B₁₂ is deficient.

Regulation of Erythrocyte Production:

In a normal person, the total volume of circulating erythrocytes remains remarkably constant because of reflexes that regulate the bone marrow's production of these cells. In the previous section, we stated that iron, folic acid, and vitamin B₁₂ must be present for normal erythrocyte production. Other factors that regulate production rate are:

1. **Erythropoietin hormone:** the direct control of erythrocyte production is exerted primarily by a hormone called erythropoietin, which is secreted into the blood mainly by a particular group of hormone-secreting connective tissue cells in the kidneys. It acts on the bone marrow to stimulate the proliferation of erythrocyte progenitor cells and their differentiation into erythrocytes.
2. **Tissue oxygenation:** erythropoietin is normally secreted in relatively small amounts, which stimulate the bone marrow to produce erythrocytes at a rate adequate to replace the usual loss. This rate is increased above basal values when there is a decreased oxygen delivery to the kidneys. Situation in which this occurs include insufficient pumping of blood by the heart, lung disease, anemia, and exposure to high altitude.
3. **Testosterone:** the male sex hormone stimulates the release of erythropoietin. This may account, at least in part, for the higher hemoglobin concentration in men than in women.

Anemia:

Is defined as a decrease in the ability of the blood to carry oxygen due to:

1. A decrease in the total number of erythrocytes, each having a normal quantity of hemoglobin.
2. A diminished concentration of hemoglobin per erythrocyte.
3. A combination of both.

Laboratory evaluation of anemia starts with analysis of a blood sample for the concentration of hemoglobin, the number of erythrocytes, and the average erythrocyte size.

Average cell size is particularly useful since it correlates well with several common types of anemia:

1. **Microcytosis** (small cell) most common occurs in iron deficiency anemia.
2. **Normocytosis** (normal size cell) accompanies acute blood loss.
3. **Macrocytosis** (large cell) is characteristic of vitamin B₁₂ or folic acid deficiency. This is due to delayed cell division because of the decrease in DNA caused by these vitamin deficiencies.

Sickle-cell anemia (polycythemia) is due to a genetic mutation that alters one amino acid in globin chain. At the low oxygen concentrations existing in many capillaries, the abnormal hemoglobin molecules interact with each other to form fiber-like structures that distort the erythrocyte membrane and cause the cell to form sickle shapes or other bizarre forms. This results both in the blockage of capillaries, with consequent tissue damage and pain, and in the destruction of the deformed erythrocytes, with consequent anemia.

WBs physiology:

They are classified according to their structure and affinity for various dyes:

- Granulocytes: refers to the three types
 1. Eosinophils
 2. Basophils

3. Neutrophils
- Agranulocytes: refers to the two types
 1. Monocyte
 2. Lymphocyte

These cells play an important role in the body's defenses (Innate and Specific Immunity).

Platelets physiology:

The circulating platelets are colorless cell fragment that contain numerous granules and are much smaller than RBs. Platelets are produced when portions of large bone marrow cells, termed megakaryocytes, become pinched off and enter the circulation. Platelets functions in blood clotting by forms the platelet plug.