Al mustaqbal university college

Medical laboratories techniques

Human physiology

Blood composition

By

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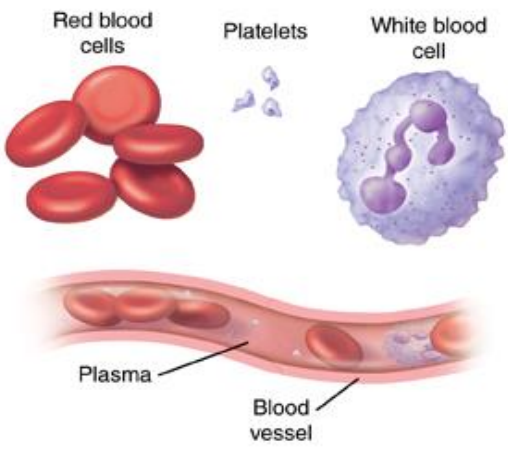
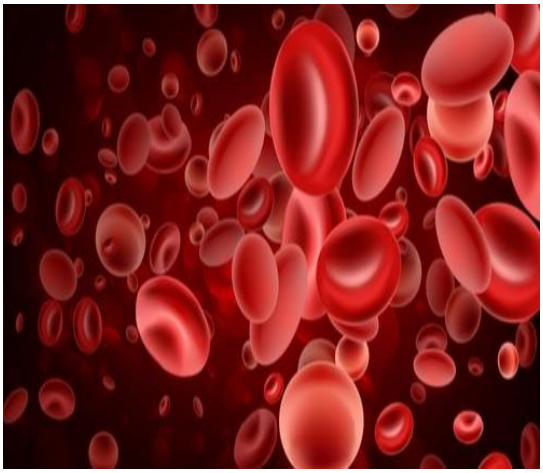




Introduction

Approximately 8% of an adult's body weight is made up of blood.

- Females have around 4-5 litres, while males have around 5-6 liters. This difference is mainly due to the differences in body size between men and women.

- It has a pH of 7.35-7.45, making it slightly basic (less than 7 is considered acidic).

- Whole blood is about 4.5-5.5 times as viscous as water, indicating that it is more resistant to flow than water. This viscosity is vital to the function of blood because if blood flows too easily or with too much resistance, it can strain the heart and lead to severe cardiovascular problems.

- Blood in the arteries is a brighter red than blood in the veins because of the higher levels of oxygen found in the arteries.

Composition of blood

Blood is classified as a connective tissue and consists of two main components:

1. Plasma, which is a clear extracellular fluid

2. Formed elements, which are made up of the blood cells and platelets The formed elements are so named because they are enclosed in a plasma membrane and have a definite structure and shape.

All formed elements are cells except for the platelets, which are tiny fragments of bone marrow cells.

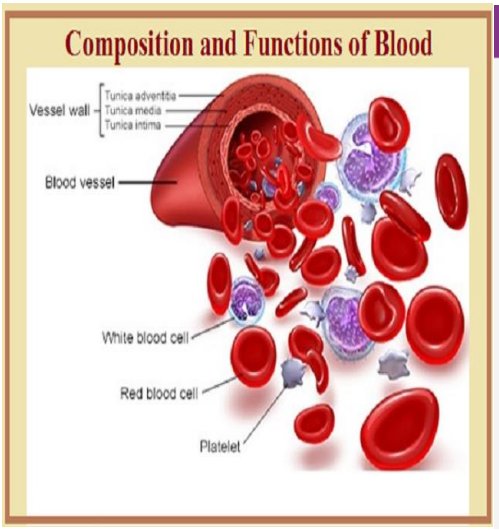
Formed elements are:

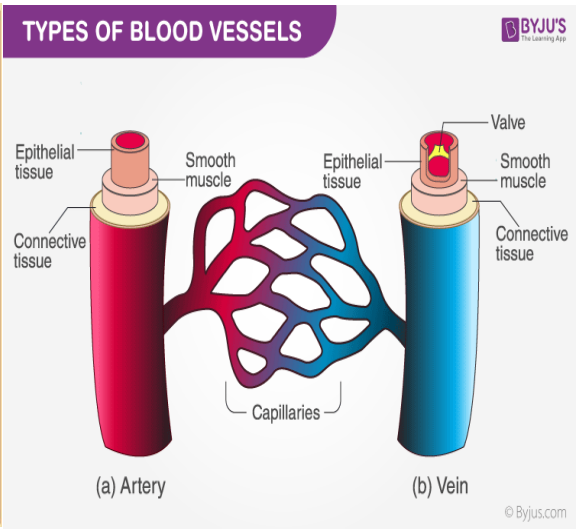
- Erythrocytes, also known as red blood cells (RBCs)

- Leukocytes, also known as white blood cells (WBCs)

- Platelets Leukocytes are further classified into two subcategories called granulocytes which consist of neutrophils, eosinophils and basophils; and agranulocytes which consist of lymphocytes and monocytes. The formed elements can be separated from plasma by centrifuge, where a blood sample is spun for a few minutes in a tube to separate its components according to their densities

RBCs are denser than plasma, and so become packed into the bottom of the tube to make up 45% of total volume. This volume is known as the haematocrit. WBCs and platelets form a narrow cream-coloured coat known as the buffy coat immediately above the RBCs. Finally, the plasma makes up the top of the tube, which is a pale yellow colour and contains just under 55% of the total volume.





Blood plasma

Blood plasma is a mixture of proteins, enzymes, nutrients, wastes, hormones and gases. The specific composition and function of its components are as follows:

Proteins

These are the most abundant substance in plasma by weight and play a part in a variety of roles including clotting, defence and transport. Collectively, they serve several functions:

They are an important reserve supply of amino acids for cell nutrition. Cells called macrophages in the liver, gut, spleen, lungs and lymphatic tissue can break down plasma proteins so as to release their amino acids. These amino acids are used by other cells to synthesise new products.

• Plasma proteins also serve as carriers for other molecules. Many types of small molecules bind to specific plasma proteins and are transported from the organs that absorb these proteins to other tissues for utilization. The proteins also help to keep the blood slightly basic at a stable pH. They do this by functioning as weak bases themselves to bind excess H+ ions. By doing so, they remove excess H+ from the blood which keeps it slightly basic.

• The plasma proteins interact in specific ways to cause the blood to coagulate, which is part of the body's response to injury to the blood vessels (also known as vascular injury), and helps protect against the loss of blood and invasion by foreign microorganisms and viruses.

• Plasma proteins govern the distribution of water between the blood and tissue fluid by producing what is known as a colloid osmotic pressure. There are three

major categories of plasma proteins, and each individual type of proteins has its own specific properties and functions in addition to their overall collective role:

1-Albumins

which are the smallest and most abundant plasma proteins. Reductions in plasma albumin content can result in a loss of fluid from the blood and a gain of fluid in the interstitial space (space within the tissue), which may occur in nutritional, liver and kidney disease. Albumin also helps many substances dissolve in the plasma by binding to them, hence playing an important role in plasma transport of substances such as drugs, hormones and fatty acids.

2. Globulins

which can be subdivided into three classes from smallest to largest in molecular weight into alpha, beta and gamma globulins. The globulins include high density lipoproteins (HDL), an alpha-1 globulin, and low density lipoproteins (LDL), a beta-1 globulin. HDL functions in lipid transport carrying fats to cells for use in energy metabolism, membrane reconstruction and hormone function. HDLs also appear to prevent cholesterol from invading and settling in the walls of arteries. LDL carries cholesterol and fats to tissues for use in manufacturing steroid hormones and building cell membranes, but it also favours the deposition of cholesterol in arterial walls and thus appears to play a role in disease of the blood vessels and heart. HDL and LDL therefore play important parts in the regulation of cholesterol and hence have a large impact on cardiovascular disease.

3. Fibrinogen

which is a soluble precursor of a sticky protein called fibrin, which forms the framework of blood clot. Fibrin plays a key role in coagulation of blood, which is discussed later in this article under Platelets.

Amino acids

These are formed from the breakdown of tissue proteins or from the digestion of digested proteins.

Nitrogenous waste

Being toxic end products of the break down of substances in the body, these are usually cleared from the bloodstream and are excreted by the kidneys at a rate that balances their production.

Nutrients

Those absorbed by the digestive tract are transported in the blood plasma. These include glucose, amino acids, fats, cholesterol, phospholipids, vitamins and minerals.

Gases

Some oxygen and carbon dioxide are transported by plasma. Plasma also contains a substantial amount of dissolved nitrogen.

Electrolytes

The most abundant of these are sodium ions, which account for more of the blood's osmolarity than any other solute.

Red Blood Cells

Red blood cells (RBCs), also known as erythrocytes, have two main functions:

1. To pick up oxygen from the lungs and deliver it to tissues elsewhere

2. To pick up carbon dioxide from other tissues and unload it in the lungs An erythrocyte is a disc-shaped cell with a thick rim and a thin sunken centre.

The plasma membrane of a mature RBC has glycoproteins and glycolipids that determine a person's blood type. On its inner surface are two proteins called spectrin and actin that give the membrane resilience and durability.

This allows the RBCs to stretch, bend and fold as they squeeze through small blood vessels, and to spring back to their original shape as they pass through larger vessels.

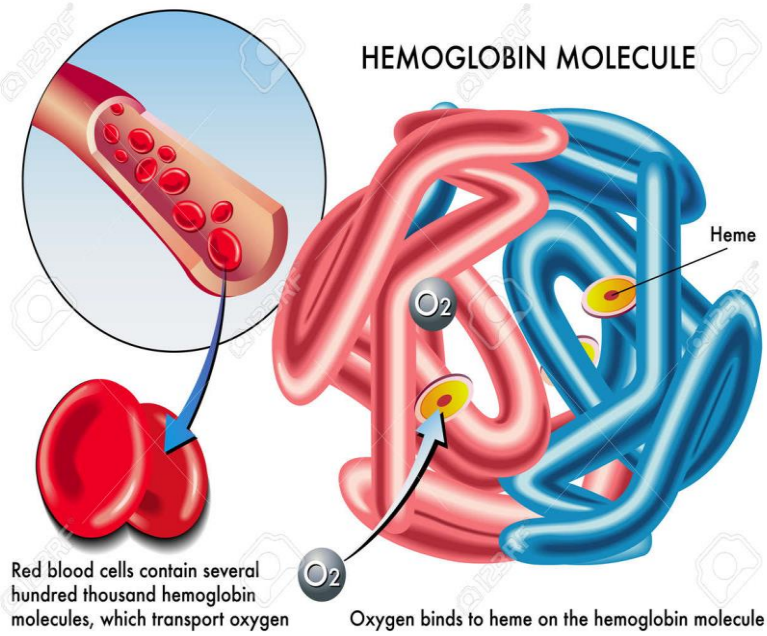
RBCs are incapable of aerobic respiration, preventing them from consuming the oxygen they transport because they lose nearly all their inner cellular components during maturation. The inner cellular.

components lost include their mitochondria, which normally provide energy to a cell, and their nucleus, which contains the genetic material of the cell and enable it to repair itself. The lack of a nucleus means that RBCs are unable to repair themselves.

However, the resulting biconcave shape is that the cell has a greater ratio of surface area to volume, enabling O_2 and CO_2 to diffuse quickly to and from Hb.

The cytoplasm of a RBC consists mainly of a 33% solution of haemoglobin (Hb), which gives RBCs their red colour.

Haemoglobin carries most of the oxygen and some of the carbon dioxide transported by the blood.



Circulating erythrocytes live for about 120 days. As a RBC ages, its membrane grows increasingly fragile. Without key organelles such as a nucleus or ribosomes, RBCs cannot repair themselves. Many RBCs die in the spleen, where they become trapped in narrow channels, broken up and destroyed.

Hemolysis refers to the rupture of RBCs, where haemoglobin is released leaving empty plasma membranes which are easily digested by cells known as macrophages in the liver and spleen.

The Hb is then further broken down into its different components and either recycled in the body for further use or disposed of.

White blood cells(WBCs)

are also known as leukocytes. They can be divided into granulocytes and agranulocytes.

The former have cytoplasms that contain organelles that appear as coloured granules through light microscopy, hence their name. Granulocytes consist of neutrophils, eosinophils and basophils. In contrast, agranulocytes do not contain granules. They consist of lymphocytes and monocytes.

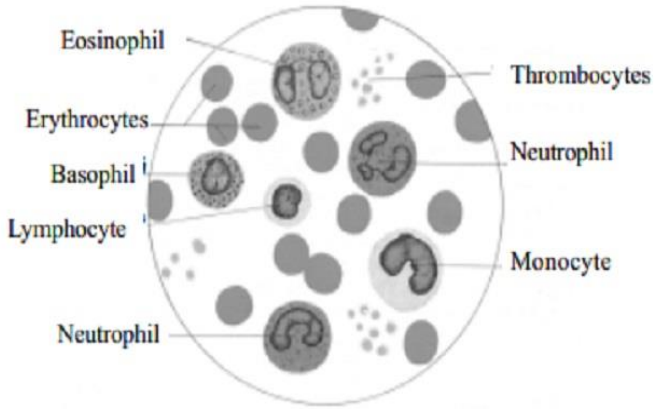


Fig. - Blood cells viewed through a microscope

Granulocytes

1. **Neutrophils**: These contain very fine cytoplasmic granules that can be seen under a light microscope. Neutrophils are also called polymorphonuclear (PMN) because they have a variety of nuclear shapes.

They play roles in the destruction of bacteria and the release of chemicals that kill or inhibit the growth of bacteria.

2-Eosinophils: These have large granules and a prominent nucleus that is divided into two lobes. They function in the destruction of allergens and inflammatory chemicals, and release enzymes that disable parasites.

3. **Basophils**: They have a pale nucleus that is usually hidden by granules. They secrete histamine which increases tissue blood flow via dilating the blood vessels, and also secrete heparin which is an anticoagulant that promotes mobility of other WBCs by preventing clotting.

Agranulocytes

1-Lymphocytes: These are usually classified as small, medium or large. Medium and large lymphocytes are generally seen mainly in fibrous connective tissue and only occasionally in the circulation bloodstream. Lymphocytes function in destroying cancer cells, cells infected by viruses, and foreign invading cells.

2. activate other cells of the immune system. They also coordinate the actions of other immune cells, secrete antibodies and serve in immune memory.

3. **Monocytes**: They are the largest of the formed elements. Their cytoplasm tends to be abundant and relatively clear. They function in differentiating into macrophages, which are large phagocytic cells, and digest pathogens, dead neutrophils, and the

debris of dead cells. Like lymphocytes, they also present antigens to activate other immune cells.

Platelets

Platelets are small fragments of bone marrow cells and are therefore not really classified as cells themselves.

Platelets have the following functions:

1. Secrete vasoconstrictors which constrict blood vessels, causing vascular spasms in broken blood vessels

2. Form temporary platelet plugs to stop bleeding 3. Secrete procoagulants (clotting factors) to promote blood clotting

4. Dissolve blood clots when they are no longer needed

5. Digest and destroy bacteria

6. Secrete chemicals that attract neutrophils and monocytes to sites of inflammation
7. Secrete growth factors to maintain the linings of blood vessels The first three functions listed above refer to important haemostatic mechanisms in which platelets play a role in during bleeding: vascular spasms, platelet plug formation and blood clotting (coagulation).

Functions of blood

Blood has three main functions: transport, protection and regulation.

1-Transport

Blood transports the following substances:

- Gases, namely oxygen (O2) and carbon dioxide (CO2), between the lungs and rest of the body

- Nutrients from the digestive tract and storage sites to the rest of the body

- Waste products to be detoxified or removed by the liver and kidney.

Hormones from the glands in which they are produced to their target cells

- Heat to the skin so as to help regulate body temperature.

Protection

Blood has several roles in inflammation:

- Leukocytes, or white blood cells, destroy invading microorganisms and cancer cells
- Antibodies and other proteins destroy pathogenic substances
- Platelet factors initiate blood clotting and help minimize blood loss.

Regulation

Blood helps regulate:

- pH by interacting with acids and bases
- Water balance by transferring water to and from tissues