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Topic: Blood Composition and Function

Blood: Composition and Function

Blood is a red colour pigment that circulates in the body. It contains plasma, red blood cells, white blood cells, and platelets. It performs various functions in the body.

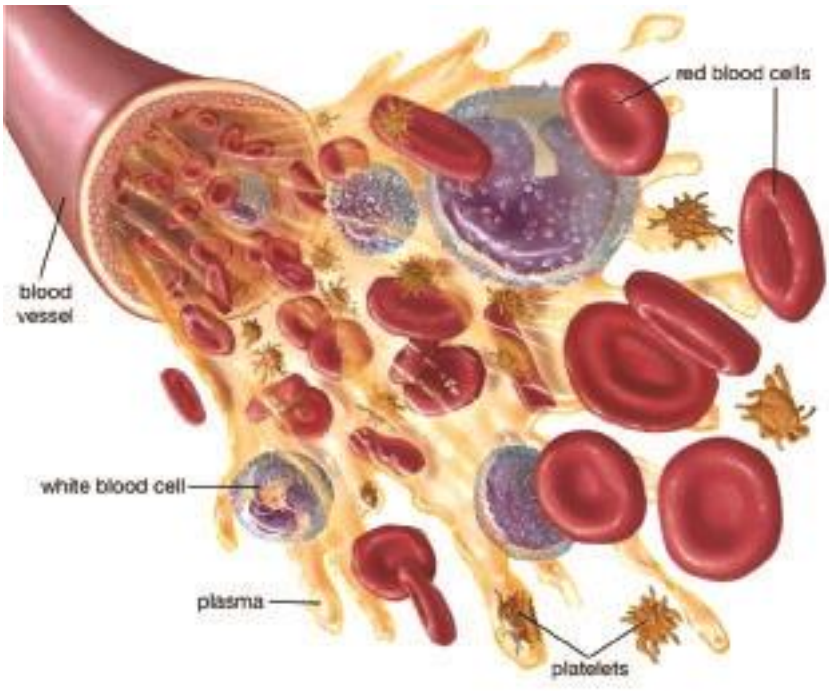

Fig. Composition of Blood

Blood is a connective tissue that helps in the transportation of substances, protects against diseases and regulates the temperature of the body.

It is red in colour due to a red pigment called haemoglobin present in its red cells.

On average, a healthy man has about 5 litres of blood in the body, while a woman has about 500 ml less than man. *So, total blood is about 60-80 ml/kg of body weight.*

Composition of blood:

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

i. Plasma, which is a clear extracellular fluid
ii. 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:

1. Proteins:

- **Albumins**
- **Globulins**
- **Fibrinogen**

These are the most abundant substance in plasma by weight and are an important reserve supply of amino acids for cell nutrition. They play a variety of roles including clotting, defense and transport.

- Macrophages in the liver, gut, spleen, lungs and lymphatic tissue can break down plasma proteins so as to release their amino acids.
- Plasma proteins also serve as carriers for other molecules.
- 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 and helps protect against the loss of blood.
- Plasma proteins govern the distribution of water between the blood and tissue fluid by producing what is known as a colloid osmotic pressure.

2. Amino acids:

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

3. Nitrogenous waste:

Being toxic end products of the breakdown 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.

4. Nutrients:

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

5. Gases:

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

6. 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 maturity.

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 oxyge n 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. Haemolysis 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.

White blood cells:

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:

1. **Neutrophils:**

   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. Lymphocytes function in destroying cancer cells, cells infected by viruses, and foreign invading

cells. In addition, they present antigens to activate other cells of the immune system. They also coordinate the actions of other immune cells, secrete antibodies and serve in immune memory.

2. **Monocytes:**

They are the largest of the formed elements. 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

Production of blood

Haemopoiesis:

Haemopoiesis is the production of the formed elements of blood. Haemopoietic tissues refer to the tissues that produce blood. The earliest haemopoietic tissue to develop is the yolk sac.

In the foetus, blood cells are produced by the bone marrow, liver, spleen and thymus. This change during and after birth. The liver stops producing blood cells around the time of birth, while the spleen stops producing them soon after birth but continues to produce lymphocytes for life.

From infancy onwards, all formed elements are produced in the red bone marrow.

Functions of blood

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

Transport

Blood transports the following substances:

- Gases, namely oxygen (O_2) and carbon dioxide (CO_2), 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 kidneys
- 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 minimise blood loss

Regulation

Blood helps regulate:

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

Blood Grouping:

In 1900-1902, K. Landsteiner classified human blood into four groups A, B, AB and O. The cells of these groups contain corresponding antigens – A, B and AB except O.

That is why O is donated to any of the groups and so is known as *Universal donor*. AB group is known as *Universal recipient* because it can receive A, B, AB, and O blood groups.

Blood Group	Can donate blood to	Can receive blood from
A	A, AB	A and O
B	B, AB	B and O
AB	Only AB	AB, A, B, and O
O	AB, A, B, and O	Only O

Rh factor:

It is a blood antigen discovered in 1940 by Landsteiner and A.S Weiner and played an important role during a blood transfusion. The Rh factor is an agglutinogen found in RBC of most people called Rh+. It was initially found in the rhesus monkey and later in man.

People who do not have this antigen in their blood are called Rh-. The Rh- blood does not carry anti- Rh antibodies naturally but could synthesize them through blood transfusion of Rh+ blood.

If Rh+ blood is transfused into an Rh- patient, the serum will produce anti-Rh agglutinin. If another dose of Rh+ blood is given, the anti-Rh agglutinin will cause clumping of RBC of the donor's blood as soon as it enters the patient receiving it.

Erythroblastosis Foetalis:

If the father's blood is Rh+ and the mother's blood is Rh- then the child to be born dies at the pregnancy or short span of time after birth due to clumping of RBC of the donor's blood by the anti-Rh agglutinin. Basically, this happens in the case of the second issue.