

Body Fluids and Circulation

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- For the healthy functioning of tissues, **all living cells** require a constant supply of:
 - Nutrients
 - Oxygen (O₂)
 - Other essential substances
- Simultaneously, the waste products or harmful substances produced by cellular activities must be removed continuously.

Need for a Transport System

- Efficient mechanisms are essential for:
 - Movement of substances **to** the cells
 - Removal of substances **from** the cells
- Different animal groups have evolved various transport methods based on their level of complexity:

Simple organisms (e.g., sponges and coelenterates):

- Circulate surrounding water through their body cavities
- Facilitates exchange of materials directly with cells

Complex organisms:

- Use special body fluids for internal transport

Types of Body Fluids

1. Blood

- Most commonly used transport fluid in higher organisms, including humans
- Transports a variety of substances throughout the body

2. Lymph (Tissue Fluid)

- Assists in the transport of certain substances, especially in tissue spaces

Blood

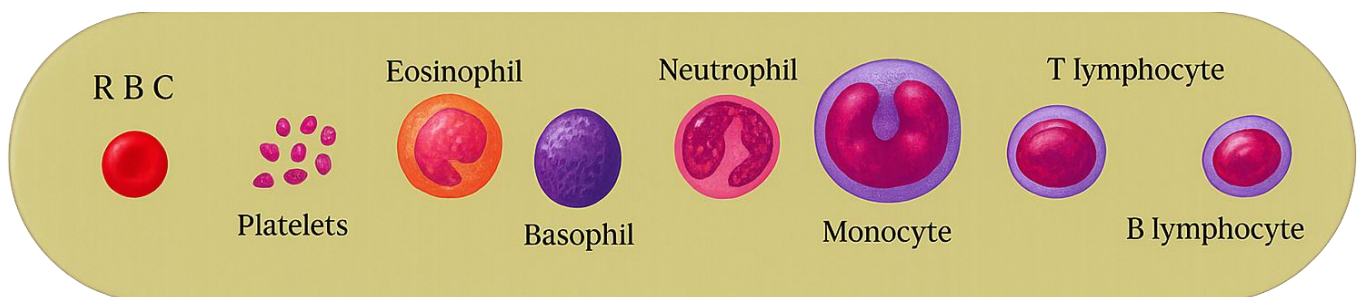
- **Blood** is a specialized connective tissue composed of:
 - A fluid matrix called **plasma**
 - Various formed elements (cells and cell fragments)

Plasma

- **Plasma** is a straw-coloured, viscous fluid that makes up about **55%** of total blood volume.
- It is composed of:
 - **Water (90–92%)** – acts as a solvent and medium for transport
 - **Proteins (6–8%)** – the main plasma proteins are:
 - Fibrinogen – essential for blood clotting
 - Globulins – involved in the immune defense mechanisms
 - Albumins – help maintain the osmotic balance of blood
- Plasma also contains:
 - Mineral ions such as Na^+ , Ca^{2+} , Mg^{2+} , HCO_3^- , Cl^-
 - Nutrients including glucose, amino acids, and lipids
 - Hormones, enzymes, and waste products in transit
 - Coagulation factors in an inactive form

Note: Plasma without clotting factors is called serum.

Formed Elements



Diagrammatic representation of formed elements in blood

The **formed elements** constitute about **45%** of blood and include:

A. Erythrocytes (Red Blood Cells or RBCs)

- Most abundant cells in the blood
- Normal count: 5–5.5 million/ mm^3 in a healthy adult male
- Produced in: Red bone marrow

- Structure: Biconcave, non-nucleated (in most mammals)
- Function: Transport of oxygen and carbon dioxide via hemoglobin, an iron-containing red pigment
- Hemoglobin content: **12–16 g per 100 ml of blood**
- Life span: ~120 days; destroyed in the **spleen** (also known as the "graveyard of RBCs")

B. Leucocytes (White Blood Cells or WBCs)

- Colourless, as they lack hemoglobin
- Nucleated and larger than RBCs
- **Count:** 6000–8000/mm³ of blood
- **Short-lived** cells with defensive functions
- Classified into **two main types**:

1. Granulocytes

- Neutrophils (60–65%) – most abundant; phagocytic; destroy microbes
- Eosinophils (2–3%) – resist infections; involved in allergic responses
- Basophils (0.5–1%) – least abundant; secrete histamine, serotonin, and heparin; involved in inflammatory reactions

2. Agranulocytes

- Lymphocytes (20–25%) – include B and T cells; responsible for specific immune responses
- Monocytes (6–8%) – phagocytic; engulf and digest pathogens

C. Platelets (Thrombocytes)

- Small, disc-shaped cell fragments derived from megakaryocytes in the bone marrow
- **Count:** 150,000–350,000/mm³ of blood
- **Function:** Release substances that aid in blood clotting
- **Clinical Note:** A significant drop in platelet count can lead to clotting disorders, increasing the risk of excessive bleeding

Blood Groups

- Although human blood appears similar, it differs in specific immunological properties.
- Based on these differences, blood grouping systems have been developed.
- The **two most widely used** blood grouping systems are:
 - ABO Blood Grouping
 - Rh (Rhesus) Blood Grouping

ABO Grouping

- Based on the presence or absence of two surface antigens (A and B) on the **red blood cells (RBCs)**.
- Corresponding natural antibodies (anti-A and anti-B) are present in the **plasma**.
- These antigens and antibodies determine the **four** major blood groups: A, B, AB, and O.

Blood Group	Antigens on RBCs	Antibodies in Plasma	Can Donate To	Can Receive From
A	A	Anti-B	A, AB	A, O
B	B	Anti-A	B, AB	B, O
AB	A and B	None	AB	A, B, AB, O (Universal recipient)
O	None	Anti-A and Anti-B	A, B, AB, O (Universal donor)	O

- Key Points:
 - Group O** individuals are called **universal donors** because their RBCs lack A and B antigens, so they can donate to all other groups.
 - Group AB** individuals are **universal recipients** because their plasma contains no antibodies against A or B antigens, allowing them to receive blood from any group.
- Important:** Before any blood transfusion, cross-matching is essential to prevent adverse immune reactions like RBC clumping (agglutination), which can be life-threatening.

Rh Grouping

- The **Rh factor** is another important antigen found on the surface of RBCs.
- It is named after the Rhesus monkey, in which it was first discovered.
 - If the Rh antigen is **present**, the person is said to be **Rh-positive (Rh⁺)**.
 - If the Rh antigen is **absent**, the person is **Rh-negative (Rh⁻)**.
- Rh Incompatibility in Blood Transfusions:
 - An Rh⁻ person should not receive Rh⁺ blood, as their immune system will recognize the Rh antigen as foreign and start producing antibodies against it.
 - A first exposure may not cause a severe reaction, but subsequent exposures can trigger dangerous immune responses.

Special Case: Rh Incompatibility in Pregnancy (Erythroblastosis Foetalis)

- A serious medical condition can arise when an **Rh-negative mother** carries an **Rh-positive foetus**:

First pregnancy:

- Generally safe, as the foetal and maternal blood do not mix significantly due to the placenta acting as a barrier.

During delivery:

- Some Rh⁺ foetal blood cells may enter the mother's bloodstream. Her immune system then starts producing anti-Rh antibodies.

Subsequent pregnancies:

- If the next foetus is also Rh⁺, the **mother's anti-Rh antibodies** can cross the placenta, destroying the foetal RBCs.
- This condition is known as erythroblastosis foetalis.
- It can lead to:
 - Severe anaemia
 - Jaundice
 - Or even death of the foetus
- Prevention:
 - This condition can be prevented by administering anti-Rh antibodies (Rho(D) immunoglobulin) to the **Rh⁻ mother** immediately after the birth of the first **Rh⁺ child**.
 - This prevents the mother's immune system from producing its own **anti-Rh antibodies**

Coagulation of Blood (Blood Clotting)

- When you suffer a **cut or injury**, bleeding usually **stops after some time**.
- This is due to a protective mechanism known as **blood coagulation** or **clotting**, which prevents excessive blood loss.

What is a Blood Clot?

- At the site of injury, a dark reddish-brown scum appears over time.
- This is called a blood clot (coagulum).
- The clot is primarily made of:
 - A mesh of protein threads called fibrins
 - Dead and damaged formed elements (RBCs, WBCs, platelets) trapped within this network

Mechanism of Blood Clotting

1. Fibrin Formation:

- Fibrins are formed by the conversion of inactive fibrinogen (present in plasma) into active fibrin.
- This reaction is catalyzed by the enzyme **thrombin**.

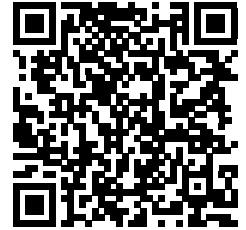


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