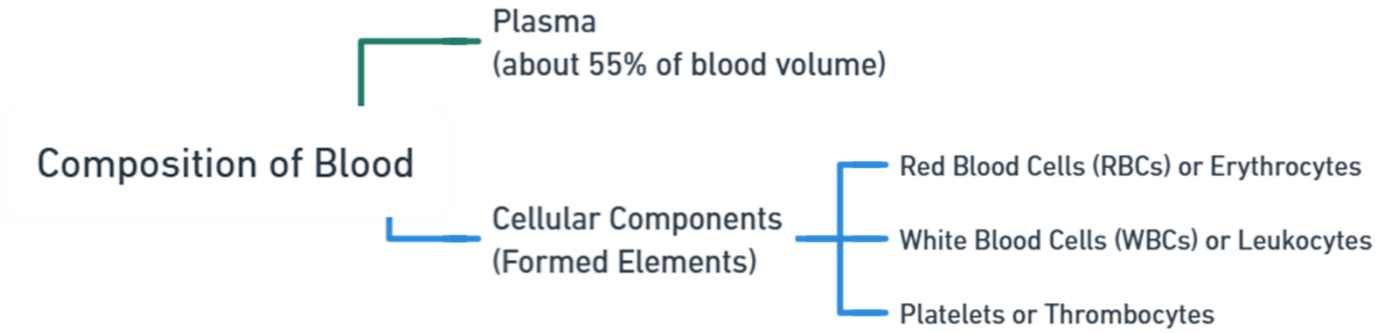
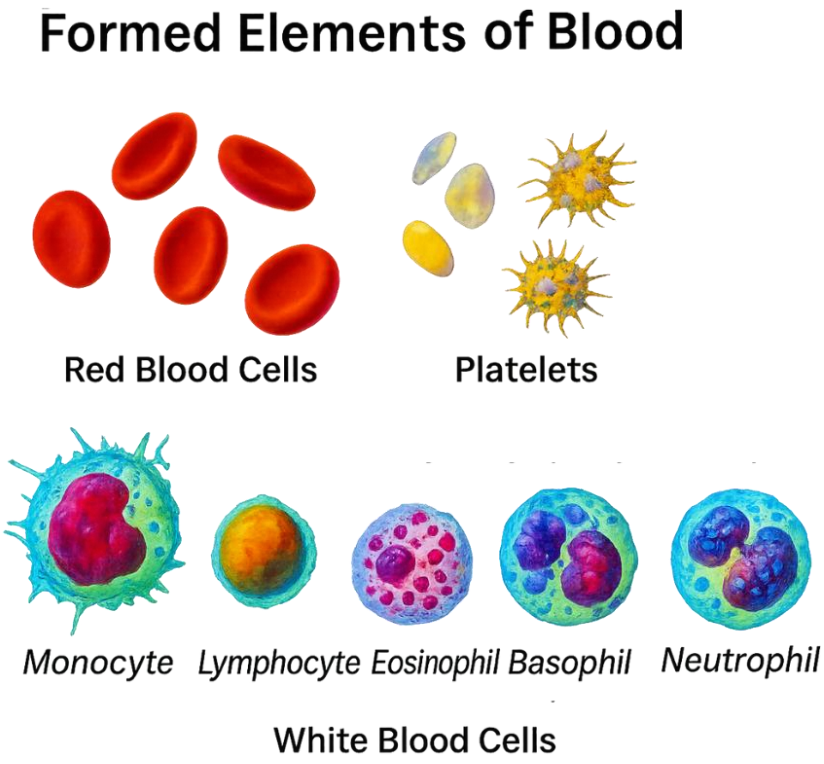
Haemopoetic System

Composition and functions of blood

- Blood is a specialized connective tissue consisting of cells suspended in a liquid matrix called plasma.
- Blood is composed of various cellular components, including red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes), suspended in plasma.
- The red blood cells are responsible for oxygen transport, while white blood cells are involved in immune responses. Platelets aid in clotting.

Composition of Blood





1. Plasma (about 55% of blood volume)

- Plasma is the liquid portion of blood, primarily made of water (about 90%) and contains dissolved proteins, glucose, mineral ions, hormones, and other substances.

Functions:

Transport Medium:

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- Carries nutrients, waste products, and hormones throughout the body.

Regulation:

- Helps regulate body temperature and maintain the acid-base balance.

2. Cellular Components (Formed Elements)

- The cellular components, or formed elements, include red blood cells (RBCs), white blood cells (WBCs), and platelets.
- Each has specific roles:

A. Red Blood Cells (RBCs) or Erythrocytes

- The most abundant blood cells, responsible for oxygen transport.

Functions:

- **Oxygen Transport**: RBCs transport oxygen from the lungs to body tissues and remove carbon dioxide, a waste product of cellular metabolism.
- **Haemoglobin**: RBCs contain haemoglobin, an oxygen-binding protein that gives them their red color.
- **Acid-Base Balance**: RBCs help maintain the blood's pH balance.

B. White Blood Cells (WBCs) or Leukocytes

- Nucleated cells crucial for the immune system, protecting the body against infections and diseases.

Types and Functions:

I. **Neutrophils**: The most abundant WBCs, which phagocytize (engulf and destroy) bacteria and foreign particles.

II. **Lymphocytes**: Produce antibodies and regulate immune responses; include:

- **B-cells**: Produce antibodies.
- **T-cells**: Directly attack infected cells and regulate immune responses.
- **Natural Killer (NK) Cells**: Kill abnormal cells, such as cancerous or virus-infected cells.

III. **Monocytes**: Transform into macrophages that phagocytize pathogens, dead cells, and debris.

IV. **Eosinophils**: Combat parasitic infections and participate in allergic reactions.

V. **Basophils**: Release histamine during allergic reactions and contribute to inflammation.

C. Platelets or Thrombocytes

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- Small cell fragments critical for blood clotting and wound healing.

Functions:

- **Clot Formation**: Platelets clump together at injury sites to form a plug, preventing excessive blood loss.
- **Wound Healing**: Release growth factors that promote tissue repair and regeneration.

Functions of blood

1. **Transportation:**
   - Carries oxygen to tissues, removes carbon dioxide, and transports nutrients, hormones, and waste products.
2. **Immune Response:**
   - Contains white blood cells that defend against infections and diseases.
3. **Clotting:**
   - Platelets form clots to prevent excessive bleeding.
4. **Regulation:**
   - Maintains pH balance and electrolyte levels (e.g., sodium, potassium).
5. **Temperature Regulation:**
   - Distributes heat throughout the body.
6. **Hormone Transport:**
   - Delivers hormones from glands to target organs.

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Hemopoiesis (Haematopoiesis)

Definition:

- Haemopoiesis (or hematopoiesis) is the biological process by which new blood cells are formed. It includes the production, multiplication, and differentiation of all types of blood cells from a common precursor — the **hematopoietic stem cell (HSC)**.
- This process is **continuous and lifelong**, ensuring the body maintains an adequate supply of red blood cells (RBCs), white blood cells (WBCs), and platelets.

Sites of Haemopoiesis:

Haemopoiesis occurs in different locations throughout life:

A. Embryonic and Fetal Life:

1. **Yolk Sac** (2–3 weeks after fertilization): First site of blood cell formation.
2. **Liver and Spleen** (2–7 months gestation): Major sites of haemopoiesis during fetal development.
3. **Bone Marrow** (from ~5 months gestation onwards): Takes over as the primary site before birth.

B. After Birth:

- **Red bone marrow** becomes the main site of haemopoiesis.
- In infants and children, it occurs in almost all bones.
- In adults, it's limited to **axial skeleton**: vertebrae, sternum, ribs, pelvis, and proximal ends of long bones (femur, humerus).

Types of Haemopoiesis:

Haemopoiesis is categorized based on the type of blood cell being formed:

1. Erythropoiesis

- Production of erythrocytes (red blood cells) responsible for oxygen transport.

Process:

- Begins with HSCs differentiating into proerythroblasts.
- Under the influence of erythropoietin (EPO), proerythroblasts develop through several stages:
  - Proerythroblast → Basophilic erythroblast → Polychromatophilic erythroblast → Orthochromatophilic erythroblast → Reticulocyte.
- Reticulocytes enter the bloodstream and mature into erythrocytes.

2. Leukopoiesis

- Production of leukocytes (white blood cells) for immune defense.

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Process:

- HSCs differentiate into myeloid or lymphoid progenitor cells.
- **Myeloid progenitor cells** develop into granulocytes (neutrophils, eosinophils, basophils) and monocytes.
- **Lymphoid progenitor cells** develop into B and T lymphocytes and natural killer (NK) cells.
- Regulated by cytokines and growth factors like GM-CSF, G-CSF, and interleukins.

3. Thrombopoiesis

➢ Production of thrombocytes (platelets) for blood clotting.

Process:

- HSCs differentiate into megakaryocyte progenitor cells.
- Under the influence of thrombopoietin (TPO), these progenitors mature into megakaryocytes.
- Megakaryocytes extend proplatelets into bone marrow blood vessels, which fragment into platelets released into the bloodstream.

Hematopoietic Stem Cells (HSCs):

- All blood cells originate from a **multipotent hematopoietic stem cell (HSC)**, which has two important properties:
  - **Self-renewal**: Can divide and produce more stem cells.
  - **Differentiation**: Can become specialized blood cells.
- From HSCs, two main lineages arise:

A. Myeloid Lineage (produces):

➢ Erythrocytes
➢ Platelets
➢ Neutrophils
➢ Eosinophils
➢ Basophils
➢ Monocytes (which become macrophages)

B. Lymphoid Lineage (produces):

➢ B lymphocytes
➢ T lymphocytes
➢ Natural killer (NK) cells

Regulation of Haemopoiesis:

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