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COMPOSITION OF BLOOD AND ITS BIOLOGICAL FUNCTIONS IN THE BODY

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Abstract

Blood is a complex and dynamic connective tissue that plays a fundamental role in maintaining homeostasis and supporting the physiological functions of the human body. It is composed of plasma, which contains water, proteins, electrolytes, hormones, and nutrients, and formed elements, including red blood cells, white blood cells, and platelets. Each component performs specialized functions: erythrocytes facilitate the transport of oxygen and carbon dioxide, leukocytes provide immune defense against pathogens and regulate inflammatory responses, and platelets are essential for hemostasis and wound healing. Beyond its transport function, blood contributes to the regulation of body temperature, osmotic balance, and pH stability, while also protecting the organism from infections and preventing excessive blood loss. Understanding the cellular and molecular composition of blood, along with its multifunctional roles, is crucial for diagnosing and managing various hematological and systemic disorders. This review provides a comprehensive overview of the structural components of blood, their physiological and biological functions, and their critical significance in health and disease.

Keywords

Blood composition, plasma, erythrocytes, leukocytes, platelets, hemostasis, immune defense, oxygen transport, homeostasis, physiological regulation, hematology, cardiovascular function

Introduction

Blood is one of the most essential and multifunctional tissues in the human body, serving as a critical medium for transport, regulation, and protection. Unlike other connective tissues, blood is a fluid that circulates continuously through the cardiovascular system, ensuring that every organ and tissue receives the oxygen, nutrients, and signaling molecules required for optimal function. Its composition and dynamic properties enable it to respond rapidly to changing physiological demands, such as physical activity, stress, or injury, making it indispensable for maintaining homeostasis and overall health. Structurally, blood is composed of two primary components: plasma and formed elements. Plasma constitutes approximately 55% of total blood volume and serves as a carrier for water, electrolytes, nutrients, hormones, waste products, and plasma proteins, including albumins, globulins, and fibrinogen. These components are not only essential for transport but also play critical roles in maintaining osmotic balance, acid-base equilibrium, and vascular integrity. The formed elements, which account for about 45% of blood volume, include red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes). Each of these cell types exhibits highly specialized functions: erythrocytes facilitate oxygen delivery and carbon dioxide removal, leukocytes provide immune defense and coordinate inflammatory responses, and platelets ensure hemostasis and tissue repair. Beyond its transport functions, blood plays a central role in regulating physiological homeostasis. It distributes heat throughout the body, modulates pH, maintains electrolyte balance, and responds to environmental or internal stresses. Additionally, it provides protection against infectious agents through immune cells and antibodies, while also contributing to tissue repair and wound healing via coagulation and growth factors. The integration of these functions illustrates blood's complex and dynamic nature, highlighting its critical importance in both health and disease. Disruptions in blood composition or function can have profound effects on the organism, leading to conditions such as anemia, coagulopathies, immunodeficiencies, and

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systemic inflammatory disorders. Therefore, understanding the cellular, biochemical, and molecular properties of blood is fundamental for medical research, clinical diagnostics, and therapeutic interventions. In particular, knowledge of blood physiology informs strategies in transfusion medicine, hematology, cardiovascular care, and immunology, and supports the development of novel treatment modalities. In the context of human development, blood's biological functions are also essential for growth, metabolic regulation, and the maintenance of organ function. In pediatric populations, for instance, proper oxygen transport, immune protection, and nutrient delivery are critical for normal development and resilience against infections or pathological conditions. Similarly, in adults, the adaptive capacity of blood to respond to stress, exercise, or injury ensures the preservation of organ function and systemic stability. In summary, blood is a multifunctional and highly specialized tissue that integrates transport, regulation, and defense mechanisms to sustain life. Its study provides critical insights into human physiology, pathophysiology, and clinical medicine. A detailed understanding of blood composition and its biological functions is essential for advancing healthcare, improving disease management, and supporting innovations in medical science. This review aims to provide a comprehensive overview of blood's structural components, their physiological roles, and their significance in maintaining health and preventing disease.

Main Section: Composition and Biological Functions of Blood

Blood is a specialized connective tissue with complex structural and functional properties, responsible for maintaining homeostasis, transporting essential substances, and protecting the body against disease. In adults, the total blood volume averages 70 mL per kilogram of body weight, accounting for approximately 7–8% of body weight, while in neonates, it ranges between 80–90 mL/kg due to higher metabolic demands. Blood consists of plasma (55%) and formed elements (45%), each playing distinct and integrated roles in physiological processes.

1. Plasma

Plasma, the liquid portion of blood, comprises approximately 90–92% water and serves as a medium for transporting nutrients, gases, electrolytes, hormones, and waste products. It contains 6–8% plasma proteins:

Albumin (3.5–5 g/dL): Maintains oncotic pressure, binds and transports fatty acids, bilirubin, and drugs. It constitutes ~60% of plasma proteins.

Globulins (2–3 g/dL): Include alpha, beta, and gamma fractions; gamma globulins function as antibodies critical for adaptive immunity.

Fibrinogen (200–400 mg/dL): Precursor of fibrin, essential for clot formation.

Electrolytes in plasma maintain osmotic balance, nerve conduction, and muscle contraction. For example, sodium (~135–145 mmol/L) regulates extracellular fluid volume, while potassium (~3.5–5.0 mmol/L) is critical for cardiac and skeletal muscle excitability. Plasma also carries gases (O_2, CO_2), nutrients (glucose: 70–110 mg/dL), and metabolic wastes (urea: 15–40 mg/dL; creatinine: 0.6–1.3 mg/dL). Plasma pH is maintained at 7.35–7.45, buffered primarily by bicarbonate (HCO_3^-: 22–28 mmol/L). Plasma plays regulatory roles: it distributes heat, transports hormones, maintains pH, and supports the immune system by carrying complement proteins, clotting factors, and cytokines. Plasma abnormalities can lead to hypoalbuminemia, coagulopathies, and immune deficiencies.

2. Red Blood Cells (Erythrocytes): Erythrocytes are anucleate, biconcave discs (~7–8 μm in diameter), optimizing their surface area (~140 μm^2 per cell) for gas exchange. Adult humans have 4.5–5.5 $\times 10^6$ erythrocytes/μL of blood; neonates have higher counts (~5–6 $\times 10^6$/μL) to meet oxygen demands. Hemoglobin concentration averages 13–17 g/dL in adult males and 12–15 g/dL in females. Each hemoglobin molecule binds four oxygen molecules via its iron-containing heme groups.

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Erythropoiesis occurs in red bone marrow and is regulated by erythropoietin (EPO), primarily secreted by the kidneys in response to hypoxia. RBC lifespan is approximately 120 days, after which senescent cells are removed by macrophages in the spleen and liver. Functionally, erythrocytes ensure oxygen delivery to tissues and CO_2 removal, supporting cellular metabolism and maintaining acid-base balance via the bicarbonate buffer system. Deficiencies or structural abnormalities, such as in sickle cell disease or thalassemia, impair oxygen delivery, leading to tissue hypoxia, organ dysfunction, and compensatory cardiomegaly in chronic cases. In neonates and children, adequate RBC function is essential for growth, cognitive development, and resilience against hypoxic injury.

3. White Blood Cells (Leukocytes): Leukocytes constitute 4,000–11,000 cells/μL of blood in adults and are primary mediators of immune defense. They are divided into **granulocytes** and **agranulocytes**:

Neutrophils (50–70%): Perform phagocytosis, produce reactive oxygen species (ROS), and are first responders to bacterial infections.

Eosinophils (1–4%): Combat parasitic infections and regulate allergic inflammation via cytotoxic granules.

Basophils (0.5–1%): Release histamine and heparin during hypersensitivity reactions.

Lymphocytes (20–40%): B cells produce antibodies; T cells regulate cellular immunity; NK cells eliminate infected or malignant cells.

Monocytes (2–8%): Differentiate into macrophages and dendritic cells for phagocytosis, antigen presentation, and cytokine secretion.

Leukocytes respond to chemotactic signals, migrate through the endothelium (diapedesis), and coordinate inflammation, tissue repair, and pathogen elimination. Dysregulation leads to immunodeficiency, chronic inflammation, or autoimmunity.

4. Platelets (Thrombocytes): Platelets are 2–4 μm anucleate cell fragments, with normal counts of 150,000–450,000/μL. Derived from megakaryocytes, platelets initiate hemostasis:

Adhesion: Platelets adhere to damaged endothelium via von Willebrand factor.

Aggregation: Platelets form a temporary plug.

Coagulation: Release of clotting factors leads to fibrin formation.

Platelets also secrete growth factors such as PDGF and VEGF to promote tissue repair and angiogenesis. Thrombocytopenia increases bleeding risk, whereas hyperactivity contributes to thrombosis and cardiovascular complications.

5. Biological and Clinical Functions of Blood - Blood integrates multiple functions critical for survival:

1. **Transport:** Oxygen, CO_2, nutrients, hormones, and metabolic wastes.
2. **Regulation:** Body temperature, osmotic pressure, electrolyte balance, and pH homeostasis.
3. **Protection:** Immune defense, coagulation, and inflammatory regulation.
4. **Metabolic Support:** Delivery of nutrients and removal of wastes to support cellular metabolism.
5. **Homeostasis:** Maintains systemic stability during stress, infection, or injury.

In **pediatric populations**, blood ensures oxygen delivery for rapid growth, immune protection, and nutrient distribution. Blood abnormalities can manifest as anemia, leukopenia, thrombocytopenia, or coagulation disorders, leading to developmental delays, immune deficiency, or bleeding complications. In adults, blood disorders contribute to cardiovascular disease, immunodeficiency, and systemic inflammation.

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6. Molecular and Cellular Mechanisms: Oxygen transport: Hemoglobin-oxygen binding dynamics (Bohr effect) adapt to tissue pH and CO_2 levels.**Immune signaling:** Cytokines (IL-1, IL-6, TNF-α) regulate leukocyte activation, differentiation, and chemotaxis.**Coagulation cascade:** Platelets, thrombin, and fibrinogen interact in intrinsic, extrinsic, and common pathways to achieve hemostasis.**Redox balance:** Blood cells regulate oxidative stress via enzymes like superoxide dismutase, catalase, and glutathione peroxidase.

Conclusion

Blood is a highly specialized and dynamic connective tissue that performs vital roles in maintaining homeostasis, supporting metabolism, and defending the body against injury and disease. Its composition—including plasma, red blood cells, white blood cells, and platelets—ensures the efficient transport of oxygen, nutrients, hormones, and metabolic wastes, while simultaneously regulating pH, osmotic balance, and body temperature. Red blood cells are essential for oxygen delivery and carbon dioxide removal, with their structure and hemoglobin content optimized for gas transport. White blood cells provide innate and adaptive immunity, responding rapidly to infections, inflammation, and tissue damage. Platelets and plasma proteins collaborate to maintain hemostasis and initiate tissue repair processes. Plasma serves as a transport medium, buffer system, and carrier of critical molecules such as antibodies, clotting factors, and signaling proteins. At the molecular and cellular levels, blood functions are tightly regulated through mechanisms such as erythropoiesis, leukocyte activation, coagulation cascades, and antioxidant defenses. Dysregulation of these processes can lead to anemia, immunodeficiency, coagulopathies, or systemic diseases, highlighting the clinical importance of understanding blood biology. In pediatric populations, the functional integrity of blood is especially critical, as oxygen delivery, immune protection, and nutrient transport directly influence growth, development, and resilience against disease. In adults, blood dysfunction contributes to cardiovascular disease, inflammatory disorders, and hematological conditions. In summary, a comprehensive understanding of blood composition, cellular mechanisms, and biological functions provides a scientific foundation for clinical diagnosis, therapeutic interventions, and the management of both pediatric and adult patients. Studying blood at molecular, cellular, and systemic levels not only enhances theoretical knowledge but also underpins practical strategies for improving human health, preventing disease, and optimizing patient outcomes.

References

1. Guyton, A. C., & Hall, J. E. (2021). *Textbook of Medical Physiology* (14th ed.). Philadelphia: Elsevier.
2. Kumar, V., Abbas, A. K., & Aster, J. C. (2020). *Robbins and Cotran Pathologic Basis of Disease* (10th ed.). Philadelphia: Elsevier.
3. Hoffbrand, A. V., Moss, P. A. H., & Pettit, J. E. (2016). *Essential Haematology* (7th ed.). Hoboken: Wiley-Blackwell.
4. Lichtman, M. A., Kipps, T. J., Seligsohn, U., et al. (2017). *Williams Hematology* (9th ed.). New York: McGraw-Hill Education.
5. McCance, K. L., & Huether, S. E. (2019). *Pathophysiology: The Biologic Basis for Disease in Adults and Children* (8th ed.). Philadelphia: Elsevier.
6. Rodak, B. F., Carr, J. H., & Cohen, H. J. (2016). *Hematology: Clinical Principles and Applications* (5th ed.). Philadelphia: Elsevier.
7. Turgeon, M. L. (2016). *Clinical Hematology: Theory and Procedures* (6th ed.). Philadelphia: Lippincott Williams & Wilkins.