

Blood

Objectives

Overview: Blood Composition and Functions

1. Describe the components of blood and their relative proportions. Define the blood hematocrit.
2. List the physical characteristics of blood. Indicate the normal volumes for males and females.
3. Discuss the functions of blood.

Blood Plasma

4. Define blood plasma and list the components and their functions.

Formed Elements

5. Indicate the formed elements of the blood, their structure, function, and development.
6. Explain the fate and destruction of erythrocytes.
7. Examine the disorders of too many and too few of each type of formed element.

Hemostasis

8. Define hemostasis.
9. Identify the events of platelet plug formation.
10. List the events of the coagulation phase of hemostasis. Differentiate between the intrinsic and extrinsic pathways of prothrombin formation.
11. Explain the mechanism and function of clot retraction and tissue repair.
12. Discuss the factors that limit clot formation.

Transfusion and Blood Replacement

13. List the reasons for transfusion of whole blood, plasma, and blood volume expanders.
14. Discuss the basis for human blood groups. Identify what factor determines each blood group.
15. Explain the results of a transfusion reaction, and how blood typing is used to avoid such a problem.

Diagnostic Blood Tests

16. Indicate how the various types of diagnostic blood tests are used.

Developmental Aspects of Blood

17. List the structures involved in formation of fetal blood.
18. Compare fetal and adult hemoglobin.

Lecture Outline

1. Overview: Blood Composition and Functions (pp. 647–648; Fig. 17.1)

- A. Components (pp. 647–648; Fig. 17.1)
 1. Blood is a specialized connective tissue consisting of living cells, called formed elements, suspended in a nonliving fluid matrix, blood plasma.
 2. Blood that has been centrifuged separates into three layers: erythrocytes, the buffy coat, and plasma.

3. The blood hematocrit represents the percentage of erythrocytes in whole blood.
- B. Physical Characteristics and Volume (p. 648)
1. Blood is a slightly basic (pH = 7.35–7.45) fluid that has a higher density and viscosity than water, due to the presence of formed elements.
 2. Normal blood volume in males is 5–6 liters, and 4–5 liters for females.
- C. Functions (p. 648)
1. Blood is the medium for delivery of oxygen and nutrients, removal of metabolic wastes to elimination sites, and distribution of hormones.
 2. Blood aids in regulating body temperature, body fluid pH, and fluid volume within fluid compartments.
 3. Blood protects against excessive blood loss through the clotting mechanism, and from infection through the immune system.

II. Blood Plasma (pp. 648–649; Table 17.1)

- A. Blood plasma consists of mostly water (90%), and solutes including nutrients, gases, hormones, wastes, products of cell activity, ions, and proteins.
- B. Plasma proteins account for 8% of plasma solutes, mostly albumin, which function as carriers.

III. Formed Elements (pp. 649–662; Figs. 17.2–17.12; Table 17.2)

- A. Erythrocytes (pp. 649–656; Figs. 17.3–17.8)
1. Erythrocytes, or red blood cells, are small cells that are biconcave in shape. They lack nuclei and most organelles, and contain mostly hemoglobin.
 - a. Hemoglobin is an oxygen-binding pigment that is responsible for the transport of most of the oxygen in the blood.
 - b. Hemoglobin is made up of the protein globin bound to the red heme pigment.
 2. Production of Erythrocytes
 - a. Hematopoiesis, or blood cell formation, occurs in the red bone marrow.
 - b. Erythropoiesis, the formation of erythrocytes, begins when a myeloid stem cell is transformed to a proerythroblast, which develops into mature erythrocytes.
 - c. Erythrocyte production is controlled by the hormone erythropoietin.
 - d. Dietary requirements for erythrocyte formation include iron, vitamin B₁₂ and folic acid, as well as proteins, lipids, and carbohydrates.
 - e. Blood cells have a short life span due to the lack of nuclei and organelles; destruction of dead or dying blood cells is accomplished by macrophages.
 3. Erythrocyte Disorders
 - a. Anemias are characterized by a deficiency in RBCs.
 - b. Polycythemia is characterized by an abnormal excess of RBCs.
- B. Leukocytes (pp. 656–662; Figs. 17.9–17.11)
1. Leukocytes, or white blood cells, are the only formed elements that are complete cells and make up less than 1% of total blood volume.
 2. Leukocytes are critical to our defense against disease.
 3. Granulocytes are a main group of leukocytes characterized as large cells with lobed nuclei and visibly staining granules; all are phagocytic.
 - a. Neutrophils are the most numerous type of leukocyte. They are chemically attracted to sites of inflammation and are active phagocytes.

- b. Eosinophils are relatively uncommon and attack parasitic worms.
 - c. Basophils are the least numerous leukocyte and release histamine to promote inflammation.
- 4. Agranulocytes are a main group of lymphocytes that lack visibly staining granules.
 - a. T lymphocytes directly attack viral-infected and tumor cells; B lymphocytes produce antibody cells.
 - b. Monocytes become macrophages and activate T lymphocytes.
- 5. Production and Life Span of Leukocytes
 - a. Leukopoiesis, the formation of white blood cells, is regulated by the production of interleukins and colony-stimulating factors (CSF).
 - b. Leukopoiesis involves differentiation of hemocytoblasts along two pathways: lymphoid and myeloid stem cells.
- 6. Leukocyte Disorders
 - a. Leukopenia is an abnormally low white blood cell count.
 - b. Leukemias are clones of a single white blood cell that remain unspecialized and divide out of control.
 - c. Infectious mononucleosis is a disease caused by the Epstein-Barr virus.
- C. Platelets (p. 662; Fig. 17.12)
 - 1. Platelets are not complete cells, but fragments of large cells called megakaryocytes.
 - 2. Platelets are critical to the clotting process, forming the temporary seal when a blood vessel breaks.
 - 3. Formation of platelets involves repeated mitoses of megakaryocytes without cytokinesis.

IV. Hemostasis (pp. 663–668; Figs. 17.13–17.14; Table 17.3)

- A. A break in a blood vessel stimulates hemostasis, a fast, localized response to reduce blood loss through clotting. (p. 663)
- B. Vascular spasms are the immediate vasoconstriction response to blood vessel injury. (pp. 663–665)
- C. Platelet Plug Formation (p. 665; Fig. 17.13)
 - 1. When endothelium is damaged, platelets become sticky and spiky, adhering to each other and the damaged vessel wall.
 - 2. Once attached, other platelets are attracted to the site of injury, activating a positive feedback loop for clot formation.
- D. Coagulation, or blood clotting, is a multi-step process in which blood is transformed from a liquid to a gel. (pp. 665–666; Figs. 17.13–17.14)
 - 1. Factors that promote clotting are called clotting factors, or procoagulants; those that inhibit clot formation are called anticoagulants.
 - 2. The clotting process involves: formation of prothrombin activator, conversion of prothrombin to thrombin, and the formation of fibrin mesh from fibrinogen in the plasma.
- E. Clot Retraction and Repair (p. 666)
 - 1. Clot retraction is a process in which the contractile proteins within platelets contract and pull on neighboring fibrin strands, squeezing plasma from the clot and pulling damaged tissue edges together.
 - 2. Repair is stimulated by platelet-derived growth factor (PDGF).

- F. Fibrinolysis removes unneeded clots through the action of the fibrin-digesting enzyme plasmin. (p. 666)
- G. Factors Limiting Clot Growth or Formation (pp. 666–667)
 - 1. Rapidly moving blood disseminates clotting factors before they can initiate a clotting cascade.
 - 2. Thrombin that is not bound to fibrin is inactivated by antithrombin III and protein C, as well as heparin.
- H. Disorders of Hemostasis (pp. 667–668)
 - 1. Thromboembolytic disorders result from conditions that cause undesirable clotting, such as roughening of vessel endothelium, slow-flowing blood, or blood stasis.
 - 2. Disseminated intravascular coagulation is a situation leading to widespread clotting throughout intact vessels, and may occur as a complication of pregnancy, septicemia, or incompatible blood transfusions.
 - 3. Bleeding disorders arise from abnormalities that prevent normal clot formation, such as a deficiency in circulating platelets, lack of synthesis of procoagulants, or hemophilia.

V. Transfusion and Blood Replacement (pp. 668–671; Fig. 17.15; Table 17.4)

- A. Transfusion of whole blood is routine when blood loss is substantial, or when treating thrombocytopenia. (pp. 668–670; Fig. 17.15; Table 17.4)
 - 1. Humans have different blood types based on specific antigens on RBC membranes.
 - 2. ABO blood groups are based on the presence or absence of two types of agglutinogens.
 - 3. Preformed antibodies (agglutinins) are present in blood plasma and do not match the individual's blood.
 - 4. The Rh factor is a group of RBC antigens that are either present in Rh⁺ blood, or absent in Rh⁻ blood.
 - 5. A transfusion reaction occurs if the infused donor blood type is attacked by the recipient's blood plasma agglutinins, resulting in agglutination and hemolysis of the donor cells.
- B. Plasma and blood volume expanders are given in cases of extremely low blood volume. (p. 671)

VI. Diagnostic Blood Tests (pp. 671–672)

- A. Changes in some of the visual properties of blood can signal diseases such as anemia, heart disease, and diabetes.
- B. Differential white blood cell counts are used to detect differences in relative amounts of specific blood cell types.
- C. Prothrombin time, which measures the amount of prothrombin in the blood, and platelet counts evaluate the status of the hemostasis system.
- D. SMAC, SMA12–60, and complete blood count (CBC) give comprehensive values of the condition of the blood.

VII. Developmental Aspects of Blood (pp. 672–673)

- A. Prior to birth, blood cell formation occurs within the fetal yolk sac, liver, and spleen, but by the seventh month, red bone marrow is the primary site of hematopoiesis.
- B. Fetal blood cells form hemoglobin-F, which has a higher affinity for oxygen than adult hemoglobin, hemoglobin-A.

Cross References

Additional information on topics covered in Chapter 17 can be found in the chapters listed below.

1. Chapter 3: Diffusion; osmosis
2. Chapter 4: Tissue repair
3. Chapter 6: Hematopoietic tissue
4. Chapter 18: Role of the heart in blood delivery
5. Chapter 19: Vasoconstriction as a mechanism of blood flow control; general overview of arteries, capillaries, and veins
6. Chapter 20: Role of the spleen in the removal of old red blood cells; macrophages
7. Chapter 21: Granulocyte function in nonspecific resistance; lymphocyte function (T and B cells) in specific immune response; role of monocytes (macrophages) in the immune response; AIDS; antigen-antibody interaction; diapedesis; chemotaxis
8. Chapter 22: Gas exchange between blood, lungs, and tissues; respiratory gas transport
9. Chapter 23: Vitamin B₁₂ absorbance; production of vitamin K in the large intestine
10. Chapter 24: Role of blood in body temperature regulation
11. Chapter 25: Erythropoietin related to renal function; plasma filtration
12. Chapter 26: Control of water and ion balance; acid-base balance

Laboratory Correlations

1. Marieb, E. N. *Human Anatomy & Physiology Laboratory Manual: Cat and Fetal Pig Versions*. Eighth Edition Updates. Benjamin Cummings, 2006.
Exercise 29: Blood
2. Marieb, E. N. *Human Anatomy & Physiology Laboratory Manual: Main Version*. Seventh Edition Update. Benjamin Cummings, 2006.
Exercise 29: Blood
(Sept. 1999): 1553.