# McCance: Pathophysiology, 6th Edition

## Chapter 25: Structure and Function of the Hematologic System

### Key Points – Print

### SUMMARY REVIEW

Components of the Hematologic System

1. Blood consists of cells suspended in a solution of about 90% water and 10% solutes. In adults the total blood volume is approximately 5.5 L.
2. Plasma, the liquid portion of the blood, contains two major groups of proteins: albumins and globulins.
3. The cellular elements of blood are the erythrocytes (red blood cells), leukocytes (white blood cells), and platelets (thrombocytes).
4. Erythrocytes are the most abundant cells of the blood, occupying approximately 48% of the blood volume in men and approximately 42% in women. Erythrocytes are responsible for tissue oxygenation.
5. Leukocytes are fewer in number than erythrocytes and constitute approximately 5000 to 10,000 cells/$mm^3$ of blood. Leukocytes defend the body against infection and remove dead or injured host cells.
6. Leukocytes are classified as either granulocytes (neutrophils, basophils, eosinophils) or agranulocytes (monocytes, macrophages, lymphocytes).
7. The neutrophil is the most abundant leukocyte (approximately 55% of the leukocytes) and is the primary granulocyte that defends against infections.
8. Lymphocytes are the primary cells of the immune response.
9. Platelets are not cells—they are disk-shaped cytoplasmic fragments. Platelets are essential for blood coagulation and control of bleeding.
10. The lymphoid organs are classified as primary (thymus and bone marrow) or secondary (spleen, lymph nodes, tonsils, and Peyer patches of the small intestine).
11. The lymphoid organs are sites of residence, proliferation, differentiation, and function of lymphocytes and mononuclear phagocytes.
12. The spleen is the largest of the secondary lymphoid organs and functions as the site of hematopoiesis in the fetus, filters and cleanses the blood, and is a reservoir for lymphocytes and other blood cells.
13. The lymph nodes are the site of development or activity of large numbers of lymphocytes, monocytes, and macrophages.
14. The MPS is composed of macrophages in tissue and lymphoid organs.

14. The MPS is the main line of defense against bacteria in the bloodstream and cleanses the blood by removing old, injured, or dead blood cells; antigen-antibody complexes; and macromolecules.

Development of Blood Cells

1. Hematopoiesis, or blood cell production, occurs in the liver and spleen of the fetus and in the bone marrow after birth.
2. Hematopoiesis involves two stages: (1) proliferation and (2) maturation.
3. Hematopoiesis continues throughout life to replace blood cells that grow old and die, are killed by disease, or are lost through bleeding.
4. Bone marrow consists of red (hematopoietic) marrow (blood vessels, mononuclear phagocytes, stem cells, blood cells in various stages of differentiation, stromal cells) and yellow marrow (fatty tissue).
5. The bone marrow contains multiple populations of *stem cells*; mesenchymal stem cells develop into fibroblasts, osteoclasts, and adipocytes; and hematopoietic stem cells develop into blood cells.
6. Regulation of hematopoiesis possibly occurs two ways: (1) by stromal cells involved in cell contact processes and (2) by cytokines or regulatory molecules.
7. Specific hematopoietic growth factors (e.g., colony-stimulating factors) are necessary for the adequate production of myeloid, erythroid, lymphoid, and megakaryocytic lineages.
8. Erythropoiesis (production of erythrocytes) is regulated by erythropoietin. Erythropoietin is secreted by the kidneys in response to tissue hypoxia and causes a compensatory increase in erythrocyte production if the oxygen content of the blood decreases because of anemia, high altitude, or pulmonary disease.
9. Hemoglobin, the oxygen-carrying protein of the erythrocyte, enables the blood to transport 100 times more oxygen than could be transported dissolved in plasma alone.
10. The iron cycle reutilizes iron released from old or damaged erythrocytes. Iron binds to transferrin in the blood, is transported to macrophages of the MPS, and is stored in the cytoplasm as ferritin.
11. Granulocytes and monocytes in the blood develop from common myeloid progenitor cells in the bone marrow under the direction of several growth factors, including stem cell factor, IL-3, and GM-CSF.
12. Platelets develop from megakaryocytes by a process called *endomitosis*, which is controlled by thrombopoietin. During endomitosis the megakaryocytes undergo mitosis but not cell division and the cytoplasm and plasma membrane fragment into platelets.

## Mechanisms of Hemostasis

1. Hemostasis, or arrest of bleeding in damaged vessels, involves (1) vasoconstriction, (2) damage to the endothelium and exposure of connective tissue resulting in formation of a platelet plug, (3) activation of the clotting cascade, (4) formation of a blood clot, and (5) activation of fibrinolysis for clot retraction and clot dissolution.
2. Platelet activation involves three linked processes: (1) adhesion, (2) activation, and (3) aggregation.
3. A blood clot is a meshwork of protein strands that stabilizes the platelet plug. The strands are made of fibrin. Fibrin is the end product of the coagulation cascade.
4. The coagulation cascade is composed of intrinsic and extrinsic pathways, with the extrinsic pathway being dominant. The intrinsic pathway is initiated by TF that forms a complex with TF-FVIIa complex.
5. The endothelium prevents the formation of spontaneous clots in normal vessels by several anticoagulant mechanisms, including production of NO and $PGI_2$, thrombin inhibitors (antithrombin III), tissue factor inhibitors (tissue factor pathway inhibitors), and degrading activated clotting factors (thrombomodulin-protein C).
6. Fibrinolysis (breakdown of blood clots) is the function of the plasminogen-plasmin system. Plasmin is a degrading enzyme of fibrin clots. It is produced from plasminogen by activated by plasminogen activators (t-PA, u-PA), thrombin, fibrin, factor XIIa, factor XIa, and kallikrein.
7. Products of fibrinolysis include fibrin degradation products, such as D-dimer.

## Clinical Evaluation of the Hematologic System

1. Tests of bone marrow function include bone marrow aspiration and bone marrow biopsy.
2. Cells contained in the marrow specimen are assessed with respect to (1) relative numbers of stem cells and their developing daughter cells and (2) morphologic structure.

## Pediatrics and the Hematologic System

1. Blood cell counts rise above adult levels at birth and then gradually decline throughout childhood.
2. The average blood volume of an infant is 75 to 77 ml/kg, which is similar to that of older children and adults.
3. In response to the change from a placental to a pulmonary oxygen supply during the first few days of life, levels of erythropoietin and the rate of blood cell formation decrease.
4. The normal erythrocyte life span is 60 to 80 days in full-term infants, 20 to 30 days in premature infants, and 120 days in children, adolescents, and adults.
5. The lymphocyte count is high at birth, rises further during the first year of life, and steadily declines until lower adult volumes are reached.

6. The neutrophil count is very high at birth, falls to adult ranges after 2 weeks, and is the same as for adults by 4 years of age.
7. The eosinophil count is high in the first year of life and is higher in children than in adolescents and adults. Monocyte counts are high in the first year of life and decrease to adult levels.
8. Platelet counts in full-term infants are comparable with those in adults and remain so throughout childhood.

Aging and the Hematologic System

1. Blood composition changes little with age. A delay in erythrocyte replenishment may occur after bleeding, presumably because of iron deficiency.
2. Lymphocyte function appears to decrease with age. Particularly affected is a decrease in cellular immunity.
3. Platelet adhesiveness probably increases with age.