# Chapter 12 - Blood

**12.1 Introduction** (Figs. 12.1-12.2)

A. Blood, a type of connective tissue, is a complex mixture of cells, chemicals and fluid.

B. Blood transports substances throughout the body, and helps to maintain a stable internal environment.

C. The blood includes red blood cells, white blood cells, platelets, and plasma.

D. Blood Volume and Composition

1. A blood hematocrit is normally 45% cells and 55% plasma.
2. Plasma is a mixture of water, amino acids, proteins, carbohydrates, lipids, vitamins, hormones, electrolytes, and cellular wastes.

**12.2 Blood Cells** (Table 12.1)

A. Red Blood Cells (Fig. 12.3)

1. Red blood cells (erythrocytes) are biconcave disks that contain one-third oxygen-carrying hemoglobin by volume.
2. When oxygen combines with hemoglobin bright red oxyhemoglobin results.
3. Deoxygenated blood (deoxyhemoglobin) is darker.
4 Red blood cells discard their nuclei during development and so cannot reproduce or produce proteins.

D. Red Blood Cell Counts

1. The typical red blood cell count is 4,600,000-6,2000,000 cells per $mm^3$ for males and 4,200,000-5,400,000 cells per $mm^3$ for females.
2. The number of red blood cells is a measure of the blood's oxygen-carrying capacity.

E. Red Blood Cell Production and Its Control (Fig. 12.5)

1. In the embryo and fetus, red blood cell production occurs in the yolk sac, liver, and spleen; after birth, it occurs in the red bone marrow.
2. The average life span of a red blood cell is 120 days.
3. The total number of red blood cells remains relatively constant due to a negative feedback mechanism utilizing the hormone erythropoietin, which is released from the kidneys and liver in response to the detection of low oxygen levels.

F. Dietary Factors Affecting Red Blood Cell Production

1. Vitamins $B_{12}$ and folic acid are needed for DNA synthesis, so they are necessary for the reproduction of all body cells, especially in hematopoietic tissue.
2. Iron is needed for hemoglobin synthesis.
3. A deficiency in red blood cells or quantity of hemoglobin results in anemia.

G. Destruction of Red Blood Cells (Fig. 12.6)

1. With age, red blood cells become increasingly fragile and are damaged by passing through narrow capillaries.
2. Macrophages in the liver and the spleen phagocytize damaged red blood cells.
3. Hemoglobin from the decomposed red blood cells is converted into heme and globin.
4. Heme is decomposed into iron that is stored or recycled and biliverdin and bilirubin that are excreted in bile.

H. White Blood Cells (Figs. 12.4. & 12.7 -12.11)

1. White blood cells (leukocytes) help defend the body against disease.
2. They are formed from hemocytoblasts in response to hormones when needed.
3. Five types of white blood cells are in circulating blood and are distinguished by size, granular appearance of the cytoplasm, shape of the nucleus, and staining characteristics.
4. The types of white blood cells are the granular neutrophils, eosinophils, and basophils, and the agranular monocytes and lymphocytes.

a. Neutrophils have red-staining fine cytoplasmic granules and a multilobed nucleus; they comprise 54-62% of leukocytes.
b. Eosinophils have coarse granules that stain deep red, a bilobed nucleus, and make up only 1-3% of circulating leukocytes.
c. Basophils have fewer granules that stain blue; they account for fewer than 1% of leukocytes.
d. Monocytes are the largest blood cells, have variably-shaped nuclei, and make up 3-9% of circulating leukocytes.
e. Lymphocytes are long-lived, have a large, round nucleus, and account for 25-33% of circulating leukocytes.

5. Functions of White Blood Cells (Fig. 12.12)
   a. Leukocytes can squeeze between cells lining walls of blood vessels (by a process called diapedesis) and attack bacteria and debris.
      i. Neutrophils and monocytes are phagocytic, with monocytes engulfing the larger particles.
      ii. Eosinophils moderate allergic reactions as well as defend against parasitic infections.
      iii. Basophils migrate to damaged tissues and release histamine to promote inflammation and heparin to inhibit blood clotting.
      iv. Lymphocytes are the major players in specific immune reactions and some produce antibodies.
6. White Blood Cell Counts
   a. Normally a cubic milliliter of blood contains 4,000 to 11,000 white blood cells.
   b. A differential white blood cell count can help pinpoint the nature of an illness, indicating whether it is caused by bacteria or viruses.
      i. A differential white blood cell count lists the percentages of the types of leukocytes in a blood sample.
   c. Leukocytosis occurs after an infection when excess numbers of leuocytes are present; leukopenia occurs from a variety of conditions, including AIDS.

I. Blood Platelets
1. Blood platelets are fragments of megakaryocytes.
2. Platelets help repair damaged blood vessels by adhering to their broken edges.
3. Normal counts vary from 130,000 to 360,000 platelets per $mm^3$.

**12.3 Blood Plasma**

A. Plasma is the clear, straw-colored fluid portion of the blood.
1. Plasma is mostly water but contains a variety of substances.
2. Plasma functions to transport nutrients and gases, regulate fluid and electrolyte balance, and maintain a favorable pH.

B. Plasma Proteins (Table 12.2)
1. The plasma proteins are the most abundant dissolved substances in the plasma.
2. Plasma proteins are not used for energy and fall into three groups--albumins, globulins, and fibrinogen.
   a. The albumins help maintain the osmotic pressure of the blood and account for 60% of the plasma proteins.
   b. The globulins, comprising 36% of the plasma proteins, are designated as alpha, beta, and gamma globulins.
      i. Alpha and beta globulins function in transporting lipids and fat-soluble vitamins.
      ii. Gamma globulins are a type of antibody.

c. Fibrinogen (4%) plays a primary role in blood coagulation.

C. Gases and Nutrients
1. The most important blood gases are oxygen and carbon dioxide.
2. The plasma nutrients include amino acids, monosaccharides, nucleotides, and lipids.
a. Since lipids are not soluble in the water of the plasma, they are surrounded by protein molecules for transport through the bloodstream as lipoproteins.
b. Lipoproteins are classified on the basis of their densities, which reflects their composition.
i. Types of lipoproteins include HDL, LDL, VLDL, and chylomicrons.

D. Nonprotein Nitrogenous Substances
1. Nonprotein nitrogenous substances generally include amino acids, urea, and uric acid.
a. Urea and uric acid are the by-products of protein and nucleic acid catabolism.

E. Plasma Electrolytes
1. Plasma electrolytes are absorbed by the intestine or are by-products of cellular metabolism.
2. They include sodium, potassium, calcium, magnesium, chloride, bicarbonate, phosphate, and sulfate ions.
3. Some of these ions are important in maintaining osmotic pressure and pH of the plasma.

**12.4 Hemostasis**

A. Hemostasis refers to the stoppage of bleeding.
1. Following injury to a vessel, three steps occur in hemostasis: blood vessel spasm, platelet plug formation, and blood coagulation.

B. Blood Vessel Spasm
1. Cutting a blood vessel causes the muscle in its walls to contract in a reflex, or engage in vasospasm.
2. This reflex lasts only a few minutes, but it lasts long enough to initiate the second and third steps of hemostasis.

C. Platelet Plug Formation (Fig. 12.13)
1. Platelets stick to the exposed edges of damaged blood vessels, forming a net with spiny processes protruding from their membranes.
2. A platelet plug is most effective on a small vessel.

D. Blood Coagulation (Figs. 12.14 - 12.16)
1. Blood coagulation is the most effective means of hemostasis.
2. Blood coagulation is very complex and uses clotting factors.
3. Damaged tissues release a chemical called tissue thromboplastin, which activates the first in a series of factors leading to the production of prothrombin activator.
2. Prothrombin activator converts prothrombin in the plasma into thrombin. This in turn, catalyzes a reaction that converts fibrinogen into fibrin.
5. The major event in blood clot formation is the conversion of soluble fibrinogen into net like insoluble fibrin causing the blood cells to catch.
6. The amount of prothrombin activator formed is proportional to the amount of tissue damage.
7. Once a blood clot forms, it promotes still more clotting through a positive feedback system.
8. After a clot forms, fibroblasts invade the area and produce fibers throughout the clots.
9. A clot that forms abnormally in a vessel is a thrombus; if it dislodges, it is an

embolus.

**12.5 Blood Groups and Transfusions**

A. After mixed success with transfusions, scientists determined that blood was of different types and only certain combinations were compatible.

B. Antigens and Antibodies
   1. Clumping of red blood cells following transfusion is called agglutination.
   2. Agglutination is due to the interaction of proteins on the surfaces of red blood cells (antigens) with certain antibodies carried in the plasma.
   3. Only a few of the antigens on red blood cells produce transfusion reactions.
      a. These include the ABO group and Rh group.

C. ABO Blood Group (Figs. 12.17-12.18; Tables 12.3-12.4)
   1. Type A blood has A antigens on red blood cells and anti-B antibodies in the plasma.
   2. Type B blood has B antigens on red blood cells and anti-A antibodies in the plasma.
   3. Type AB blood has both A and B antigens, but no antibodies in the plasma.
   4. Type O blood has neither antigen, but both types of antibodies in the plasma.
   5. Adverse transfusion reactions are avoided by preventing the mixing of blood that contains matching antigens and antibodies.
      a. Adverse reactions are due to the agglutination of red blood cells.

E. Rh Blood Group (Fig. 12.19)
   1. The Rh factor was named after the rhesus monkey.
   2. If the Rh factor surface protein is present on red blood cells, the blood is Rh positive; otherwise it is Rh negative.
   3. There are no corresponding antibodies in the plasma unless a person with Rh-negative blood is transfused with Rh-positive blood; the person will then develop antibodies for the Rh factor.
   4. Erythroblastosis fetalis develops in Rh-positive fetuses of Rh-negative mothers but can now be prevented.