Unit 10: Blood

I. Blood
   A. The only fluid tissue in the human body
      B. Classified as a connective tissue
      C. Components of blood
      1. Living cells
         a. Formed elements
      2. Non-living matrix
         a. Plasma
   D. If blood is centrifuged
      1. Erythrocytes sink to the bottom (45% of blood, a percentage known as the hematocrit)
      2. Buffy coat contains leukocytes and platelets (less than 1% of blood)
         a. Buffy coat is a thin, whitish layer between the erythrocytes and plasma
      3. Plasma rises to the top (55% of blood)

II. Physical Characteristics of Blood
   A. Color range
      1. Oxygen-rich blood is scarlet red
      2. Oxygen-poor blood is dull red
   B. pH must remain between 7.35–7.45
      C. Blood temperature is slightly higher than body temperature at 100.4°F
      D. In a healthy man, blood volume is about 5–6 liters or about 6 quarts
      E. Blood makes up 8% of body weight

III. Blood Plasma
   A. Composed of approximately 90% water
      B. Includes many dissolved substances
      1. Nutrients
      2. Salts (electrolytes)
      3. Respiratory gases
      4. Hormones
      5. Plasma proteins
      6. Waste products

C. Plasma proteins
1. Most abundant solutes in plasma
2. Most plasma proteins are made by liver
3. Various plasma proteins include
a. Albumin—regulates osmotic pressure
b. Clotting proteins—help to stem blood loss when a blood vessel is injured
c. Antibodies—help protect the body from pathogens

D. Acidosis
1. Blood becomes too acidic

E. Alkalosis
1. Blood becomes too basic
2. In each scenario, the respiratory system and kidneys help restore blood pH to normal

IV. Formed Elements

A. Erythrocytes
1. Red blood cells (RBCs)

B. Leukocytes
1. White blood cells (WBCs)

C. Platelets
1. Cell fragments

D. Characteristics of Formed Elements of the Blood
1. Erythrocytes (red blood cells or RBCs)
a. Main function is to carry oxygen
b. Anatomy of circulating erythrocytes
(1) Biconcave disks
(2) Essentially bags of hemoglobin
(3) Anucleate (no nucleus)
(4) Contain very few organelles
c. 5 million RBCs per cubic millimeter of blood
d. Hemoglobin
(1) Iron-containing protein
(2) Binds strongly, but reversibly, to oxygen
(3) Each hemoglobin molecule has four oxygen binding sites
(4) Each erythrocyte has 250 million hemoglobin molecules

(5) Normal blood contains 12–18 g of hemoglobin per 100 mL blood

e. Homeostatic imbalance of RBCs

(1) Anemia is a decrease in the oxygen-carrying ability of the blood

(2) Sickle cell anemia (SCA) results from abnormally shaped hemoglobin

(3) Polycythemia is an excessive or abnormal increase in the number of erythrocytes

2. Leukocytes (white blood cells or WBCs)

a. Crucial in the body's defense against disease

b. These are complete cells, with a nucleus and organelles

c. Able to move into and out of blood vessels (diapedesis)

d. Can move by ameboid motion

e. Can respond to chemicals released by damaged tissues

f. 4,000 to 11,000 WBC per cubic millimeter of blood

g. Abnormal numbers of leukocytes

(1) Leukocytosis

(a) WBC count above 11,000 leukocytes/mm3

(b) Generally indicates an infection

(2) Leukopenia

(a) Abnormally low leukocyte level

(b) Commonly caused by certain drugs such as corticosteroids and anticancer agents

(3) Leukemia

(a) Bone marrow becomes cancerous, turns out excess WBC

h. Types of leukocytes

(1) Granulocytes

(a) Granules in their cytoplasm can be stained

(b) Possess lobed nuclei

(c) Include neutrophils, eosinophils, and basophils

(2) Agranulocytes

(a) Lack visible cytoplasmic granules
(b) Nuclei are spherical, oval, or kidney-shaped
(c) Include lymphocytes and monocytes
(3) List of the WBCs from most to least abundant
(a) Neutrophils
(b) Lymphocytes
(c) Monocytes
(d) Eosinophils
(e) Basophils
(f) Easy way to remember this list
I. Never
II. Let
III. Monkeys
IV. Eat
V. Bananas
i. Types of granulocytes
(1) Neutrophils
(a) Multilobed nucleus with fine granules
(b) Act as phagocytes at active sites of infection
(2) Eosinophils
(a) Large brick-red cytoplasmic granules
(b) Found in response to allergies and parasitic worms
(3) Basophils
(a) Have histamine-containing granules
(b) Initiate inflammation
j. Types of agranulocytes
(1) Lymphocytes
(a) Nucleus fills most of the cell
(b) Play an important role in the immune response
(2) Monocytes
(a) Largest of the white blood cells
(b) Function as macrophages
(c) Important in fighting chronic infection
3. Platelets
a. Derived from ruptured multinucleate cells (megakaryocytes)

b. Needed for the clotting process
c. Normal platelet count = 300,000/mm3

V. Hematopoiesis
A. Blood cell formation
B. Occurs in red bone marrow
C. All blood cells are derived from a common stem cell (hemocytoblast)
D. Hemocytoblast differentiation
1. Lymphoid stem cell produces lymphocytes
2. Myeloid stem cell produces all other formed elements
E. Formation of Erythrocytes
1. Unable to divide, grow, or synthesize proteins
2. Wear out in 100 to 120 days
3. When worn out, RBCs are eliminated by phagocytes in the spleen or liver
4. Lost cells are replaced by division of hemocytoblasts in the red bone marrow
5. Control of Erythrocyte Production
a. Rate is controlled by a hormone (erythropoietin)
b. Kidneys produce most erythropoietin as a response to reduced oxygen levels in the blood
c. Homeostasis is maintained by negative feedback from blood oxygen levels
F. Formation of White Blood Cells and Platelets
1. Controlled by hormones
a. Colony stimulating factors (CSFs) and interleukins prompt bone marrow to generate leukocytes
b. Thrombopoietin stimulates production of platelets

VI. Hemostasis
A. Stoppage of bleeding resulting from a break in a blood vessel
B. Hemostasis involves three phases
1. Vascular spasms
a. Vasoconstriction causes blood vessel to spasm
b. Spasms narrow the blood vessel, decreasing blood loss
2. Platelet plug formation

a. Collagen fibers are exposed by a break in a blood vessel
b. Platelets become "sticky" and cling to fibers
c. Anchored platelets release chemicals to attract more platelets
d. Platelets pile up to form a platelet plug

3. Coagulation (blood clotting)
a. Injured tissues release tissue factor (TF)
b. PF3 (a phospholipid) interacts with TF, blood protein clotting factors, and calcium ions to trigger a clotting cascade
c. Prothrombin activator converts prothrombin to thrombin (an enzyme)
d. Thrombin joins fibrinogen proteins into hair-like molecules of insoluble fibrin
e. Fibrin forms a meshwork (the basis for a clot)

C. Blood usually clots within 3 to 6 minutes
D. The clot remains as endothelium regenerates
E. The clot is broken down after tissue repair

I. Undesirable Clotting
A. Thrombus
1. A clot in an unbroken blood vessel
2. Can be deadly in areas like the heart

B. Embolus
1. A thrombus that breaks away and floats freely in the bloodstream
2. Can later clog vessels in critical areas such as the brain

II. Bleeding Disorders
A. Thrombocytopenia
1. Platelet deficiency
2. Even normal movements can cause bleeding from small blood vessels that require platelets for clotting

B. Hemophilia
1. Hereditary bleeding disorder
2. Normal clotting factors are missing

VII. Blood Groups and Transfusions
A. Large losses of blood have serious consequences

1. Loss of 15–30% causes weakness
2. Loss of over 30% causes shock, which can be fatal

B. Transfusions are the only way to replace blood quickly

C. Transfused blood must be of the same blood group

D. Human Blood Groups

1. Blood contains genetically determined proteins
2. Antigens (a substance the body recognizes as foreign) may be attacked by the immune system
3. Antibodies are the "recognizers"
4. Blood is "typed" by using antibodies that will cause blood with certain proteins to clump (agglutination)
5. There are over 30 common red blood cell antigens
6. The most vigorous transfusion reactions are caused by ABO and Rh blood group antigens

E. ABO Blood Groups

1. Based on the presence or absence of two antigens
   a. Type A
   b. Type B
   c. The lack of these antigens is called type O
   d. The presence of both antigens A and B is called type AB
   e. The presence of antigen A is called type A
   f. The presence of antigen B is called type B
   g. The lack of both antigens A and B is called type O
2. Blood type AB can receive A, B, AB, and O blood
   a. Universal recipient
3. Blood type B can receive B and O blood
4. Blood type A can receive A and O blood
5. Blood type O can receive O blood
   a. Universal donor

F. Blood Typing

1. Blood samples are mixed with anti-A and anti-B serum
2. Coagulation or no coagulation leads to determining blood type
3. Typing for ABO and Rh factors is done in the same manner

4. Cross matching—testing for agglutination of donor RBCs by the recipient's serum, and vice versa

G. Rh Blood Groups

1. Named because of the presence or absence of one of eight Rh antigens (agglutinogen D) that was originally defined in Rhesus monkeys
2. Most Americans are Rh+ (Rh positive)
3. Problems can occur in mixing Rh+ blood into a body with Rh− (Rh negative) blood
4. Rh Dangers During Pregnancy
   a. Danger occurs only when the mother is Rh− and the father is Rh+, and the child inherits the Rh+ factor
   b. RhoGAM shot can prevent buildup of anti-Rh+ antibodies in mother's blood
   c. The mismatch of an Rh− mother carrying an Rh+ baby can cause problems for the unborn child
      (1) The first pregnancy usually proceeds without problems
      (2) The immune system is sensitized after the first pregnancy
      (3) In a second pregnancy, the mother's immune system produces antibodies to attack the Rh+ blood (hemolytic disease of the newborn)

VIII. Developmental Aspects of Blood

A. Sites of blood cell formation

1. The fetal liver and spleen are early sites of blood cell formation
2. Bone marrow takes over hematopoiesis by the seventh month

B. Fetal hemoglobin differs from hemoglobin produced after birth

C. Physiologic jaundice results in infants in which the liver cannot rid the body of hemoglobin breakdown products fast enough