- [ ] I. Unit 10: Blood
  - [ ] A. Blood
    - [ ] 1. The only fluid tissue in the human body
    - [ ] 2. Classified as a connective tissue
    - [ ] 3. Components of blood
      - [ ] a) Living cells
        - [ ] (1) Formed elements
      - [ ] b) Non-living matrix
        - [ ] (1) Plasma
    - [ ] 4. If blood is centrifuged
      - [ ] a) Erythrocytes sink to the bottom (45% of blood, a percentage known as the hematocrit)
      - [ ] b) Buffy coat contains leukocytes and platelets (less than 1% of blood)
        - [ ] (1) Buffy coat is a thin, whitish layer between the erythrocytes and plasma
      - [ ] c) Plasma rises to the top (55% of blood)
  - [ ] B. Physical Characteristics of Blood
    - [ ] 1. Color range
      - [ ] a) Oxygen-rich blood is scarlet red
      - [ ] b) Oxygen-poor blood is dull red
    - [ ] 2. pH must remain between 7.35–7.45
    - [ ] 3. Blood temperature is slightly higher than body temperature at 100.4°F
    - [ ] 4. In a healthy man, blood volume is about 5–6 liters or about 6 quarts
    - [ ] 5. Blood makes up 8% of body weight
  - [ ] C. Blood Plasma
    - [ ] 1. Composed of approximately 90% water
    - [ ] 2. Includes many dissolved substances
      - [ ] a) Nutrients
      - [ ] b) Salts (electrolytes)
      - [ ] c) Respiratory gases
      - [ ] d) Hormones

- e) 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 (immunoglobulins) - help protect the body
- f) Waste products
  - (1) Acidosis
    - (a) Blood becomes too acidic
  - (2) Alkalosis
    - (a) Blood becomes too basic
    - (b) In each scenario, the respiratory system and kidneys help restore blood pH to normal

D. Formed Elements

- 1. Erythrocytes
  - a) Red blood cells (RBCs)
- 2. Leukocytes
  - a) White blood cells (WBCs)
- 3. Platelets
  - a) Cell fragments
- 4. Characteristics of Formed Elements of the Blood
  - a) Erythrocytes (red blood cells or RBCs)
    - (1) Main function is to carry oxygen
    - (2) Anatomy of circulating erythrocytes
      - (a) Biconcave disks
      - (b) Essentially bags of hemoglobin
      - (c) Anucleate (no nucleus)
      - (d) Contain very few organelles

- (3) 5 million RBCs per cubic millimeter of blood
- (4) Hemoglobin
  - (a) Iron-containing protein
  - (b) Binds strongly, but reversibly, to oxygen
  - (c) Each hemoglobin molecule has four oxygen binding sites
  - (d) Each erythrocyte has 250 million hemoglobin molecules
  - (e) Normal blood contains 12–18 g of hemoglobin per 100 mL blood
- (5) Homeostatic imbalance of RBCs
  - (a) Anemia is a decrease in the oxygen-carrying ability of the blood
  - (b) Sickle cell anemia (SCA) results from abnormally
  - (c) Polycythemia is an excessive or abnormal increase in the number of erythrocytes

b) Leukocytes (white blood cells or WBCs)

- (1) Crucial in the body's defense against disease
- (2) These are complete cells, with a nucleus and organelles
- (3) Able to move into and out of blood vessels (diapedesis)
- (4) Can move by ameboid motion
- (5) Can respond to chemicals released by damaged tissues
- (6) 4,000 to 11,000 WBC per cubic millimeter of blood
- (7) Abnormal numbers of leukocytes
  - (a) Leukocytosis
    - (i) WBC count above 11,000 leukocytes/mm3
    - (ii) Generally indicates an infection
  - (b) Leukopenia
    - (i) Abnormally low leukocyte level
    - (ii) Commonly caused by certain drugs such as corticosteroids and anticancer agents
  - (c) Leukemia
    - (i) Bone marrow becomes cancerous, turns out excess WBC
- (8) Types of leukocytes

- [ ] (a) Granulocytes
  - [ ] (i) Granules in their cytoplasm can be stained
  - [ ] (ii) Possess lobed nuclei
  - [ ] (iii) Include neutrophils, eosinophils, and basophils
- [ ] (b) Agranulocytes
  - [ ] (i) Lack visible cytoplasmic granules
  - [ ] (ii) Nuclei are spherical, oval, or kidney-shaped
  - [ ] (iii) Include lymphocytes and monocytes
- [ ] (c) List of the WBCs from most to least abundant
  - [ ] (i) Neutrophils
  - [ ] (ii) Lymphocytes
  - [ ] (iii) Monocytes
  - [ ] (iv) Eosinophils
  - [ ] (v) Basophils

- [ ] (9) Types of granulocytes
  - [ ] (a) Neutrophils
    - [ ] (i) Multilobed nucleus with fine granules
    - [ ] (ii) Act as phagocytes at active sites of infection
  - [ ] (b) Eosinophils
    - [ ] (i) Large brick-red cytoplasmic granules
    - [ ] (ii) Found in response to allergies and parasitic worms
  - [ ] (c) Basophils
    - [ ] (i) Have histamine-containing granules
    - [ ] (ii) Initiate inflammation
    - [ ] (iii) also produce anticoagulant called heparin
- [ ] (10) Types of agranulocytesuu
  - [ ] (a) Lymphocytes
    - [ ] (i) Nucleus fills most of the cell
    - [ ] (ii) Play an important role in the immune response
  - [ ] (b) Monocytes

- [ ] (i) Largest of the white blood cells
- [ ] (ii) Function as macrophages
- [ ] (iii) Important in fighting chronic infection

- [ ] c) Platelets
  - [ ] (1) Derived from ruptured multinucleate cells (megakaryocytes)
  - [ ] (2) Needed for the clotting process
  - [ ] (3) Normal platelet count = 300,000/mm3

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

- [ ] F. Hemostasis

- [ ] 1. Stoppage of bleeding resulting from a break in a blood vessel
- [ ] 2. Hemostasis involves three phases
  - [ ] a) Vascular spasms
    - [ ] (1) Vasoconstriction causes blood vessel to spasm
    - [ ] (2) Spasms narrow the blood vessel, decreasing blood loss
  - [ ] b) Platelet plug formation
    - [ ] (1) Collagen fibers are exposed by a break in a blood vessel
    - [ ] (2) Platelets become “sticky” and cling to fibers
    - [ ] (3) Anchored platelets release chemicals to attract more platelets
    - [ ] (4) Platelets pile up to form a platelet plug
  - [ ] c) Coagulation (blood clotting)
    - [ ] (1) Injured tissues release tissue factor (TF)
    - [ ] (2) PF3 (a phospholipid) interacts with TF, blood protein clotting factors, and calcium ions to trigger a clotting cascade
    - [ ] (3) Prothrombin activator converts prothrombin to thrombin (an enzyme)
    - [ ] (4) Thrombin joins fibrinogen proteins into hair-like molecules of insoluble fibrin
    - [ ] (5) Fibrin forms a meshwork (the basis for a clot)
- [ ] 3. Blood usually clots within 3 to 6 minutes
- [ ] 4. The clot remains as endothelium regenerates
- [ ] 5. The clot is broken down after tissue repair
- [ ] 6. 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
- [ ] 7. 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

- [ ] G. Blood Groups and Transfusions
  - [ ] 1. Large losses of blood have serious consequences
    - [ ] a) Loss of 15–30% causes weakness
    - [ ] b) Loss of over 30% causes shock, which can be fatal
  - [ ] 2. Transfusions are the only way to replace blood quickly
  - [ ] 3. Transfused blood must be of the same blood group
  - [ ] 4. Human Blood Groups
    - [ ] a) Blood contains genetically determined proteins
    - [ ] b) Antigens (a substance the body recognizes as foreign) may be attacked by the immune system
    - [ ] c) Antibodies are the “recognizers”
    - [ ] d) Blood is “typed” by using antibodies that will cause blood with certain proteins to clump (agglutination)
    - [ ] e) There are over 30 common red blood cell antigens
    - [ ] f) The most vigorous transfusion reactions are caused by ABO and Rh blood group antigens
  - [ ] 5. ABO Blood Groups
    - [ ] a) Based on the presence or absence of two antigens
      - [ ] (1) Type A
      - [ ] (2) Type B
      - [ ] (3) The lack of these antigens is called type O
      - [ ] (4) The presence of both antigens A and B is called type AB
      - [ ] (5) The presence of antigen A is called type A
      - [ ] (6) The presence of antigen B is called type B
      - [ ] (7) The lack of both antigens A and B is called type O

- b) Blood type AB can receive A, B, AB, and O blood
  - (1) Universal recipient
- c) Blood type B can receive B and O blood
- d) Blood type A can receive A and O blood
- e) Blood type O can receive O blood
  - (1) Universal donor

6. Blood Typing

- a) Blood samples are mixed with anti-A and anti-B serum
- b) Coagulation or no coagulation leads to determining blood type
- c) Typing for ABO and Rh factors is done in the same manner
- d) Cross matching - testing for agglutination of donor RBCs by the recipient's serum, and vice versa

7. Rh Blood Groups

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

H. Developmental Aspects of Blood

1. Sites of blood cell formation

- [ ] a) The fetal liver and spleen are early sites of blood cell formation
- [ ] b) Bone marrow takes over hematopoiesis by the seventh month

- [ ] 2. Fetal hemoglobin differs from hemoglobin produced after birth
- [ ] 3. Physiologic jaundice results in infants in which the liver cannot rid the body of hemoglobin breakdown products fast enough