Chapter 12: Blood

- General characteristics of blood
  - Average temperature: 100.4 °F
  - pH range: 7.35 – 7.45
  - Type of tissue: Connective tissue
  - Functions: Transport material and substances throughout the body and distribute heat
  - Blood cells: erythrocytes (red blood cells), leukocytes (white blood cells), and thrombocytes (platelets)
  - Blood matrix: blood plasma

- Blood composition
  **REFER TO FIGURE 12.1, FIGURE 12.2, and TABLE 12.1**
  - In a given blood sample, the hematocrit or the percentage of erythrocytes is on the average approximately 45% blood cells and 55% blood plasma. Leukocytes and thrombocytes made up no more than 1% of total blood volume

- Erythrocytes
  - Erythrocytes derive from an undifferentiated stem cell called hemocytoblast.
  - General characteristics
    **REFER TO FIGURE 12.4 AND FIGURE 12.5**
    - Shape of the erythrocyte is described as a biconcave disk. Mature erythrocytes will discard their nuclei. Therefore, erythrocytes will not undergo mitosis to produce new generations of erythrocytes.
    - Erythrocytes possess a complex protein called hemoglobin. Hemoglobin occupies a third of the volume of the cell. Hemoglobin will bind weakly to oxygen molecules.
    - Oxyhemoglobin blood or oxygenated blood is used to describe when oxygen combines with the hemoglobin. The appearance of oxyhemoglobin blood is bright red.
    - Deoxyhemoglobin blood or deoxygenated blood is used to describe when oxygen is released from the hemoglobin. Deoxyhemoglobin blood appearance will be a darker red. When blood escapes the blood vessels due to tissue damage, that blood is deoxyhemoglobin. The oxygen molecules will quickly detach from the hemoglobin and escape into the atmosphere.
  - Function: To carry oxygen to our tissues so that our cells can utilize the oxygen to do work and metabolize.
  - Erythrocyte count
    - Male: 4,600,000 – 6,200,000 erythrocytes per cubic millimeter
    - Female: 4,500,000 – 5,100,000 erythrocytes per cubic millimeter
    - The number of erythrocytes is a measure of the blood’s oxygen-carrying capacity.

- Lifecycle of the erythrocyte
  **REFER TO FIGURE 12.6**
  1. Nutrients from food are absorbed in the intestine.
  2. Vitamin B12, folic acid, and iron are transported via blood to red bone marrow
  3. Erythrocyte production occurs in the red bone marrow
  4. Erythrocytes mature, lose their nuclei, and circulated for about 120 days
  5. With age, erythrocytes becomes fragile and damaged from passing through capillaries
  6. Macrophages in the liver and spleen phagocytizes damaged erythrocytes

- Erythrocyte production and regulation
  **REFER TO FIGURE 12.5**
  - Production
    - In embryo and fetus: yolk sac, liver, and spleen
After birth, red bone marrow (erythropoiesis = process of manufacturing erythrocytes. Follows negative feedback mechanism.)

- Regulation
  - Negative feedback system using the hormone released from the kidneys, erythropoietin
  - Dietary factors: Vitamin B\textsubscript{12}, iron, and folic acid necessary for erythropoiesis
  - A deficiency in erythrocytes or hemoglobin results in anemia.

- Recycling of the erythrocyte

  **REFER TO FIGURE 12.6**

  - Components of hemoglobin can be recycled
    - Globin component (protein) can be recycled to bind to other proteins to make new hemoglobin structures.
    - Heme component (protein) consists of iron and biliverdin. The iron and biliverdin will be separated to be recycled.
      - Iron is transported back to red bone marrow to be stored and recycled
      - Some of the biliverdin are converted into bilirubin to be excreted in bile

- Leukocytes

  **REFER TO FIGURE 12.4**

  - Leukocytes are derived from an undifferentiated stem cell called hemocytoblast.
  - General characteristics
    - Complete cell that does not discard its nucleus. Therefore, leukocytes will be able to undergo mitosis to make more leukocytes.
    - Diapedesis is the ability of leukocytes to leave circulation by squeezing through slits of the blood vessel walls to attach pathogens and clean debris in tissues. Cells in the affected tissues will release particular chemicals to communicate and encourage leukocytes to undergo diapedesis.

  **REFER TO FIGURE 12.12**

  - Functions:
    - To fight against infections and diseases.
    - To encourage inflammations
  - Types of leukocytes: classified based on size of the cell, the appearance of the cytoplasm, and the shape of the nuclei

  **REFER TO FIGURES 12.7, 12.8, 12.9, 12.10, AND 12.11**

  - Granulocytes
    - Neutrophils
      - comprise of 54-62% of the total leukocytes
      - Multi-lobed nucleus
      - Function: undergo phagocytosis and consume small particles and matter
    - Eosinophils
      - comprise of 1-3% of total leukocytes
      - Coarse granules that stain red when preserved on a slide
      - Bi-lobed nucleus
      - 1 ½ -2x bigger than erythrocytes
      - Function: aid to control inflammations/ moderate allergic reactions and defend the body against parasitic worm infections
    - Basophils
      - comprise of less than 1% of total leukocytes
      - Granules stain blue when preserved on a slide
      - 1 ½ - 2x bigger than erythrocytes
- Function: releases histamine to promote inflammation and releases heparin to inhibit blood clotting (particular in blood vessels)

- Agranulocytes
  - Monocytes
    - 3-9% of total leukocytes
    - Largest blood cell
    - Nuclei has variable shapes
    - Function: undergo phagocytosis to consume large particles and matter. Monocytes are also able to become permanent or fixed in organs and tissues and will then be classified as MACROPHAGES
  - Lymphocytes (discuss in detail in Chapter 14)
    - 25-33% of total leukocytes
    - Long-lived cells
    - Round nucleus with small rim of cytoplasm visible
    - Approximately the same size as erythrocytes
    - Function: aid in the immune system and produce antibodies

- Leukocyte count: For both male and females: 5,000 – 10,000 leukocytes per cubic millimeter
  - Leukocytosis occurs when leukocyte count is above the normal range. Leukocyte count that is above normal may indicate a viral, bacterial, or fungal infection due to the excess of leukocytes.
  - Leukopenia occurs when the leukocyte count is below the normal range. Leukopenia correlates to illnesses such as cancer or the flu due to the destruction or deficiency in leukocytes.

- Thrombocytes
  - Thrombocytes are derived from the fragmentation of large undifferentiated multinucleate blood cells called megakaryocytes
  - Normal count: 130,000 to 360,000 thrombocytes per mm3
  - Function: Repair damaged blood vessels (clotting)

- Blood Plasma
  - Characteristics:
    - Clear, straw-colored fluid portion of blood
  - Composition
    - 92% water
    - Major gases: oxygen and carbon dioxide
    - Nutrients: amino acids, monosaccharides, nucleotides, lipids
    - Plasma proteins:
      - Albumins help maintain osmotic pressure of the blood
      - Globulins
        - Alpha and beta globulins transport lipids and fat-soluble vitamins throughout the body
        - Gamma globulins form antibodies
      - Fibrinogens = promote blood coagulation
    - Lipoproteins: complex of lipids and proteins to be transported throughout the body
      - Types of lipoproteins
        - High-density lipoproteins (HDLs) = high ratio of protein to low ratio of lipid
        - Low-density (LDLs) = high ratio of cholesterol to low ratio of protein
        - Very low-density (VLDLs) = high ratio of triglycerides to low ratio of protein
o Chylomicrons = very high ratio of triglycerides to very low ration of protein. Chylomicrons will carry dietary fats to muscles and adipose cells.
  ▪ Nitrogenous waste substances: urea and uric acid (products of protein and nucleic acid catabolism)
  ▪ Electrolytes: sodium, potassium, chloride, phosphate, bicarbonate, sulfate
  o Functions: transport nutrients and gases, regulate fluid and electrolyte balance, maintain pH
• Hemostasis = Refers to stoppage of bleeding due to a laceration or break of a blood vessel
• 3 Steps:
  1. Blood vessel spasm = smooth muscles of the blood vessel will contract (vasospasm) to lessen the blood loss
  2. Platelet plug formation = condition that occurs as blood escapes the severed blood vessel and the thrombocytes adhere to the edges of the broken blood vessel, collagen in the connective tissue, and to one another. Platelets release a chemical called serotonin to cause vasoconstriction to further reduce the blood loss.
  REFER TO FIGURE 12.13
  3. Blood coagulation forms the blood clot. Complex series of events that uses biochemicals or clotting factors to encourage coagulation. The cascade of events for coagulation involves converting the plasma protein fibrinogen into threadlike proteins called fibrin.
  REFER TO FIGURE 12.14 AND FIGURE 12.16
  • The damaged tissues release a chemical called thromboplastin
  • The presence of thromboplastin causes the production of prothrombin activator (the amount produced is correlated to the degree of tissue damage)
  • Prothrombin activator converts the alpha globulin, prothrombin, into thrombin
  • Thrombin is used to shred fibrinogen into long threads of fibrin
  • Long threads of fibrin adhere to broken edges of the blood vessel to form a mesh or net that traps the blood; and thus, forming the blood clot and prevents further blood loss
  • Underneath the blood clot, fibroblasts invade the damaged tissue region to strength and seal the broken edge. Enzymes will digest the blood clot once the tissue repair is complete.
  • Positive feedback: Promotes more clotting to occur by producing more thrombin until blood clot is completely formed.
• Abnormal blood clots
  o Thrombus = clot formed in an unbroken vessel
  o Embolus = a dislodged thrombus or fragmented thrombus circulates in the blood stream and causing an obstruction or narrowing of the vessel causing and reduction in blood flow
• ABO Blood Types and Transfusions
  o Agglutination = interaction of proteins (antigens) on the surfaces of erythrocytes with certain antibodies carried in the plasma
  o Agglutination occurs when there is an incompatible transfusion of blood—the antigens and antibodies interact causing erythrocytes to drop from circulation
  REFER TO TABLE 12.4, FIGURE 12.18
  o ABO Blood groups:
  REFER TO TABLE 12.3 AND FIGURE 12.17
    ▪ Type A blood – possess A antigens, anti-B antibodies
    ▪ Type B blood – possess B antigens, anti-A antibodies
    ▪ Type AB blood – possess A and B antigens, no antibodies
    ▪ Type O blood – possess no antigens, both antibodies
  o Rh groups:
    ▪ Rh⁺ blood contains the Rh factor, no anti-Rh antibodies
- Rh\(^-\) blood does not have Rh factor, ONLY produces anti-Rh antibodies IF exposed to Rh\(^+\) blood

**Erythroblastosis fetalis** develops in Rh\(^+\) fetus of Rh\(^-\) mothers. During the birth of the first child with Rh\(^-\) blood, the child’s blood will “sensitize” the mother’s blood once the membrane of the placenta breaks and exposes the fetal blood to the mother’s blood. The fetal blood will stimulate the anti-Rh antibodies to be produced in the mother. If the mother happens to become pregnant with another child with Rh\(^+\) blood then her blood will attack the future fetal blood and erythrocytes. Erythroblastosis fetalis will result with symptoms including severe jaundice, anemia leading to heart failure and respiratory distress, enlarged liver and spleen, and overall swelling of the child. An immediate blood transfusion for the newborn child can treat this severe disease. This condition can be prevented by injecting a drug called RhoGAM that shields the anti-Rh antibodies before they attack. *REFER TO FIGURE 12.19*