Chapter 14: The Lymphatic System and Immunity

- Major function of the Lymphatic System
  - Network of vessels that collect and carry excess fluid from interstitial spaces back to blood circulation
  - Organs of the lymphatic system aid in defense against diseases and infections.
- Lymphatic pathways— one-way path toward the heart
  REFER TO FIGURES 14.1, 14.2, 14.4, 14.5
  - **Lymphatic capillaries**: tiny, closed-ended tubes that extend into the interstitial spaces
    - Tissue fluid enters the capillaries is called lymph
  - **Lymphatic vessels**: similar to veins but thinner
    - Lymphatic capillaries converge to form small lymphatic vessels
    - Smaller lymphatic vessels will converge to form large lymphatic vessels
    - Possess valves to prevent backflow of lymph
    - Valves close due to the high pressure in the vessels due to the increase in lymph volume
  - **Lymphatic trunks**
    - When large branches of lymphatic vessels converge to form a few lymphatic pathways before returning to the heart
  - **Collecting ducts**: returns lymph to circulation
    - Lymphatic trunks converge as collecting ducts located in close proximity to the heart to return lymph to circulation
    - Main collecting ducts
      - Thoracic duct drains into left subclavian vein
      - Right lymphatic duct drains into the right subclavian vein
- Interstitial fluid vs. Lymph
  - Water and dissolved substances that left the blood capillaries during diffusion and filtration is called interstitial fluid
  - Tissue fluid becomes lymph once it enters a lymphatic capillary
  - Lymph
    - Rising osmotic pressure in the tissues and lumen of the lymphatic capillaries forces some of the excess fluid into lymphatic capillaries
    - Lymph movement
      - No pumps to draw the lymph toward the heart
      - Hydrostatic pressure, muscle contractions against the vessels, and breathing will propel the lymph through the lymphatic vessels
    - Edema = condition that interferes with the flow of lymph
      - Example: surgery may remove or disturb lymphatic tissues or vessels
- Lymph nodes
  REFER TO FIGURES 14.6, 14.8
  - Anatomy: vascular bean-shaped structure
    - Covered with connective tissue that extend inward to divide the node into nodules and sinuses
    - Afferent lymphatic vessels will enter the cortex of the lymph node to bring unfiltered lymph to the medulla of the lymph node where lymphocytes and macrophages will undergo phagocytosis to clean debris and pathogens
    - Efferent lymphatic vessels will exit the lymph node through a medial sinus called the hilum and transport the filtered lymph toward the heart
  - Location: Along larger lymphatic vessels and concentrated mainly in the axial portion of the body
  - Functions

        - Filters the lymph to remove pathogens and debris
        - Encourages lymphocyte production due to the monitoring of the lymph and the concentration of pathogens in the lymph.
        - Prepares the body for a possible immune response
- Organs of the Lymphatic System
  REFER TO FIGURE 14.9
    - Tonsils
        - Masses of tissues made up of lymphoid tissue that contain leukocytes to fight against infections
        - Location: surrounding the oral cavity and pharynx
        - If infected or inflamed, tonsils can be surgically removed
    - Thymus
        - Anatomy and location:
            - Soft, bi-lobed organ behind the sternum
            - Connective tissue that extends inward to divide into lobules
        - Lobules contain T lymphocytes (T cells)
        - T cells leave the thymus to provide immunity
        - Thymosin is a hormone that is secreted to induce maturation of the T cells once they leave the thymus. Thymosin helps to "program" the lymphocytes. Thymosin is most active during childhood.
    - Spleen
      REFER TO FIGURE 14.10
        - Location: upper left abdominal cavity; lateral to the stomach
        - Largest lymphatic organ
        - Anatomy: similar to the organization of lymph nodes
            - Possess white pulp and red pulp
                - White pulp contains many lymphocytes
                - Red pulp contains RBC, macrophages, and lymphocytes
        - Functions: Filter blood not lymph and destroys worn out blood cells
- Immunity
    - Pathogens: disease-causing agents that can produce infections within the body; bears "non-self" or foreign antigens
    - Species Resistance = a species is resistant to diseases that affect other species based on physiological or chemical factors that hinder growth of the pathogen
    - Types of defenses
        - Nonspecific defenses (innate)—general defenses (1^{st} /2^{nd} lines of defense)
        - Specific defenses (immunity)—targeted defenses(3^{rd} line of defense)
    - Three divisions of defense:
        - First line of defense:
            - Mechanical barriers– intact skin and mucous membranes keep most pathogens from the environment from entering the body
        - Second line of defense
            - Chemical barriers
            - Fever
            - Inflammation
            - Phagocytosis
                - Mononuclear phagocytic system
        - Third line of defense
            - Specific Defenses (Immunity)

- Immunity = mounted response by the body against a specific, recognized foreign molecules
- Antigens = proteins, polysaccharides, glycoproteins that are displayed on a cell's surface
- Haptens are smaller molecules that can combine and the combined structure can be recognized as an antigen
- After birth, the body makes an inventory of all "self" antigens
- Responses
  - Humoral response or antibody-mediated immunity - "humoral" refers to fluid
    - Production of antibodies that will released in the body fluids to fight specific foreign antigen carrying cells
  - Cellular response or cell-mediated immunity
    - Specific immunity cells that will directly interact with the pathogen

- Cells of the Immunity
  REFER TO FIGURE 14.12
  - T lymphocytes (T cells)
    - Recall that the red bone marrow produces blood cells
    - Some of the undifferentiated lymphocytes will circulate in the blood to reach and reside in the thymus to become T cells
    - Types of T cells
      - Helper T cells = become activated when antigen receptors combine with a displayed, foreign antigen and will stimulates B cells through the release of chemicals called cytokines
      - Cytotoxic T cells = recognizes nonself antigens, particularly cancerous cells; releases proteins that can cut holes into the foreign cell and destroy
      - Natural killer cells = monitors the body and attacks a pathogenic cell by attaching to the cell to release its fluid directly into the pathogenic cell to promote lysis or to releases toxin into the pathogenic cell to promote apoptosis
      - Memory T cells = provides a "no-delay" response to future exposures to the same foreign antigen
    - Functions:
      - Provides a cell-mediated immunity or cellular immune response– T cells attack foreign, antigen-bearing cells
      - Secrete cytokines (polypeptides) which is a chemical recruits and can enhance cellular response to foreign antigens
      - Activate specific B lymphocytes (B cells)
      - Secrete toxins to kill target cells
      - Produce growth-inhibiting factors
      - Produce interferons that can interfere with tumor cells or viruses
        - Interferons are hormone-like peptide antiviral substances that interfere with replication of viral DNA or even degrade viral DNA
  - B lymphocytes
    - Recall that red bone marrow produces blood cells.
    - Unlike T cells, B lymphocytes or B cells remain in the red bone marrow until they mature.
    - At maturation, B cells circulate in the blood or reside in lymphatic organs
    - Functions:
      - Provide an antibody-mediated immunity or humoral (fluid) immune response

        - Types of B cells
            - Plasma cells that secrete antibodies
            - Memory B cells provide a "no-delay" response to future exposures to the same foreign antigen
        - Steps of Antibody-mediated Immunity
          REFER TO FIGURES 14.13, 14.14, AND TABLE 14.2
            1. Macrophage consumes bacterium. It displays the bacteria's antigens on the macrophage's surface
            2. A specific type of helper T cell will bind to the antigen
            3. Once connected, the helper T cell becomes activated and releases the cytokines to lead cells to the area
            4. The activated helper T cell interacts with a specific B cell that has already found the same antigen. Helper T cell activates that B cell
            5. Cytokines from the helper T cell causes the B cell to proliferate and differentiate into plasma cells
            6. Plasma cells create the appropriate antibodies needed to counter the antigen
            7. The antibodies are released from the plasma cells and attack the pathogen
- Antibodies – derived from the plasma proteins, gamma globulins
    - Types of antibodies
        - IgG = found in tissue fluid and plasma
        - IgA = found in exocrine gland secretions such as in breast milk, saliva, and tears
        - IgM = found in plasma; ABO antibodies
        - IgD = found on the surface of B cells; B cell activation
        - IgE = found in exocrine gland secretions; will lead to all levels of allergic reactions
    - Antibody actions
        - Direct attack
            - Agglutination—the interactions of the antigens and antibodies to cause clumping
            - Precipitation – antibody interaction with the antigen to increase the pathogenic cell's density so that it will drop out of circulation and flow
            - Neutralization – complex between the antibody and antigen to that promotes deactivation of the antigen or cover the toxic portion of the antigen
        - Activation of complement
            - Opsonization – complex between the antibody and antigen so that the pathogenic cell is "coated" with a substance that makes phagocytosis via leukocytes easier
            - Chemotaxis – release of chemicals once the antibody and antigen are interacted to promote and attract the mononuclear phagocytic system cells
            - Lysis – when the antibody and antigen interact, the antibody will imbed structures into the entire cell membrane of the pathogen to form a "pore-like" opening to allow fluid to enter the pathogen and burst
        - Stimulation of localized changes
            - Inflammation – isolate, quarantine, and dispose of the pathogenic population
- Immune Responses
  REFER TO FIGURE 14.16
    - Primary immune response
        - Occurs when B and T cells first encounter the foreign antigen
        - Response is slow due to the lag time between the recognition of the foreign antigen and the production of antibodies from the B cells and the attacks from the T cells
    - Secondary immune response
        - Utilizes memory B and memory T cells
        - Guards the body against future exposures to the same foreign antigen

        - More rapid response because the memory B and T cells are aware of how to defend and attack the pathogen
        - Long-lasting
- Classification of Immunity
  REFER TO TABLE 14.3
    - Naturally acquired active immunity
        - Exposure to the antigen itself; stimulates an immune response with symptoms
    - Artificially acquired active immunity
        - Exposure to vaccine with dead or weak pathogens; stimulates an immune response with little or no symptoms
    - Artificially acquired passive immunity
        - Injection of gamma globulins containing antibodies; short-term immunity with no immune response (injection of an antiserum of antibodies)
    - Naturally acquired passive immunity
        - Antibodies are passed to fetus from pregnant female with active immunity; short-term immunity for infant without immune response
- Allergic Reactions
    - Allergen = foreign substance that stimulates an allergic reaction which are excessive to immune responses
    - Types of allergic reactions
        - Delayed-reaction allergy – affect anyone at any time
            - Repeated exposure to substances
            - Inflammation
        - Immediate-reaction allergy
            - Inherited ability to overproduce IgE or intense exposure to the allergen that can create the onset of overproduction of IgE
            - Anaphylactic shock – physical and psychological stress leading to symptoms such as apprehension, hives, vomiting, and swelling of passageways
                - Injection of epinephrine will "calm" the allergic reaction
- Transplantation and Tissue Rejection
    - Transplant: almost all organs can be transplanted from same species donor or even from other species
        - Examples:
          *corneas *kidneys *livers *heart
          *pancreas *bone marrow *skin
    - Tissue Rejection = recipient's immune system react to foreign antigens (donor)
        - Resembles cellular immune response against the antigens
        - Immunosuppressive drugs that will hinder the immunity to be active. The recipient will be susceptible to all pathogens for months after the transplant.

- Autoimmunity
    - Autoimmunity is the inability to distinguish self and non-self antigens
        - The immune system will attack all cells.
    - Treatment usually suppresses the symptoms of the autoimmune disorder but will not cure the disorder.
    - Examples of autoimmune disorders:
      *AIDS
      *Lupus
      *Grave's disease
      *Rheumatoid arthritis

*Cohn’s disease
*Multiple Sclerosis
*Psoriasis