

- I. Unit 12: The Lymphatic System and Body Defenses
 - A. The Lymphatic System
 - 1. Consists of two semi-independent parts
 - a) Lymphatic vessels
 - b) Lymphoid tissues and organs
 - 2. Lymphatic system functions
 - a) Transports escaped fluids back to the blood
 - b) Plays essential roles in body defense and resistance to disease
 - B. Lymphatic Characteristics
 - 1. Lymph - excess tissue fluid carried by lymphatic vessels
 - 2. Properties of lymphatic vessels
 - a) One way system toward the heart
 - b) No pump
 - c) Lymph moves toward the heart
 - (1) Milking action of skeletal muscle
 - (2) Rhythmic contraction of smooth muscle in vessel walls
 - C. Relationship of Lymphatic Vessels to Blood Vessels
 - 1. Lymphatic Vessels
 - a) Lymph capillaries
 - (1) Walls overlap to form flap-like minivalves
 - (2) Fluid leaks into lymph capillaries
 - (3) Capillaries are anchored to connective tissue by filaments
 - (4) Higher pressure on the inside closes minivalves
 - (5) Fluid is forced along the vessel
 - b) Lymphatic collecting vessels
 - (1) Collect lymph from lymph capillaries
 - (2) Carry lymph to and away from lymph nodes
 - (3) Return fluid to circulatory veins near the heart
 - (a) Right lymphatic duct
 - (b) Thoracic duct

- 2. Lymph
 - a) Harmful materials that enter lymph vessels
 - (1) Bacteria
 - (2) Viruses
 - (3) Cancer cells
 - (4) Cell debris
- 3. Lymph Nodes
 - a) Filter lymph before it is returned to the blood
 - b) Defense cells within lymph nodes
 - (1) Macrophages - engulf and destroy foreign substances
 - (2) Lymphocytes - provide immune response to antigens
- 4. Lymph Node Structure
 - a) Most are kidney-shaped and less than 1 inch long
 - b) Cortex
 - (1) Outer part
 - (a) Contains follicles - collections of lymphocytes
 - c) Medulla
 - (1) Inner part
 - (a) Contains phagocytic macrophages
- 5. Flow of Lymph Through Nodes
 - a) Lymph enters the convex side through afferent lymphatic vessels
 - b) Lymph flows through a number of sinuses inside the node
 - c) Lymph exits through efferent lymphatic vessels
 - d) Fewer efferent than afferent vessels causes flow to be slowed
- 6. Other Lymphoid Organs
 - a) Several other organs contribute to lymphatic function
 - (1) Spleen
 - (a) Located on the left side of the abdomen
 - (b) Filters blood
 - (c) Destroys worn out blood cells

- (d) Forms blood cells in the fetus
- (e) Acts as a blood reservoir
- (2) Thymus
 - (a) Located low in the throat, overlying the heart
 - (b) Functions at peak levels only during childhood
 - (c) Produces hormones (like thymosin) to program lymphocytes
- (3) Tonsils
 - (a) Small masses of lymphoid tissue around the pharynx
 - (b) Trap and remove bacteria and other foreign materials
 - (c) Tonsillitis is caused by congestion with bacteria
- (4) Peyer's patches
 - (a) Found in the wall of the small intestine
 - (b) Resemble tonsils in structure
 - (c) Capture and destroy bacteria in the intestine
- 7. Mucosa-Associated Lymphatic Tissue (MALT)
 - a) Includes
 - (1) Peyer's patches
 - (2) Tonsils
 - (3) Other small accumulations of lymphoid tissue
 - b) Acts as a sentinel to protect respiratory and digestive tracts
- D. Body Defenses
 - 1. The body is constantly in contact with bacteria, fungi, and viruses
 - 2. The body has two defense systems for foreign materials
 - a) Innate (nonspecific) defense system
 - b) Adaptive (specific) defense system
 - 3. Immunity - specific resistance to disease
 - 4. Immune System
 - 5. Body Defenses
 - a) Innate defense system (nonspecific defense system)
 - (1) Mechanisms protect against a variety of invaders

- (2) Responds immediately to protect body from foreign materials
- b) Adaptive defense system (specific defense system)
 - (1) Specific defense is required for each type of invader
- 6. Innate Body Defenses
 - a) Innate body defenses are mechanical barriers to pathogens such as
 - (1) Body surface coverings
 - (a) Intact skin
 - (b) Mucous membranes
 - (2) Specialized human cells
 - (3) Chemicals produced by the body
 - b) Surface Membrane Barriers: First Line of Defense
 - (1) Skin and mucous membranes
 - (a) Physical barrier to foreign materials
 - (b) Also provide protective secretions
 - (i) pH of the skin is acidic to inhibit bacterial growth
 - (ii) Sebum is toxic to bacteria
 - (iii) Vaginal secretions are very acidic
 - (2) Stomach mucosa
 - (a) Secretes hydrochloric acid
 - (b) Has protein-digesting enzymes
 - (3) Saliva and lacrimal fluid contain lysozymes, an enzyme that destroy bacteria
 - (4) Mucus traps microorganisms in digestive and respiratory pathways
 - c) Cells and Chemicals: Second Line of Defense
 - (1) Phagocytes
 - (a) Cells such as neutrophils and macrophages
 - (b) Engulf foreign material into a vacuole
 - (c) Enzymes from lysosomes digest the material
 - (2) Natural killer cells
 - (a) Can lyse (disintegrate or dissolve) and kill cancer cells

- (b) Can destroy virus-infected cells
- (3) Inflammatory response
 - (a) Triggered when body tissues are injured
 - (b) Four most common indicators of acute inflammation
 - (i) Redness
 - (ii) Heat
 - (iii) Swelling
 - (iv) Pain
 - (c) Results in a chain of events leading to protection and healing
 - (d) Functions of the inflammatory response
 - (i) Prevents spread of damaging agents
 - (ii) Disposes of cell debris and pathogens through phagocytosis
 - (a) Phagocytosis
 - (i) Neutrophils move by diapedesis to clean up damaged tissue and/or pathogens
 - (ii) Monocytes become macrophages and complete disposal of cell debris
 - (iii) Sets the stage for repair
- (4) Antimicrobial proteins
 - (a) Attack microorganisms
 - (b) Hinder reproduction of microorganisms
 - (c) Most important
 - (i) Complement proteins
 - (a) A group of at least 20 plasma proteins
 - (b) Activated when they encounter and attach to cells (complement fixation)
 - (c) Damage foreign cell surfaces
 - (d) Release vasodilators and chemotaxis chemicals, cause opsonization
 - (ii) Interferon
 - (a) Proteins secreted by virus-infected cells

- (b) Bind to healthy cell surfaces to interfere with the ability of viruses to multiply
- (5) Fever
 - (a) Abnormally high body temperature
 - (b) Hypothalamus heat regulation can be reset by pyrogens (secreted by white blood cells)
 - (c) High temperatures inhibit the release of iron and zinc from the liver and spleen needed by bacteria
 - (d) Fever also increases the speed of tissue repair
- d) Adaptive Defense System: Third Line of Defense
 - (1) Immune response is the immune system's response to a threat
 - (2) Immunology is the study of immunity
 - (3) Antibodies are proteins that protect from pathogens
 - (4) Three aspects of adaptive defense
 - (a) Antigen specific - recognizes and acts against particular foreign substances
 - (b) Systemic - not restricted to the initial infection site
 - (c) Memory - recognizes and mounts a stronger attack on previously encountered pathogens
 - (5) Types of Immunity
 - (a) Humoral immunity = antibody-mediated immunity
 - (i) Provided by antibodies present in body fluids
 - (b) Cellular immunity = cell-mediated immunity
 - (i) Targets virus-infected cells, cancer cells, and cells of
 - (6) Antigens (nonself)
 - (a) Any substance capable of exciting the immune system and provoking an immune response
 - (b) Examples of common antigens
 - (i) Foreign proteins (strongest)
 - (ii) Nucleic acids
 - (iii) Large carbohydrates

- (iv) Some lipids
- (v) Pollen grains
- (vi) Microorganisms
- (c) Self-antigens
 - (i) Human cells have many surface proteins
 - (ii) Our immune cells do not attack our own proteins
 - (iii) Our cells in another person's body can trigger an immune response because they are foreign
 - (a) Restricts donors for transplants
- (d) Allergies
 - (i) Many small molecules (called haptens or incomplete antigens) are not antigenic, but link up with our own proteins
 - (ii) The immune system may recognize and respond to a protein-hapten combination
 - (iii) The immune response is harmful rather than protective because it attacks our own cells
- (7) Cells of the adaptive defense system
 - (a) Lymphocytes respond to specific antigens
 - (i) B lymphocytes (B cells)
 - (ii) T lymphocytes (T cells)
 - (b) Macrophages help lymphocytes
 - (c) Immunocompetent - cell becomes capable of responding to a specific antigen by binding to it
 - (d) Cells of the adaptive defense system
 - (i) Lymphocytes
 - (a) Originate from hemocytoblasts in the red bone marrow
 - (b) B lymphocytes become immunocompetent in the bone marrow (remember B for Bone marrow)
 - (c) T lymphocytes become immunocompetent in the thymus (remember T for Thymus)
 - (ii) Macrophages

- (a) Arise from monocytes
 - (b) Become widely distributed in lymphoid organs
 - (c) Secrete cytokines (proteins important in the
 - (d) Tend to remain fixed in the lymphoid organs
- (8) Humoral (Antibody-Mediated) Immune Response
- (a) B lymphocytes with specific receptors bind to a specific antigen
 - (b) The binding event activates the lymphocyte to undergo clonal selection
 - (c) A large number of clones are produced (primary humoral response)
 - (d) Most B cells become plasma cells
 - (i) Produce antibodies to destroy antigens
 - (ii) Activity lasts for 4 or 5 days
 - (e) Secondary humoral responses
 - (i) Memory cells are long-lived
 - (ii) A second exposure causes a rapid response
 - (iii) The secondary response is stronger and longer lasting
 - (f) Some B cells become long-lived memory cells (secondary humoral response)
 - (g) Active Immunity
 - (i) Occurs when B cells encounter antigens and produce antibodies
 - (ii) Active immunity can be
 - (a) Naturally acquired during bacterial and viral infections
 - (b) Artificially acquired from vaccines
 - (h) Passive Immunity
 - (i) Occurs when antibodies are obtained from someone else
 - (a) Conferred naturally from a mother to her fetus (naturally acquired)
 - (b) Conferred artificially from immune serum or gamma globulin (artificially acquired)
 - (ii) Immunological memory does not occur
 - (iii) Protection provided by “borrowed antibodies”

- (iv) Monoclonal antibodies
- (v) Antibodies prepared for clinical testing or diagnostic services
- (vi) Produced from descendants of a single cell line
- (vii) Examples of uses for monoclonal antibodies
 - (a) Diagnosis of pregnancy
 - (b) Treatment after exposure to hepatitis and rabies
- (i) Antibodies (Immunoglobulins or Igs)
 - (i) Soluble proteins secreted by B cells (plasma cells)
 - (ii) Carried in blood plasma
 - (iii) Capable of binding specifically to an antigen
 - (iv) Antibody structure
 - (a) Four amino acid chains linked by disulfide bonds
 - (b) Two identical amino acid chains are linked to form a heavy chain
 - (c) The other two identical chains are light chains
 - (d) Specific antigen-binding sites are present
- (v) Antibody classes
 - (a) Antibodies of each class have slightly different roles
 - (b) Five major immunoglobulin classes (MADGE)
 - (i) IgM - can fix complement
 - (ii) IgA - found mainly in mucus
 - (iii) IgD - important in activation of B cell
 - (iv) IgG - can cross the placental barrier and fix complement
 - (v) IgE - involved in allergies
- (vi) Antibody function
 - (a) Antibodies inactivate antigens in a number of ways
 - (i) Complement fixation
 - (ii) Neutralization
 - (iii) Agglutination
 - (iv) Precipitation

- (9) Cellular (Cell-Mediated) Immune Response
 - (a) Antigens must be presented by macrophages to an immunocompetent T cell (antigen presentation)
 - (b) T cells must recognize nonself and self (double recognition)
 - (c) After antigen binding, clones form as with B cells, but different classes of cells are produced
 - (d) T cell clones
 - (i) Cytotoxic (killer) T cells
 - (a) Specialize in killing infected cells
 - (b) Insert a toxic chemical (perforin)
 - (ii) Helper T cells
 - (a) Recruit other cells to fight the invaders
 - (b) Interact directly with B cells
 - (iii) Regulatory T cells
 - (a) Release chemicals to suppress the activity of T and B cells
 - (b) Stop the immune response to prevent uncontrolled activity
 - (iv) A few members of each clone are memory cells
- E. Organ Transplants and Rejection
 - 1. Major types of grafts
 - a) Autografts - tissue transplanted from one site to another on the
 - b) Isografts - tissue grafts from an identical person (identical twin)
 - c) Allografts - tissue taken from an unrelated person
 - d) Xenografts - tissue taken from a different animal species
 - 2. Autografts and isografts are ideal donors
 - 3. Xenografts are never successful
 - 4. Allografts are more successful with a closer tissue match
- F. Disorders of Immunity: Allergies (Hypersensitivity)
 - 1. Abnormal, vigorous immune responses
 - 2. Types of allergies
 - 3. Immediate hypersensitivity

- a) Triggered by release of histamine from IgE binding to mast cells
- b) Reactions begin within seconds of contact with allergen
- c) Anaphylactic shock - dangerous, systemic response
- 4. Types of allergies (continued)
 - a) Delayed hypersensitivity
 - (1) Triggered by the release of lymphokines from activated helper T cells
 - (2) Symptoms usually appear 1–3 days after contact with antigen
- G. Disorders of Immunity: Immunodeficiencies
 - 1. Production or function of immune cells or complement is abnormal
 - 2. May be congenital or acquired
 - 3. Includes AIDS (Acquired Immune Deficiency Syndrome)
 - 4. The immune system does not distinguish between self and nonself
 - 5. The body produces antibodies and sensitized T lymphocytes that attack its own tissues
 - 6. Examples of autoimmune diseases
 - a) Multiple sclerosis - white matter of brain and spinal cord are destroyed
 - b) Myasthenia gravis - impairs communication between nerves and skeletal muscles
 - c) Type I diabetes mellitus - destroys pancreatic beta cells that produce insulin
 - d) Rheumatoid arthritis - destroys joints
 - e) Systemic lupus erythematosus (SLE)
 - (1) Affects kidney, heart, lung and skin
 - f) Glomerulonephritis - impairment of renal function
 - 7. Self Tolerance Breakdown
 - a) Inefficient lymphocyte programming
 - b) Appearance of self-proteins in the circulation that have not been exposed to the immune system
 - (1) Eggs
 - (2) Sperm
 - (3) Eye lens
 - (4) Proteins in the thyroid gland

- (4) Proteins in the thyroid gland
- 8. Cross-reaction of antibodies produced against foreign antigens with
 - a) Rheumatic fever
- H. Developmental Aspects of the Lymphatic System and Body Defenses
 - 1. Except for thymus and spleen, the lymphoid organs are poorly developed before birth
 - 2. A newborn has no functioning lymphocytes at birth, only passive immunity from the mother
 - 3. If lymphatics are removed or lost, severe edema results, but vessels grow back in time