I. Lymphatic System
   A. Lymphatic Vessels (Lymphatics)
      1. Lymphatic Capillaries (Terminal Lymphatics)
         a. Absent in the following areas:
            1) Avascular Tissue
            2) Central Nervous System
            3) Bone
            4) Bone Marrow
            5) Teeth
         b. Structure
            1) Lined with Endothelial cells, but basement membrane is incomplete or absent
               a) Cells overlap forming one-way valves
                  1] Interstitial Fluids flow into
                  2] Allows Proteins, Viruses, Bacteria & Cell Debris to enter
            2) Closed end starts near arterial end of blood capillaries
            3) Have a larger diameter lumen than blood capillaries
         c. Lacteals – Lymphatic capillaries in the small intestine
            1) Transport lipids
2. Lymphatic Vessels
   a. Structure
      1) Thinner than Veins
      2) More Valves than Veins
      3) Have Three Tunics
      4) Anastomose More than Veins
      5) Lymph Nodes at Intervals
   b. Sets of Lymphatic Vessels
      1) Superficial Lymphatics
      2) Deep Lymphatics

3. Lymphatic Trunks
   a. Empty into Ducts
4. Lymphatic Ducts
   a. Thoracic Duct
      1) Cisterna chyli – Inferior end
         a) Receives lymph from Right and Left Lumbar Trunks and Intestinal Trunk
      2) As it ascends it receives lymph from Left Jugular, Left Subclavian, and Left Bronchomediastinal Trunks
      3) Empties into Bloodstream at junction of Left Internal Jugular Vein and Left Subclavian Vein
      4) Drains Left Upper Extremity, Left Side of Head and Thorax, and EVERYTHING below the Diaphragm
   b. Right Lymphatic Duct
      1) Receives lymph from Right Jugular, Right Subclavian, and Right Bronchomediastinal Trunks
      2) Empties into Bloodstream at junction of Right Internal Jugular Vein and Right Subclavian Vein
      3) Drains Right Upper Extremity, and Right Side of Head and Thorax

5. Edema
B. Encapsulated Lymphatic Organs
1. Lymph Nodes
   a. Histology
      1) Hilum (Formerly called Hilus)
      2) Capsule
         a) Stroma (Framework)
            1] Trabeculae
            2] Reticular Fibers
      3) Parenchyma (Functioning Part)
         a) Cortex
            1] Outer Cortex with Germinal Center – B cells
            2] Deep Cortex with T cells
         b) Medulla
            1] Medullary cords – B cells and Plasma cells
b. Lymph flow within lymph node
   1) Afferent Lymphatic Vessels
   2) Subcapsular Space (Sinus)
   2) Cortical Sinuses
   3) Medullary Sinuses
   4) Efferent Lymphatic Vessels

c. Local Concentrations
   1) Axillary Region
   2) Inguinal Region
   3) Cervical Region
   4) Angle of Jaws
   5) Mesentery of Small Intestine

d. Bubo

e. Clinical Application: Lymphatics and Breast Cancer
   1) Metastasize
   2) Radical Mastectomy
2. Spleen
   a. Functions
      1) Does NOT Filter Lymph – only Efferent Vessels
      2) Proliferation of Lymphocytes
      3) Blood Cleansing Phagocytosis
         a) Bacteria, Viruses, Toxins & Debris
         b) Old & Defective Blood Cells
      4) Stores & Recycles Breakdown Products of RBC’s
      5) Blood Cell Formation during Fetal Development
      6) Blood Reserve
   b. Histology
      1) White Pulp – resembles lymphoid nodules
         a) Lymphocytes Encircling Central Arteries
      2) Red Pulp – red blood cells primarily
         a) Blood Sinusoids from Trabecular Arteries
         b) Splenic Cords of Reticular Tissue
      3) Capsule
3. Thymus Gland
   a. Histology
      1) Capsule
         a) Septa
      2) Two Thymic Lobes
         a) Lobules
            1] Thymic Cortex
               a] T Lymphocytes (T cells) – actively dividing
               b] Thymic Epithelial Cells (TECs) - maintain Blood-Thymus barrier
            2] Medulla
               a] Mature T cells migrate here
               b] Thymic (Hassal’s) corpuscles
   b. Involution
C. Diffuse Lymphatic Tissue

1. Mucosa-associated lymphoid tissue (MALT)
   a. Peyer’s Patch – Aggregated Lymphoid Nodules
   b. Appendix (Vermiform appendix)
   c. Tonsils
      1) Pharyngeal Tonsil (Adenoid) – Posterior nasopharynx
      2) Palatine Tonsils – Posterior arches of oral cavity
      3) Lingual Tonsil – Base of tongue
      4) Histology
         a) Crypt – Invagination of epithelium
         b) Germinal Center
      5) Tonsillitis
         a) Tonsillectomy
         b) Adenectomy
II. Adaptive (Specific) Immunity
   A. Specific Defenses
      1. Cell-mediated (Cellular) Immunity – T cells
      2. Antibody-mediated (Humoral) Immunity – B cells
   B. Properties of Adaptive Immunity
      1. Specificity Memory
      2. Versatility
      3. Specificity
      4. Tolerance – Ability to Differentiate Self from Nonself Antigens
         a. Clinical Applications: Autoimmunity
            1) Multiple sclerosis (MS)
            2) Myasthenia gravis
            3) Graves’ disease
            4) Systemic lupus erythematosus (SLE)
            5) Glomerulonephritis
            6) Rheumatoid arthritis (RA)
            7). Insulin-dependent diabetes mellitus (IDDM) – Type I (Juvenile)
   C. Response generated by
      1. Complete Antigens with at least two Antigenic determinant sites (Epitopes) – Activate B cells & Antibody production
         – usually Foreign Proteins & Polysaccharides
      2. Haptens – only when attached to carrier molecules
         a. Normally Haptens (partial antigens) do not activate
D. Immunocompetent Lymphocytes

1. Types of Lymphocytes
   a. Cytotoxic T cells \( (T_C) \)
   b. Memory \( T_C \)
   c. Suppressor cells
   d. Helper T cells \( (T_H) \)
   e. Memory \( T_H \)
   f. Suppressor T cells
   g. B cells
      1) Plasma cells
   h. Memory B cells

2. Primary (Central) lymphoid organs – Production & Maturation
   a. Bone marrow
   b. Thymus
      1) Clinical Application: Immunodeficiency
         a) Thymus
            1] Absence
            2] Fails to grow
            3] Involution (Atrophy)
         b) Acquired Immunodeficiency Syndrome (AIDS)
            1] Human Immunodeficiency Virus (HIV) – Helper T cells

3. Secondary (Peripheral) lymphoid organs - Immune response
E. Antibodies – Immunoglobulins (Igs)

1. Gamma globulins

2. Classes – Determined by heavy chain
   a. IgM – circulates as a pentamer
   b. IgA – circulates as monomer or dimer (from glands)
   c. IgD – on surface of B cells
   d. IgG – most common 80%, can cross placenta
   e. IgE – attached to basophils and mast cells

3. Monomers
   a. Two heavy chains
      1) Constant (C) segment (region)
      2) Variable (V) segment (region)
   b. Two light chains
      1) Constant (C) segment (region)
      2) Variable (V) segment (region)
   c. Antigen-binding site
      1) Antigenic determinant sites (Epitopes)

4. Immune Complex
   a. Precipitation
   b. Agglutination