Chapter 21
The Lymphatic System

• Absorbs 1/4 to 1/2 of plasma protein and tissue fluid (2 to 4 L/day), and returns it to the bloodstream

• Interference with lymphatic drainage can lead to severe edema
Lymph and Lymphatic Capillaries

• **Lymph**
  – clear, colorless fluid, similar to plasma but contains much less protein

• **Lymphatic capillaries**
  – closed at one end
  – tethered to surrounding tissue by protein filaments
  – endothelial cells loosely overlapped
    • allow bacteria and cells entrance to lymphatic capillary
    • creates valve-like flaps that open when interstitial fluid pressure is high, and close when its low
Lymphatic Capillary

- Lymph
- Tissue fluid
- Opening
- Anchoring filament
- Endothelium of lymphatic capillary
Valve in a Lymphatic Vessel
Lymphatic Vessels

• Larger ones composed of 3 layers
  – tunica interna: endothelium and valves
  – tunica media: elastic fibers, smooth muscle
  – tunica externa: thin outer layer
Route of Lymph Flow

- Lymphatic capillaries
- Collecting vessels: course through many lymph nodes
- Lymphatic trunks: drain major portions of body
- Collecting ducts:
  - right lymphatic duct - union of right jugular, subclavian and bronchomediastinal lymphatic trunks
  - thoracic duct - on left side, larger and longer, begins as a prominent sac in abdomen called the cisterna chyli, receives lymph from below diaphragm, left arm, left side of head, neck and thorax
  - each collecting duct drains into subclavian vein
Lymphatic Drainage of Mammary and Axillary Regions

- R. lymphatic duct
- R. subclavian v.
- Axillary lymph nodes
- Lymphatics of breast
Drainage of Thorax

- Internal jugular vv.
- R. jugular trunk
- R. lymphatic duct
- R. subclavian trunk
- R. subclavian v.
- R. bronchomediastinal trunk
- Superior vena cava
- Azygos v.
- Diaphragm
- Lumbar trunks
- L. jugular trunk
- L. subclavian trunk
- L. subclavian v.
- L. bronchomediastinal trunk
- Thoracic duct
- Hemiazygos v.
- Cisterna chyli
- Intestinal trunk
- Inferior vena cava
Mechanisms of Lymph Flow

- Lymph flows at low pressure and speed
- Valves prevent backward flow
- Moved along primarily by rhythmic contractions of lymphatic vessels—stretching of vessels stimulates contraction
- Flow aided by skeletal muscle pump
- Thoracic pump aids flow from abdominal to thoracic cavity
- Rapidly flowing bloodstream in subclavian veins, draws lymph into it
- Exercise significantly increases lymphatic return
Lymphatic Tissue

• Diffuse lymphatic tissue: lymphocytes in mucous membranes and CT of many organs
• Mucosa-associated lymphatic tissue: particularly prevalent in passages open to the exterior
• Lymphatic nodules: dense oval masses of lymphocytes, congregate in response to pathogens
• Peyer patches: more permanent congregation, clusters found at junction of small to large intestine
Lymph Node

- Lymph nodes are only organs that filter lymph
- Fewer efferent vessels, slows flow through node
  - reticular cells, macrophages phagocytize foreign matter
  - lymphocytes respond to antigens
  - common sites for metastatic cancer
- Cortex gives off trabeculae, divide parenchyma into compartments containing stroma (reticular CT) and parenchyma (lymphocytes and macrophages) subdivided into cortex (lymphatic nodules) and medulla
Lymph Node

- Cortex
  - Lymphatic nodule
  - Germinal center
  - Cortical sinus
- Capsule
- Afferent lymphatic vessel
- Valve
- Trabecula
- Medulla
  - Medullary sinus
  - Medullary cord
- Artery
- Vein
- Hilum
- Efferent lymphatic vessel
- Medullary cords
- Medullary sinus
- Macrophage
- Trabecula
- Lymphocytes
- Reticular fibers
- Venule
Tonsil

- Covered by epithelium
- Pathogens get into crypts and encounter lymphocytes
Location of Tonsils

• Palatine tonsils: pair at the posterior margin of oral cavity; most often infected
• Lingual tonsils: pair at the root of tongue
• Pharyngeal tonsils: single tonsil on wall of pharynx
Thymus

- Trachea
- Thyroid
- Thymus
- Lungs
- Heart
- Diaphragm
- Liver
Thymus

- Contains developing lymphocytes, secretes hormones (thymopoietin and thymosins) to regulate their later activity
- Very large in fetus, after age 14 begins involution (shrinkage) and in elderly mostly composed of fatty and fibrous tissue
- Cortex gives off trabeculae, divide parenchyma into lobules of cortex and medulla
Spleen

• Inferior to diaphragm, dorsal to stomach
• Parenchyma appears in fresh specimens as
  – red pulp: sinuses filled with erythrocytes
  – white pulp: lymphocytes, macrophages; surrounds small branches of splenic artery
• Functions
  – blood production in fetus
  – blood reservoir
  – RBC disposal
  – immune reactions: filters blood, quick to detect antigens
Overview of Immunity

• First line of defense – non-specific
  – Physical barriers: skin, mucous
  – Chemical barriers: tears, sweat

• Second line of defense – non-specific
  – Inflammatory response
  – Phagocytes
  – Natural killer cells

• Third line of defense - specific
  – Humoral (blood)-mediated immunity
  – Cell (tissue)-mediated immunity
Comparison of B- Cells and T-cells

• B- lymphocytes
  – Produced in red bone marrow
  – Differentiate and mature in bone marrow
  – Immunoglobulin receptors
  – Humoral-mediated immunity (blood)

• T-lymphocytes
  – Produced in red bone marrow
  – Differentiate and mature in Thymus
  – CD(common determinant) protein receptors
  – Cell-mediated immunity (tissues)
Stages of Specific Immunity

• In lymph nodes
  – Antigen processing and presentation

• Activation of T-lymphocytes
  – Production of cytokines
  – T- cell clonal selection (tissue)

• Activation of B- lymphocytes
  – B-cell clonal selection
  – Production of antibodies (blood)
B Cell Clonal Selection

• In the blood:
  – Antibodies
    • Opsinization
    • Agglutination
    • Complement fixation
    • Neutralization
  – Memory cells
    • Circulate to be ready for a secondary infection
Clonal Selection

1. Immunocompetent B cells exposed to antigen. Antigen binds only to B cells with complementary receptors.

2. B cell displays processed antigen fragments. Helper T cell binds to B cell and secretes helper factor.

3. Helper factor stimulates B cell to divide repeatedly and form a clone.

4. Some cells of the clone become memory B cells. Most differentiate into plasma cells.

5. Plasma cells synthesize and secrete antibody.
T Cell Clonal Selection

• In the tissues:
  – T-helper – increases the immune response
  – T-suppressor – decreases the immune response
  – T-Cytotoxic – attacks cells; directly lyses them
  – T- delayed – part of the delayed hypersensitivity reaction

• Memory cell:
  – Ready in the blood if needed – can become any of the types of T-cells (a bench warmer)
Central Role of Helper T Cells

- Macrophage, B cell, or other antigen-presenting cell
  - Helper T (T4) cell
  - Secretes
    - Macrophage-activating factor
    - Other lymphokines
  - Secretes
    - Interleukin-2
    - Helper factors
  - Secretes
    - Interleukin-1
    - Other lymphokines

- Nonspecific defense
- Humoral immunity
- Cellular immunity
Immunity to Disease

- Innate immunity
- Acquired immunity
  - Natural Active
  - Artificial Active
  - Natural Passive
  - Artificial Passive
Innate and Acquired Immunity

- Innate
  - Racial (genetics)
  - Population
  - Behavioral
- Acquired
  - Passive Antibodies given
    - Natural From Mother
    - Artificial Anti-Venom
  - Active Antigens given
    - Artificial Immunization
    - Natural Illness
Immunity to Disease

• Innate immunity
• Acquired immunity
  – Natural Active
  – Artificial Active
  – Natural Passive
  – Artificial Passive
Natural Active Immunity

• Infection
• Disease
• Memory Cells and Antibodies Produced
Artificial Active

– Immunization
  • Given Antigens
  • Antigens stimulate immune response but not disease
– First Generation - Whole microbe
– Second Generation - Part of microbe
– Third Generation - Synthetic
  • DNA
– Booster
– Adjuvants
Natural Passive

• Congenital Immunity - mother to child
  – Placenta
  – Colostrum - Breast milk
    • temporary immunity - 3-6 months
    • IgA antibodies
Artificial Passive

• Antiserums
  – Hyperimmune serum
  – Prophylactic serum
  – Convalescent
  – Gamma Globulin