Lymphatic System and Lymphoid Organs and Tissues

- Lymphatic system – a transport system for tissue fluids
  1. elaborate network of one-way drainage vessels returning lymph to systemic circulation
  2. Lymph: interstitial fluid entering lymphatic vessels
     a) 3L interstitial fluid per day
  3. Lymph nodes: cleanse lymph

- Lymphoid organs and tissues – places for surveillance, proliferation, and action
  - provide structural basis of immune system by housing phagocytic cells and lymphocytes
  - Structures include spleen, thymus, tonsils, lymph nodes, other lymphoid tissues

What is Lymph?

- Water plus solutes
  - Plasma-derived - includes some plasma proteins
  - Cell-derived – includes cellular secretions, hormones, wastes
  - Chylomicrons – lymphatic lipoproteins in fatty lymph called chyle
- Returns to circulatory system via veins; essential for fluid balance.
Distribution and Structure of Lymphatic Vessels

Lymph vessels include:

- Lymphatic capillaries and lacteals (intestinal)
- Collecting lymphatic vessels
  - Three tunics, backflow prevention valves, anastomosis
- Lymphatic trunks — regional drainage
- Lymphatic ducts - drain to subclavian veins
  - Right lymphatic duct
  - Thoracic duct
    - Cisterna chyli
- Lymph nodes along the way

Lymphatic capillaries

- Blind-ended vessels
  - More permeable than blood
    1. Endothelial cells overlap - one-way minivalves
      a) Minivalves are anchored by collagen filaments
    2. Increases in ECF volume opens minivalves
- Weave between tissue cells and blood capillaries
  - Absent from bones, teeth, bone marrow, and CNS
- Can take up and transport larger molecules and particles prevented from entering blood capillaries
  - Example: proteins, cell debris, pathogens, and cancer cells
    - Can act as route for pathogens or cancer cells to travel
Lymph Transport

- Lymph system is a low-pressure system like venous system
- Lymph is propelled by same mechanisms:
  - Milking action of skeletal muscle
  - Pressure changes in thorax during breathing
  - Valves to prevent backflow
  - Pulsations of nearby arteries
  - Contractions of smooth muscle in walls of lymphatics
- Physical activity increases flow of lymph; immobilization of area keeps needed inflammatory material in area for faster healing
**Wuchereria bancrofti**

transmitted by mosquitoes -
Filarial worm parasite of the lymphatic vessels

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**Extreme Accumulation of Lymph - Elephantiasis**

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**Lymphoid Cells, Tissues, and Organs**

1. **Cells: Lymphocytes**
   - cells of the *adaptive* immune system
   - mature into one of two main types
     - T cells and B cells protect against **antigens**
       - T cells: manage immune response, and some also attack and destroy infected cells
       - B cells: produce **plasma cells**, which secrete **antibodies**
         - Antibodies mark antigens for destruction by phagocytosis or otherwise neutralize them
         - Populatate lymphatic nodules
Lymphoid Cells (cont.)

2. Other lymphoid immune cells
   - Macrophages phagocytize foreign substances and help activate T cells
   - Dendritic cells capture antigens and deliver them to lymph nodes; also help activate T cells

3. Supporting lymphoid cell
   - Reticular cells produce reticular fibers called stroma in lymphoid organs
     • Stroma: network-like support that acts as scaffolding for immune cells

Lymphoid Tissues and Organs

• Two main types of lymphoid tissues
  - Diffuse lymphoid tissue: loose arrangement of lymphoid cells and some reticular fibers
    • Found in virtually every body organ
    • Larger collections just under epithelium of mucous membranes
  - Lymphoid follicles (nodules): solid, spherical bodies consisting of tightly packed lymphoid cells and reticular fibers
    • Contain germinal centers of proliferating B cells
    • May form part of larger lymphoid organs (nodes)
    • Isolated aggregations of Peyer's patches and in appendix
Lymphoid Organs

- **Lymphoid organs** are grouped into two functional categories
  - **Primary lymphoid organs**: areas where T and B cells mature—*red bone marrow* and *thymus*
    - T and B cells originate in bone marrow, but only B cells matures there; T cells mature in thymus
  - **Secondary lymphoid organs**: areas where mature lymphocytes first encounter their antigen and become activated
    - Nodes, spleen, MALT (mucosa-associated lymphoid tissue) and diffuse lymphoid tissues

![Figure 20.4 Lymphoid organs](image)

**Primary lymphoid organs**
- Thymus
- Red bone marrow

**Secondary lymphoid organs**
- Lymph nodes
- Tonsils
- Spleen
- Peyer’s patches (aggregated lymphoid nodules in small intestine)
- Appendix

Lymph Nodes

- Principal secondary lymphoid organs of body
- Hundreds of nodes are found throughout body
  - Most are embedded deep
  - Some are nearer to body surface

- Two main functions of lymph nodes
  1. Act as lymph “filters”
     - Lymph vessels enter and exit — lymph slows
     - Macrophages remove and destroy microorganisms and debris preventing unwanted substances from being delivered to blood
  2. Immune system activation: offer a place for lymphocytes to become activated and mount an attack against antigens
Structure of a Lymph Node

- Vary in shape and size
  - most are bean shaped
  - Small, less than 2.5 cm (~1 inch)
- Surrounded by external fibrous capsule
- Capsule fibers extend inward as trabeculae that divide node into compartments
- Two histologically distinct regions of node:
  1. Cortex
  2. Medulla
Remaining Lymphoid Organs:

- Spleen
- Thymus
- Mucosa Associated Lymphoid Tissue
  - Tonsils
  - Peyer’s patches
- Appendix

Spleen - Largest lymphoid organ
- Blood-rich organ about size of fist located in left side of abdominal cavity
  - Capsule and trabeculae
  - Lymph vessels exit but do not enter
- Functions
  - Site of lymphocyte proliferation and immune surveillance and response – white pulp portion
  - Cleanses blood of aged blood cells and platelets – red pulp portion
    - Macrophages remove debris
  - Some breakdown products of blood stored here
  - Some components of blood may accumulate here for release when needed

(c) Photograph of the spleen in its normal position in the abdominal cavity, anterior view.
Thymus

- **Thymus**: bilobed lymphoid organ found in inferior neck
  - Extends into mediastinum and partially overlies heart
- Functions as lymphoid organ where T cells mature
  - Most active and largest in size during childhood
  - Stops growing during adolescence, then gradually atrophies
  - Still produces immunocompetent cells, though more slowly

Mucosa-associated lymphoid tissue (MALT)

- Protects from pathogens trying to enter body
- Found in mucosa of respiratory tract, genitourinary organs, and digestive tract; largest collections of MALT found in
  - Tonsils
    - Form ring of lymphatic tissue around pharynx; appear as swellings of mucosa
    - Palatine tonsils  Lingual tonsil
    - Pharyngeal tonsil  Tubal tonsils
  - Peyer’s patches
  - Appendix
Tonsils
- Function is to gather and remove pathogens in food or air
- Contain follicles with germinal centers and scattered lymphocytes
- Are not fully encapsulated
- Overlying epithelium invaginates, forming tonsillar crypts
  - Bacteria or particulate matter enters crypts, where they are trapped and destroyed
    - Risky to lure bacteria into tissues, but allows immune cells to become activated and build memory cells against these potential pathogens

Peyer’s Patches
- Clusters of lymphoid follicles in wall of distal portion of small intestine
  - Also called aggregated lymphoid nodules
- Structurally similar to tonsils
- Location aids in functions
  1. Destroy bacteria, preventing them from breaching intestinal wall
  2. Generate “memory” lymphocytes

Appendix
- **Appendix**: offshoot of first part of large intestine
- Contains a large number of lymphoid follicles
- Location aids in functions (like Peyer’s patches)
  1. Destroy bacteria, preventing them from breaching intestinal wall
  2. Generate “memory” lymphocytes