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
Internal jugular vein

Entrance of right lymphatic duct into vein

Entrance of thoracic duct into vein

Thoracic duct

Cisterna chyli

Collecting lymphatic vessels

Regional lymph nodes:
- Cervical nodes
- Axillary nodes
- Inguinal nodes

Drained by the right lymphatic duct
- Drained by the thoracic duct

(b)
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
Figure 20.1a Distribution and special features of lymphatic capillaries.

(a) Structural relationship between a capillary bed of the blood vascular system and lymphatic capillaries.
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
Lymphatic capillaries are blind-ended tubes in which adjacent endothelial cells overlap each other, forming flaplike minivalves.
Figure 20.2a The lymphatic system.

- Right jugular trunk
- Right lymphatic duct
- Right subclavian trunk
- Right subclavian vein
- Right bronchomediastinal trunk
- Brachiocephalic veins
- Superior vena cava
- Azygos vein
- Cisterna chyli
- Right lumbar trunk
- Inferior vena cava
- Thoracic duct
- Left jugular trunk
- Left subclavian trunk
- Left subclavian vein
- Entrance of thoracic duct into vein
- Left bronchomediastinal trunk
- Hemiazygos vein
- Left lumbar trunk
- Intestinal trunk
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
Extreme Accumulation of Lymph - Elephantiasis

Fig. 281. — Elephantiasis of the scrotum in a native of Fiji.
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
       - Populate lymphatic nodules
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
Figure 20.3 Reticular connective tissue in a human lymph node.
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.

**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
Figure 20.2b The lymphatic system.

- **Internal jugular vein**
- **Entrance of right lymphatic duct into vein**
- **Entrance of thoracic duct into vein**
- **Thoracic duct**
- **Cisterna chyli**
- **Collecting lymphatic vessels**
- **Regional lymph nodes:**
  - **Cervical nodes**
  - **Axillary nodes**
  - **Inguinal nodes**

- Drained by the right lymphatic duct
- Drained by the thoracic duct
Figure 20.5a Lymph node.

(a) Longitudinal view of the internal structure of a lymph node and associated lymphatics
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
Diaphragm
Spleen
Adrenal gland
Left kidney
Splenic artery
Pancreas

(c) Photograph of the spleen in its normal position in the abdominal cavity, anterior view.
Figure 20.6b The spleen.

(b) Diagram of spleen histology
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
Tonsils

tonsillar crypts
lymphatic follicles
ergeminal centers
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