The Lymphatic System

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The Lymphatic System

• Functions Of The Lymphatic System

• Transport Excess Interstitial Fluid Back To Bloodstream

• Transport Dietary Lipids

• House Lymphocytes

• Generate An Immune Response
Orders Of Lymphatic Vessels

• **Lymph capillaries** - smallest lymph vessels, first to receive lymph

• **Lymphatic collecting vessels** - collect from lymph capillaries

• **Lymph nodes** - scattered along collecting vessels

• **Lymph trunks** - collect lymph from collecting vessels

• **Lymph ducts** - empty into veins of the neck
Lymphatic Capillaries

- Located near blood capillaries
  - Receive tissue fluid from CT
  - Minivalve flaps open and allow fluid to enter
- Highly permeability allows entrance of tissue fluid, bacteria, viruses, and cancer cells
- **Lacteals** – specialized lymphatic capillaries
  - Located in the villi of the small intestines
  - Receive digested fats, Fatty lymph – **chyle**
Lymphatic Collecting Vessels

- Accompany blood vessels
- Composed of the same three tunics as blood vessels
- Contain *more valves* than veins do
  - helps direct the flow of blood
- Lymph propelled by:
  - contraction of skeletal muscles
  - pulse pressure of nearby arteries
  - Tunica media of the lymph vessels
Lymph Nodes

- Cleanse the lymph of pathogens
- Human body contains around 500
- Lymph nodes are organized in clusters
Microscopic Anatomy of a Lymph Node

- Fibrous capsule – surrounds lymph nodes
- Trabeculae – connective tissue strands
- Lymph vessels
  - Afferent lymphatic vessels
  - Efferent lymphatic vessels
Lymph Trunks

- Lymphatic collecting vessels converge
- Five major lymph trunks
  - **Lumbar trunks**
    - Receives lymph from lower limbs
  - **Intestinal trunk**
    - Receives chyle from digestive organs
  - **Bronchomediastinal trunks**
    - Collects lymph from thoracic viscera
  - **Subclavian trunks**
    - Receive lymph from upper limbs and thoracic wall
  - **Jugular trunks**
    - Drain lymph from the head and neck
Lymph Ducts

- **Cisterna chyli** - located at the union of lumbar and intestinal trunks
- **Thoracic duct** - ascends along vertebral bodies
  - Empties into venous circulation
  - Junction of left internal jugular and left subclavian veins
  - Drains three quarters of the body
- **Right lymphatic duct** - empties into right internal jugular and subclavian veins
The Immune System

- Recognizes specific foreign molecules
- Destroys pathogens effectively
- Key cells – lymphocytes
- Also includes lymphoid tissue and lymphoid organs
1. Microbe adheres to phagocyte
2. Phagocyte engulfs the particle
3. Phagocytic vesicle is fused with a lysosome
4. Microbe in fused vesicle is killed and digested by lysosomal enzymes within the phagolysosome
5. Indigestible and residual material is removed by exocytosis
Lymphocytes

- Infectious organisms attacked by inflammatory response, macrophages, then lymphocytes

- **T Lymphocytes**
  - Helper T-lymphocytes have receptors (CD4+) that can recognize an antigen
    - Secrete cytokines (chemical signals that bind to receptors on other lymphatic cells and activate them) and
    - Present the antigen to a B-lymphocyte.
  - Cytotoxic T lymphocytes attack foreign cells directly
    - Receptors (CD8) bind to antigen-bearing cells
    - Perforates cell membrane
    - Signals cell to undergo apoptosis (self destruction)

- **B lymphocytes**
  - Become plasma cells
  - Secrete antibodies – bind and mark cells for destruction by macrophages
Lymphocyte Function

**Figure 20.7**

**a**
1. T lymphocyte...  
2. ...binds to target cell, secretes proteins that lyse the cell’s membrane, and signals the cell to die.
3. T lymphocyte detaches and...  
4. ...target cell dies by apoptosis.

**b**
1. B lymphocyte...  
2. ...gives rise to plasma cell, which secretes antibodies.
3. Antibodies bind to antigens on bacteria, marking the bacteria for destruction.
4. Antibody-coated bacteria are avidly phagocytized.
Lymphocyte Activation

- Lymphocytes originate in bone marrow
- Some travel to the thymus gland - T lymphocytes
- Some stay in bone marrow - B lymphocytes
- Able to recognize a unique antigen
  - Gain immunocompetence
  - Travels through blood stream
  - Meets and binds to a specific antigen
Lymphocyte Activation

• Activating T or B cells produce
  • **Effector lymphocytes** - short-lived, attack immediately
  • **Memory lymphocytes** - wait until body encounters their antigen again

• Basis of acquired immunity
• Guard against subsequent infections
Lymphocyte Activation

Figure 20.8

1. Lymphocytes destined to become T cells migrate to the thymus and develop immunocompetence there. B cells develop immunocompetence in red bone marrow.

2. After leaving the thymus or bone marrow as naive immunocompetent cells, lymphocytes establish themselves in the lymph nodes, spleen, and other lymphoid tissues where the antigen challenge occurs.

3. Antigen-activated immunocompetent lymphocytes circulate continuously in the bloodstream and lymph and throughout the lymphoid organs of the body.
Lymphoid Tissue

- Lymphoid tissue - areolar connective tissue and lymphocytes
- Most important tissue of the immune system
  - Mucous membranes of digestive, urinary, respiratory, and reproductive tracts
  - Mucosa-associated lymphoid tissue (MALT)
  - Makes up lymphoid organs (except thymus)
Lymphoid Organs

- Primary lymphoid organs
  - Bone marrow
  - Thymus
- Secondary lymphoid organs
  - Designed to gather and destroy infectious microorganisms
  - Lymph nodes, spleen, tonsils
  - Aggregated lymphoid nodules - masses of lymphoid tissue NOT surrounded by a fibrous capsule.
- Appendix
Thymus

• Immature lymphocytes develop into T lymphocytes
• Secretes thymic hormones
• Most active in childhood
• Functional tissue atrophies with age
• Composed of cortex and medulla
  • Medulla contains Hassall’s corpuscles (thymic corpuscles)
• Differs from other lymphoid organs
  • Functions strictly in lymphocyte maturation
  • Arises from epithelial tissue
Lymphoid Organs

• Lymph nodes
  • Lymph percolates through lymph sinuses
  • Most antigenic challenges occur in lymph nodes
  • Antigens destroyed – and activate B and T lymphocytes

• Spleen
  • Largest lymphoid organ
  • Two main blood-cleansing functions
    • Removal of blood-borne antigens
    • Removal and destruction of old or defective blood cells
  • Site of hematopoiesis in the fetus
Spleen

- Destruction of antigens
- Site of B cell maturation into plasma cells
- Phagocytosis of bacteria and worn-out blood cells
- Storage of platelets
- White pulp
  - Thick sleeves of lymphoid tissue
  - Provides the immune function of the spleen
- Red pulp - surrounds white pulp, composed of
  - Venous sinuses – filled with whole blood
  - Splenic cords – reticular CT rich in macrophages
Tonsils

- Simplest lymphoid organs
- Four groups of tonsils
  - Palatine, lingual, pharyngeal and tubal tonsils
- Arranged in a ring to gather and remove pathogens
- Underlying lamina propria consists of MALT
Aggregated Lymphoid Nodules And Appendix

- MALT – abundant in walls of intestines
- Fight invading bacteria
- Generate a wide variety of memory lymphocytes
  - Aggregated lymphoid nodules (Peyer’s patches)
    - Located in the distal part of the small intestine
  - Appendix – tubular offshoot of the cecum