Chapter 16  Adapted form Tortora 10th ed.

LECTURE OUTLINE

A. Introduction (p. 511)
   1. Most people remain healthy despite exposure to pathogens, UV rays, toxins, cuts, etc.
   2. **Resistance** is the ability to ward off damage or disease through our defenses; lack of resistance is termed **susceptibility**.
   3. The two general types of resistance are:
      i. nonspecific resistance or innate defenses
      ii. specific resistance or immunity
   4. The **lymphatic and immune system** consists of:
      i. a fluid called **lymph**
      ii. **lymphatic vessels**
      iii. several structures and organs that contain **lymphatic tissue**
      iv. **red bone marrow** (the site of lymphocyte production)
   5. Lymph is interstitial fluid that has entered and flows through lymphatic vessels.
   6. Lymphatic tissue is a specialized form of connective tissue that contains large numbers of lymphocytes (the two major types being T cells and B cells).

B. Functions of the Lymphatic and Immune System (p. 512)
   1. The lymphatic system has the following major functions:
      i. draining excess interstitial fluid
      ii. transporting dietary lipids
      iii. carrying out **immune responses** against specific microbes and abnormal cells

C. Lymphatic Vessels and Lymph Circulation (p. 512)
   1. **Lymphatic capillaries** are dead-end lymphatic vessels located in spaces between cells.
   2. Lymphatic capillaries merge to form larger **lymphatic vessels**.
   3. Lymphatic vessels resemble veins but have thinner walls and more valves.
   4. Along the length of lymphatic vessels are **lymph nodes** which contain B cells and T cells.
   5. Lymphatic vessels travel close to veins in the skin's subcutaneous tissue; in the viscera, they travel close to arteries, forming plexuses (networks) around them.
   6. **Lymphatic capillaries**:
      i. are located throughout the body except in:
         a. avascular tissues
         b. central nervous system
         c. portions of the spleen
         d. red bone marrow
      ii. have a slightly larger diameter than blood capillaries
      iii. have walls consisting of overlapping **endothelial cells**, associated with anchoring filaments, which permit interstitial fluid to flow into but not out of the lymphatic capillaries
iv. are called lacteals when located in villi; lacteals transport lipid-rich lymph called chyle from the small intestine into lymphatic vessels and ultimately into the blood

7. Lymph Trunks and Ducts:
   i. The lymphatic vessels that exit the most proximal group of each chain of lymph nodes merge to form lymph trunks; the major trunks are the:
      a. lumbar trunks
      b. intestinal trunk
      c. bronchomediastinal trunks
      d. subclavian trunks
      e. jugular trunks
   
   ii. These trunks deliver their lymph into the thoracic duct and the right lymphatic duct.
   iii. Thoracic (left lymphatic) duct:
      a. is about 38 - 45 cm long and begins at its lower end as a dilation called the cisterna chyli anterior to the second lumbar vertebra
      b. is the main collecting duct of the lymphatic system
      c. receives lymph from the left side of the head, neck, and chest, the left upper limb, and the entire body below the ribs
      d. the cisterna chyli receives lymph from the right and left lumbar trunks and the intestinal trunk
      e. the lumbar trunks receive lymph from the lower limbs, wall and viscera of the pelvis, kidneys, adrenal glands, and the deep lymphatics from most of the abdominal wall
      f. the intestinal trunk drains lymph from the stomach, intestines, pancreas, spleen, and part of the liver
      g. in the neck, the thoracic duct also receives lymph from the left jugular, left subclavian, and left bronchomediastinal trunks
      h. the left jugular trunk receives lymph from the left side of the head and neck
      i. the left subclavian trunk drains lymph from the left upper limb
      j. the left bronchomediastinal trunk receives lymph from the left side of the deeper parts of the anterior thoracic wall, upper part of the anterior abdominal wall, anterior part of the diaphragm, left lung, and left side of the heart
      k. the thoracic duct delivers lymph to the junction of the left internal jugular and subclavian veins
   iv. Right lymphatic duct:
      a. is about 1.2 cm long
      b. drains lymph from the upper right side of the body
      c. receives lymph from:
         - the right jugular trunk, which drains the right side of the head and neck
         - the right bronchomediastinal trunk, which drains the right upper limb
         - the right bronchomediastinal trunk, which drains the right side of the thorax, right lung, right side of the heart, and part of the liver
      d. the right lymphatic duct delivers lymph to the junction of the right internal jugular and subclavian veins

8. Formation and Flow of Lymph:
   i. More fluid is filtered out of blood capillaries than is reabsorbed by them.
ii. Each day, about 3 liters of this interstitial fluid drains into lymphatic capillaries.
iii. This lymph flows through lymphatic vessels and eventually into the blood of the subclavian veins.
iv. One major function of lymphatic vessels is to return fluid and any leaked plasma proteins to the blood.
v. The flow of lymph toward the subclavian veins is maintained primarily by the compressive contractions of muscles and the actions of one-way valves within lymphatic vessels.

D. Lymphatic Organs and Tissues (p. 516)
1. Lymphatic organs and tissues are classified into two groups:
   i. **primary lymphatic organs** are the sites where stem cells divide and become **immunocompetent**; these organs include red bone marrow and the **thymus**, structures where B and T lymphocytes are produced
   ii. **secondary lymphatic organs and tissues** are the **lymph nodes, spleen** and **lymphatic nodules**; these are the sites where most immune responses occur

2. **Thymus**:
   i. The thymus is a bilobed lymphatic organ located in the superior mediastinum, posterior to the sternum and between the lungs.
   ii. An enveloping layer of connective tissue holds the two thymic lobes closely together.
   iii. Each lobe is enclosed by a connective tissue **capsule** which has inward extensions called **trabeculae** that divide the interior into **lobules**.
   iv. Each lobule consists of:
      a. outer **cortex** that contains numerous T cells, **dendritic cells**, **epithelial cells**, and macrophages
      b. central **medulla** that consists of widely scattered, mature T cells, epithelial cells, dendritic cells, macrophages, and thymic (Hassall's) corpuscles; the epithelial cells secrete thymic hormones, which are believed to aid in the maturation of T cells
   v. The thymus is large in infants, reaching its maximum size at puberty; after puberty, the gland atrophies while fat and areolar tissue gradually replace much of the thymic tissue.

3. **Lymph Nodes**:
   i. Lymph nodes are bean-shaped structures, ranging from 1 - 25 mm in length, located along the length of lymphatic vessels.
   ii. They are scattered throughout the body, usually in groups; the groups are arranged into superficial and deep sets.
   iii. Each node has several major characteristics:
      a. it is covered by a dense connective tissue **capsule** that has inward extensions called **trabeculae**
      b. it has a **stroma** (framework) that consists of the capsule, trabeculae, reticular fibers, and fibroblasts
      c. it has a **parenchyma** organized into an outer cortex, **inner cortex** and **medulla**
      d. the outer cortex contains aggregates of B cells called **lymphatic nodules**
- a central **germinal center** contains B cells, that proliferate into antibody-producing **plasma cells**, as well as follicular dendritic cells, which help initiate immune responses, and macrophages
e. the inner cortex or **paracortex** contains T cells and dendritic cells
f. the medulla contains B cells, plasma cells and macrophages

iv. Lymph enters a node via several **afferent lymphatic vessels**, flows through the **subcapsular sinus**, **trabecular sinuses**, **medullary sinuses** and then finally exits the node via one or two **efferent lymphatic vessels**.
v. The slight depression on one side of the node is the **hilus** where efferent lymphatic vessels emerge, and blood vessels enter and exit the node.
vi. As lymph flows through a lymph node, it is filtered:
   a. foreign substances are trapped by reticular fibers
   b. macrophages destroy these foreign substances by phagocytosis
   c. lymphocytes destroy other foreign substances via immune responses

4. **Spleen:**
   i. The approximately 12 cm long, oval-shaped spleen is the largest mass of lymphatic tissue in the body.
   ii. It is located in the left hypochondriac region between the stomach and diaphragm.
   iii. The superior surface is smooth and convex; neighboring organs make indentations including the gastric impression (stomach), renal impression (left kidney), and colic impression (left flexure of colon).
   iv. The spleen has a hilus at which the splenic artery enters, and the splenic vein and efferent lymphatic vessels leave.
v. The spleen is enclosed by a **capsule** (with trabeculae) of dense connective tissue; the capsule is covered by the visceral peritoneum.
vi. The **stroma** of the spleen consists of capsule plus trabeculae, reticular fibers, and fibroblasts.
vii. The **parenchyma** of the spleen consists of:
   a. **white pulp**, which is lymphatic tissue containing mostly macrophages and lymphocytes, arranged around central arteries; functions of the white pulp include:
      - B cells and T cells carry out immune functions
      - macrophages phagocytize blood-borne pathogens
   b. **red pulp**, which consists of **venous sinuses** filled with blood and cords of splenic tissue called **splenic (Billroth’s) cords**; functions of the red pulp include:
      - phagocytosis of worn-out or damaged erythrocytes, leukocytes, and platelets
      - storage of platelets
      - production of blood cells (hemopoiesis) during fetal development
5. **Lymphatic Nodules:**
   i. **lymphatic nodules** are egg-shaped masses of lymphatic tissue that are not enclosed by a capsule and are usually small and scattered; they are located in the lamina propria of mucous membranes and are referred to as **mucosa-associated lymphoid tissue (MALT)**.
   
i. some occur in multiple, large aggregations in specific parts of the body, e.g., tonsils in the pharynx, aggregated lymphatic follicles (Peyer’s patches) in the ileum, and in the appendix
   
   ii. the five **tonsils** form a ring at the junctions of the oral cavity, pharynx, and nasal cavity where they protect, via immune responses, against invasion by foreign substances that are inhaled or ingested; the tonsils are:
   
   a. single **pharyngeal tonsil** or **adenoid** in the posterior wall of the nasopharynx
   
   b. pair of **palatine tonsils** in the lateral, posterior regions of the oral cavity
   
   c. pair of **lingual tonsils** on the base of the tongue

E. **Principal Groups of Lymph Nodes** (p. 523)
   1. The principal groups of lymph nodes are described by region and the general areas they drain as follows:
   
<table>
<thead>
<tr>
<th>Exhibit</th>
<th>Description</th>
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<tbody>
<tr>
<td>16-1</td>
<td>Principal Lymph Nodes of the Head and Neck</td>
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<tr>
<td>16-2</td>
<td>Principal Lymph Nodes of the Upper Limbs</td>
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<tr>
<td>16-3</td>
<td>Principal Lymph Nodes of the Lower Limbs</td>
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<td>16-4</td>
<td>Principal Lymph Nodes of the Abdomen and Pelvis</td>
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<tr>
<td></td>
<td>i. Parietal Lymph Nodes</td>
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<td>ii. Visceral Lymph Nodes</td>
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<td>16-5</td>
<td>Principal Lymph Nodes of the Thorax</td>
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<td></td>
<td>i. Parietal Lymph Nodes</td>
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<td>ii. Visceral Lymph Nodes</td>
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F. **Development of Lymphatic Tissues** (p. 528)
   1. Lymphatic vessels develop from **lymph sacs** that arise from developing veins, which are derived from **mesoderm**.
   2. The first lymph sacs to develop are the two **jugular lymph sacs**; these develop into the lymphatic vessels of the thorax, upper limbs, neck, and head.
   3. The single **retroperitoneal lymph sac** develops into the lymphatic vessels of the abdominal viscera and diaphragm.
   4. The **cysterna chyli** lymph sac develops into the inferior portion of the thoracic duct and the cysterna chyli of the thoracic duct.
   5. The two **posterior lymph sacs** develop into the lymphatic vessels of the abdominal wall, pelvic region, and lower limbs.
   6. Except for the anterior part of the sac that develops into the cisterna chyli, all lymph sacs become invaded by **mesenchymal cells** and are converted into groups of lymph nodes.
   7. The spleen develops from **mesenchymal cells**; the thymus develops from the **third pharyngeal pouch**.

G. **Aging and the Lymphatic and Immune System** (p. 530)
   1. Elderly individuals become more susceptible to all types of infections and malignancies.
   2. As the lymphatic system ages:
i. response to vaccines is decreased
ii. more autoantibodies tend to be produced
iii. fewer T cells respond to infections
iv. B cells also become less responsive and there is a decrease in the rate of antibody production; thus, there is an increased susceptibility to infections

H. Key Medical Terms Associated with the Lymphatic System (p. 532)
   1. Students should familiarize themselves with the glossary of key medical terms.