Chapter 15

The Lymphatic System and Immunity
Objectives

• Describe general functions of the lymphatic system and list the main lymphatic structures
• Compare nonspecific and specific immunity
• Name the major disorders associated with the lymphatic system
Objectives

• Discuss the major types of immune system molecules
• Discuss and contrast the development and functions of B and T cells
Objectives

• Describe the mechanisms of allergy, autoimmunity, and isoimmunity
• List the major types of immune deficiencies and explain their causes
The Lymphatic System

• Lymph—fluid in the tissue spaces that carries protein molecules and other substances back to the blood
1. Blood plasma filters out
2. Liquid enters as interstitial fluid
3. Enters lymphatic capillaries
4. Venules
Lymph is filtered along way by organs and glands
5. Veins
6. Right lymphatic duct and thoracic duct
7. Blood veins in neck
The Lymphatic System

- Lymphatic vessels—permit only one-way movement of lymph
  - Lymphatic capillaries—tiny blind-ended tubes distributed in tissue spaces
    - Microscopic in size
    - Sheets consisting of one cell layer of simple squamous epithelium
    - Poor “fit” between adjacent cells results in porous walls
    - Called lacteals in the intestinal wall (for fat transportation)
The Lymphatic System

• Lymphatic vessels
  – Right lymphatic duct
    • Drains lymph from the right upper extremity and right side of head, neck, and upper torso
  – Thoracic duct
    • Largest lymphatic vessel
    • Has an enlarged pouch along its course, called cisterna chyli
    • Drains lymph from about three fourths of the body
The Lymphatic System

- Lymphedema—swelling (edema) of tissues caused by blockage of lymphatic vessels
  - Lymphangitis—inflammation of lymphatic vessels, may progress to septicemia (blood infection)
  - Elephantiasis—severe lymphedema of limbs resulting from parasite infestation of lymphatic vessels
The Lymphatic System

• Lymph nodes
  – Filter lymph
  – Located in clusters along the pathway of lymphatic vessels
  – Lymphoid tissue—mass of lymphocytes and related cells inside a lymphoid organ; provides immune function and development of immune cells
  – Lymph nodes and other lymphoid organs have functions that include defense and WBC formation
The Lymphatic System

• Lymph nodes
  – Flow of lymph: to node via several afferent lymphatic vessels and drained from node by a single efferent lymphatic vessel
  – Lymphadenitis—swelling and tenderness of lymph nodes
  – Cancer cells can easily move through lymphatic vessels to other parts of the body in a process called *metastasis*
The Lymphatic System

• Lymphoma—malignant tumor of lymph nodes
  – Two types: Hodgkin disease and non-Hodgkin lymphoma

• Thymus
  – Lymphoid tissue organ located in mediastinum
  – Total weight of about 35–40 g—a little more than an ounce
The Lymphatic System

• Thymus
  – Plays a vital and central role in immunity
  – Produces T lymphocytes or T cells
  – Secretes hormone called thymosin
  – Lymphoid tissue is largely replaced by fat in the process called involution
The Lymphatic System

• Tonsils
  – Composed of three masses of lymphoid tissue around the openings of the mouth and throat
    • Palatine tonsils ("the tonsils")
    • Pharyngeal tonsils (adenoids)
    • Lingual tonsils
  – Subject to chronic infection
  – Enlargement of pharyngeal tonsils may impair breathing
The Lymphatic System

• Spleen
  – Largest lymphoid organ in body
  – Located in upper left quadrant of abdomen
  – Often injured by trauma to abdomen
  – Surgical removal called *splenectomy*
  – Functions include phagocytosis of bacteria and old RBCs; acts as a blood reservoir
  – Splenomegaly—enlargement of the spleen
The Immune System

• Protects body from pathological bacteria, foreign tissue cells, and cancerous cells
• Made up of defensive cells and molecules
• Nonspecific immunity
  – Skin—mechanical barrier to bacteria and other harmful agents
The Immune System

• Nonspecific immunity
  – Tears and mucus—wash eyes and trap and kill bacteria
  – Inflammation attracts immune cells to site of injury, increases local blood flow, increases vascular permeability; promotes movement of WBCs to site of injury or infection
Healthy tissue

Bacteria enter tissue (for example)

Tissue damage occurs

Inflammation mediators are released

Chemotaxis

Increased blood flow

Increased vascular permeability

Increased numbers of leukocytes and mediators at site of tissue damage

Bacteria are contained, destroyed, and phagocytized

No bacteria remain

Bacteria remain

Tissue repair

Additional mediators activated
The Immune System

• Specific immunity—ability of body to recognize, respond to, and remember harmful substances or bacteria
• Inherited or inborn immunity—inherited immunity to certain diseases from time of birth
The Immune System

• Acquired immunity
  – Natural immunity—exposure to causative agent is not deliberate
    • Active—active disease produces immunity—measles
    • Passive—immunity passes from mother to fetus through placenta or from mother to child through mother’s milk
The Immune System

• Acquired immunity
  – Artificial immunity—exposure to causative agent is deliberate
    • Active—vaccination results in immunity
    • Passive—protective material developed in another individual’s immune system and given to previously nonimmune individual—i.e. antibodies in mother’s milk
Immune System Molecules

• Antibodies
  – Protein compounds with specific combining sites
  – Combining sites attach antibodies to specific antigens (foreign proteins), forming antigen-antibody complex—called *humoral* or *antibody-mediated* immunity
  – Antigen-antibody complexes may:
    • Neutralize toxins
    • Clump or agglutinate enemy cells
    • Promote phagocytosis
Immune System Molecules

• Complement proteins
  – Group of proteins normally present in blood in inactive state
  – Complement cascade
    • Important mechanism of action for antibodies
      – Complement-binding sites on antibody are exposed after attaching to antigen
      – Complement triggers a series (cascade) of reactions that produce tiny protein rings that create holes in the surface of a foreign cell
Immune System Molecules

• Complement proteins
  – Complement cascade
    • Ultimately causes cell lysis by permitting entry of water through a defect created in the plasma membrane of the foreign cell
  – Complement proteins play many other roles in immunity, including the inflammatory response
Immune System Cells

• Phagocytes
  – Types
    • Neutrophils—short-lived phagocytic cells
    • Monocytes—develop into phagocytic macrophages and migrate to tissues (Figure 15-15)
    • Dendritic cells (DCs)—often found at or near external surfaces
Phagocytosis
Immune System Cells

• Phagocytes
  – Ingest and destroy foreign cells or other harmful substances via phagocytosis
  – Macrophages and DCs act as antigen-presenting cells (APCs) by displaying ingested antigens on their outer surface to trigger specific immune cells
Immune System Cells

• Lymphocytes
  – Most numerous of immune system cells
  – Development of B cells—primitive stem cells migrate from bone marrow and go through two stages of development
Immune System Cells

• Lymphocytes
  – Development of B cells
    • First stage—stem cells develop into immature B cells
      – Takes place in the liver and bone marrow before birth and in the bone marrow only in adults
      – B cells are small lymphocytes with antibody molecules (which they have synthesized) in their plasma membranes
      – After they mature, inactive B cells migrate chiefly to lymph nodes
Immune System Cells

– Development of B cells
  • Second stage—inactive B cell develops into activated B cell
    – Initiated by inactive B cell’s contact with antigens, which bind to its surface antibodies, plus signal chemicals from T cells
    – Activated B cell, by dividing repeatedly, forms two clones of cells—plasma (effector) cells and memory cells
    – Plasma cells secrete antibodies into blood; memory cells are stored in lymph nodes
    – If subsequent exposure to antigen that activated B cell occurs, memory cells become plasma cells and secrete antibodies
– Function of B cells—indirectly, B cells produce humoral immunity

  • Activated B cells develop into plasma cells
  • Plasma cells secrete antibodies into the blood
  • Circulating antibodies produce humoral immunity
Immune System Cells

– Development of T cells—stem cells from bone marrow migrate to thymus gland
  • First stage—stem cells develop into T cells
    – Occurs in thymus during few months before and after birth
    – T cells migrate chiefly to lymph nodes
  • Second stage—T cells develop into activated T cells
    – Occurs when, and if, antigen binds to T cell’s surface proteins and chemical signal received from another T cell
    – As with B cells, clones made up of effector cells and memory cells are formed
Stem cells

Develop in thymus gland shortly before and after birth into

T cells

Migrate to lymph nodes, liver, and spleen; binding of antigens to proteins on surfaces of T cells and chemical signal from other T cells changes them into

Activated T cells

Subsequent exposure to antigen changes memory cells to

Memory cells

Kill infected cells and tumor cells; trigger B and T-cell activation; regulate various immune functions

Effector cells
Immune System Cells

– Functions of T cells—produce cell-mediated immunity

  • Cytotoxic T cells—kill infected or tumor cells by releasing a substance that poisons infected or tumor cells
  • Helper T cells—release chemicals that attract and activate macrophages to kill cells by phagocytosis; produce chemicals that help activate B cells
  • Regulatory T cells—release chemicals to suppress immune responses
Hypersensitivity of the Immune System

- Inappropriate or excessive immune response
- Allergy—hypersensitivity to harmless environmental antigens (allergens)
  - Immediate allergic responses usually involve humoral immunity
  - Delayed allergic responses usually involve cell-mediated immunity
Hypersensitivity of the Immune System

• Autoimmunity—inappropriate, excessive response to self-antigens
  – Causes autoimmune diseases
  – Systemic lupus erythematosus (SLE)—chronic inflammatory disease caused by numerous antibodies attacking a variety of tissues
Hypersensitivity of the Immune System

• Isoimmunity—excessive reaction to antigens from another human
  – May occur between mother and fetus during pregnancy
  – May occur in tissue transplants (causing rejection syndrome)
Immune System Deficiency

• Congenital immune deficiency or immunodeficiency (rare)
  – Results from improper lymphocyte development before birth
  – Severe combined immune deficiency (SCID)—caused by disruption of stem cell development
Immune System Deficiency

• Acquired immune deficiency
  – Develops after birth
  – Acquired immunodeficiency syndrome (AIDS)—caused by HIV infection of T cells