Basic A & P II Dr. L. Bacha
Chapter Outline (Martini and Nath 2010)

Chapt. 20: The Lymphoid System and Immunity

✳ read the introductory material under section 20-1 on page 667

LYMPHATIC SYSTEM STRUCTURE AND FUNCTION

✳ what does the **lymphoid system** consist of (bottom of p.667)?

(1)

(2)

(3)

(4)

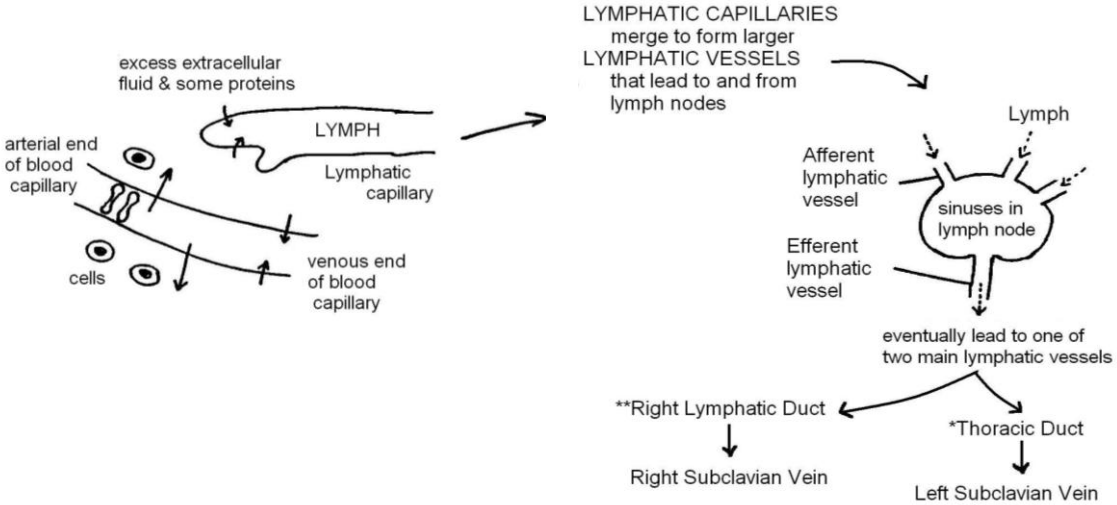
- the three primary functions of the lymphatic system are:
  1. returns excess interstitial fluid to the venous system
  2. surveillance and defense - protects the body from foreign cells, bacteria, cancer cells, etc.
  3. transports absorbed fats from the intestine to the venous system

Lymphatic Vessels

During capillary exchange, more fluid leaves the blood capillary than returns to it. The lymphatic vessels provide a pathway through which excess interstitial fluid is transported from the interstitial tissues to the bloodstream. (The structure of lymphatic vessels allows interstitial fluid to move into them, but not out.)

Lymphatic Capillaries

- the flow of lymph from the interstitial tissue begins with **lymphatic capillaries** located in the spaces between cells (in the interstitial tissue) in most tissues of the body
- read about the four ways that lymphatic capillaries differ from blood capillaries (p. 668)
- describe the basal lamina (basement membrane) of a lymphatic capillary:
- describe the endothelial cells of a lymphatic capillary:
  - the region of overlap acts as a one-way valve, permitting what and preventing what?
- observe the sectional view of a lymphatic capillary in Fig. 20-2



- lymphatic capillaries merge to form larger **lymphatic vessels**, which carry lymph into and out of lymph nodes; ultimately, lymph flows into one of two main channels and then drains into venous blood:
  - * **thoracic duct** (left lymphatic duct)
    - the thoracic duct empties into what vein?
    - the thoracic duct collects lymph from what general parts of the body *(first sentence top of p.670)*?

  - ** **right lymphatic duct**
    - the right lymphatic duct empties into what vein?
    - the right lymphatic duct collects lymph from what side of the body?

The flow of lymph is maintained primarily from the squeezing, massaging action produced by contractions of skeletal muscles. It is also aided by intestinal and other body movements, valves in lymphatic vessels that insure flow of lymph in one direction, and pressure gradients created during breathing.

Lymphocytes

✳ Types of Lymphocytes

- list the three classes of lymphocytes that circulate in blood:

(1) **T cells** (T lymphocytes)

- what percent of circulating lymphocytes are T cells?
- name and give the function of the three primary types of T cells:
  -
  -
  -

(2) **B cells** (B lymphocytes)
- B cells differentiate into what type of cell?

- what are plasma cells responsible for?

(3) **NK cells**
- what do they attack?

✳ Lymphocyte Production
- occurs in red bone marrow and lymphoid tissues

Lymphoid Tissues and Organs

LYMPHOID TISSUE (LYMPHATIC TISSUE)
characterized by:
- lymphocytes - the most numerous type of cell; three varieties: **T cells, B cells and NK cells**
- also plasma cells (derived from B lymphocytes), macrophages, and dendritic cells
- a supportive framework (stroma) of reticular cells and reticular fibers

1. **Diffuse Lymphatic Tissue**
   - an unorganized accumulation of numerous lymphocytes, etc.
2. **Nodular Lymphatic Tissue**
   - formed by **lymphatic nodules** (lymphoid nodules)
     - are round or oval, dense accumulations of numerous lymphocytes
     - each has a lighter staining center called a **germinal center**, what does the germinal center contain?

Both types of lymphatic tissue are found:
1. throughout the body, in the CT below the epithelium of many organs, such as the trachea, esophagus, stomach, intestines, urinary bladder, etc.
2. as part of lymphoid organs

✳ ***MALT*** (Fig. 20-6a)
- what is MALT?

✳***Tonsils*** (Fig. 22-6b)
- associated with the pharynx; provide an immune response against inhaled or ingested foreign microbes, etc.
- types of tonsils:
  - **palatine tonsils** are located in what cavity?
  - **pharyngeal tonsil** lies in what part of the pharynx?
    - what is another name for a pharyngeal tonsil?
  - **lingual tonsils** lie at the base of what?

Lymphoid Organs

✳ ***Lymph Nodes*** (Fig. 20-7)

- what is the size range of lymph nodes?
- what does their shape resemble?
- observe the general distribution of lymph nodes shown in Fig. 20-1
  - note that they occur singly or in clusters in certain parts of the body
  - list the names of the five clusters of lymph nodes shown in Fig. 20-1:
  - note that lymph nodes are in the pathway of lymphatic vessels, which carry lymph into and out of the lymph node *(so lymph flows through lymph nodes before entering the bloodstream!)*
- *structure* *(see Fig. 20-7)*:
  - the cortex contains lymphatic nodules, diffuse lymphatic tissue, and sinuses (channels through which lymph flows)
  - the medulla contains diffuse lymphatic tissue (called medullary cords) and medullary sinuses
- *functions*:
  1. filter lymph
     - as lymph flows through channels called sinuses, numerous macrophages in the sinuses phagocytize microbes and debris that enter the lymph; this prevents them from reaching the blood and spreading to other parts of the body
  2. a site for immune surveillance and response, including lymphocyte proliferation and antibody production
     - lymphocytes in the lymph nodes monitor the lymph for the presence of antigens and mount an immune response against the antigens
- define **lymphadenopathy**:

✳ ***Thymus*** (Fig. 20-8)

- where is the thymus located:
- when does it reach its greatest size?
- *function of the thymus*:
  - secretes hormones that stimulate T lymphocytes (T cells) to become **immunocompetent** (become programmed against specific antigens by developing specific antigens receptors) in the thymus

✳ ***Spleen*** (Fig. 20-9)

- the spleen is the largest lymphatic organ in the body
- located in the upper left abdominal cavity
- consists of red pulp and white pulp
  - **red pulp** contains numerous red blood cells and blood vessels with numerous macrophages
  - **white pulp** is diffuse and nodular lymphatic tissue

◦ list the three main *functions of the spleen* (p. 676):

(1)

(2)

(3)

The Lymphoid System and Body Defenses

Name and read about the two general categories of body defenses (starting on the bottom of p.678):

Nonspecific Defenses

- *includes many general, nonspecific defense mechanisms to prevent the entrance of potential pathogens and to destroy them if they gain entrance into the body.*
- list the 7 major categories of nonspecific defenses and examine Fig. 20-10:

1. Physical Barriers

- to cause trouble, an antigenic compound or pathogen must enter body tissues, which requires what?
- read the paragraphs on physical barriers and list various features of the skin and mucous membranes that help provide protection:

2. Phagocytes

- what do phagocytes remove?
- what do phagocytes respond to?
- phagocytes include neutrophils, eosinophils, and macrophages

- *more about macrophages*:
  - from what cells are most macrophages derived?
  - do **fixed macrophages** travel throughout the body or are they incapable of movement?
    - what are microglia?
    - what are Kupffer cells?
  - do **free macrophages** travel throughout the body or are they incapable of movement?
    - name the free macrophages in the lungs:

3. Immunological surveillance

- immunological surveillance is the constant monitoring of normal tissues by what types of cells?
- these cells are responsible for recognizing and destroying what?
- what does the plasma membrane of an abnormal cell contain that are generally not found on the membranes of normal cells?
- how do the natural killer cells recognize an abnormal cell?
- are NK cells as selective about their targets as other lymphocytes, or do they respond to a variety of abnormal antigens?

4. Interferons

- interferons are small proteins released by what cells?
- what do they trigger the production of?
- what do they interfere with?
- what do they stimulate?

5. Complement

- a group of special proteins in the plasma that, when activated, carry out what 4 main effects *(list the headings under* "Effects of Complement Activation" *in italics on page 683)*?

6. Inflammation (see Fig. 20-13)

- what is inflammation (the inflammatory response)?
- list the 4 cardinal signs and symptoms of inflammation:

- list examples of various stimuli that can produce inflammation:

- each of these stimuli does what?

  - the changes alter the chemical composition of interstitial fluid due to chemicals released by damaged cells and to foreign substances that may have been introduced with the injury

  these chemicals cause:
  - vasodilation
  - an increase in and capillary permeability
  - WBCs to be attracted to the area (chemotaxis)
  - repair of damaged tissues

My summary of the 4 cardinal signs of inflammation (and sometimes a fifth!)

✷ **REDNESS (ERYTHEMA) -** due to vasodilation and, therefore, an increase in blood flow to the injured area

✷ **HEAT -** due to vasodilation and, therefore, an increase in blood flow to the injured area

✷ **EDEMA -** due to an increase in capillary permeability and the resulting exudation of plasma into the interstitial tissue at the site of injury

✷ **PAIN** due to: injury of nerve fibers
irritation by toxins
increased pressure caused by edema
chemicals released by mast cells

✷ sometimes **IMPAIRMENT OF FUNCTION** due to tissue destruction, swelling, and pain

7. Fever

- fever is a systemic response that occurs during widespread infection and inflammation due to chemicals called **pyrogens**
- define **fever**:
- what sorts of stimuli can either act as pyrogens or stimulate the release of pyrogens by macrophages?
- how can a fever be beneficial?
- high fevers are dangerous because the excess heat can denature enzymes

Specific Defenses: Immunity

✶ specific defense, or immunity, is provided by the coordinated activities of what?

✶ summarize the following two types of immunity, including the cells that are responsible for each type, and what each type defends against:

cell mediated immunity -

antibody-mediated immunity -

An Introduction to the Immune Response

⁂ observe Fig. 20-15 for an overview

ANTIGENS (Ag) = substances that trigger immunity

characteristic of antigens:

1. usually high molecular weight
2. most are proteins
3. normally are foreign substances (not usually a part of the body; the body recognizes its own substances as "self")

examples of antigens:

1. whole microbes or components of microbes, such as the cell walls, capsules, and flagella of bacteria; fungi; viruses
2. bacterial toxins
3. non-microbes such as pollen, transplanted organs, transfused blood cells, and drugs

Self Antigens: Major Histocompatibility Complex (MHC)

- a group of proteins on the external surfaces of a person's own cells
- these **self-antigens** are not foreign or antigenic to that person, but are antigenic to other individuals

Cells that respond to antigens:

1. **Lymphocytes:**
   T lymphocytes (T cells) – *play a role in cell-mediated immunity*
   B lymphocytes (B cells) – *play a role in antibody-mediated immunity*

   } have specific **antigen receptors** for specific antigenic determinants of antigens

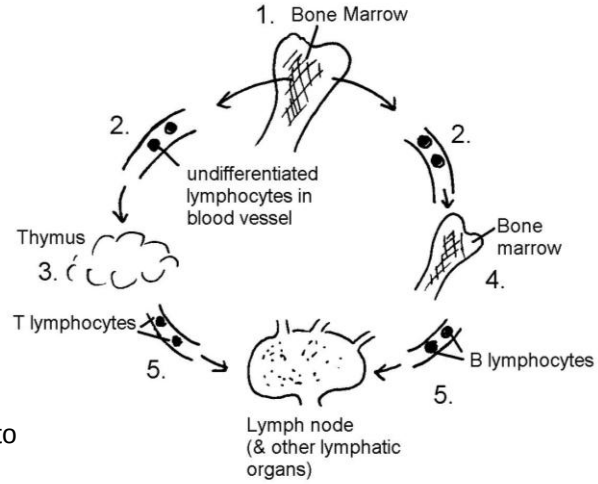
2. **Antigen-presenting cells (APCs)**
   - various types, such as macrophages

   function:
   - to phagocytize antigens and then present fragments of these antigens on their own surfaces *(like signal flags)* where they can be "spotted" by T cells

more about Lymphocytes…

LYMPHOCYTE FORMATION IN THE FETUS:

1. Stem cells in the bone marrow give rise to undifferentiated lymphocytes.
2. Undifferentiated lymphocytes enter the blood.
3. Some lymphocytes become **immunocompetent** in the thymus to become T lymphocytes .
4. Other lymphocytes become **immunocompetent** in the bone marrow to become B lymphocytes.
5. T lymphocytes and B lymphocytes then circulate to lymphatic tissues and lymphatic organs.



*So...more about "**immunocompetent**":*

- when a lymphocyte becomes immunocompetent, it displays a unique type of **antigen receptor** on its surface
- these antigen receptors (10^4 to 10^5 per cell!) enable the lymphocyte to recognize and bind to only one specific type of antigen
- It is interesting to realize that lymphocytes become immunocompetent **before** being exposed to antigens they may encounter. Our genes, not antigens, determine what specific foreign substances our immune system will be able to recognize and resist. Only some of the antigens that lymphocytes are programmed against will ever invade the body.
- after becoming immunocompetent, the T lymphocytes and B lymphocytes circulate to lymph nodes, the spleen, and other lymphatic tissues and lymphatic organs where they may or may not encounter the antigen to which they are programmed against.

ANTIBODY-MEDIATED IMMUNITY

Summary of antibody-mediated immunity:

an antigen enters the body
↓
the antigen binds to specific antigen receptors on **B cells**
↓
B cells become activated, with stimulation from helper T cells
↓
activated B cells undergo proliferation and differentiation to produce a large population of B cells that are identical (a clone) with specific receptors against the antigen
↓
the B cells differentiate into two types of cells:

1. **Plasma cells** - synthesize and secrete **antibodies** that carry out actions to help destroy the antigen
2. **Memory B cells** - remain in lymphatic tissue a long time after the original exposure to the specific antigen

Antibodies

Antibody Structure

- antibodies are also known as **immunoglobulins** (Igs)
- each antibody molecule has atleast two antigen-binding sites, they are different for each type of antibody and are the parts that recognize and attach to a specific antigen
- list the five different classes of antibodies (see Table 20-1 on page 697):

- Table 20.3 shows the characteristics and functions of each of the five classes:
  - what is the largest class of antibody?
  - what class of antibody can cross the placenta from the mother to the fetus?
  - what class forms the antibodies that bind with antigens of the ABO blood groups during incompatible blood transfusions?
  - which is the first to be secreted by plasma cells after an antigen arrives?
  - which is located on mast cells and basophils and involved in allergic reactions?
  - which provides local protection in glandular secretions, such as mucus, tears, saliva and semen?

Antibody Actions

- list (and read about!) the seven ways that the formation of an antigen-antibody complex may cause the elimination of the antigen (*the headings in italics starting on p. 696)*:

1.
2.
3.
4.
5.
6.
7.

Monoclonal Antibodies

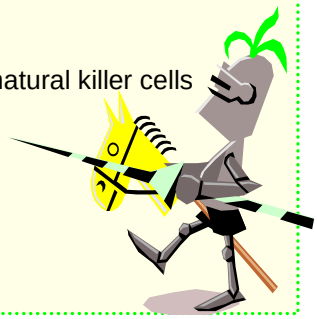
- scientists can fuse together a B lymphocyte and a tumor cell in the laboratory to form a **hybridoma**
- hybridomas are a long-term source of one specific type of antibody

CELL-MEDIATED IMMUNITY

Summary of cell-mediated immunity:

an antigen enters the body
↓
it is phagocytized by macrophages
which then present the antigen on their surfaces like signal flags
↓
specific antigen-receptors on **T cells** bind with the antigen and the T cell becomes activated
↓
activated T cells undergo proliferation and differentiation to produce a large population of T cells that are identical (a clone) with specific receptors against the antigen
↓
the T cells differentiate into three major types:

1. **Helper T cells** – secrete chemicals (cytokines) that enhance activation and proliferation of T cells , B cells, and natural killer cells
2. **Cytotoxic T cells** – release chemicals that destroy the cells that have the antigen
3. **Memory T cells** – remain in lymphatic tissue a long time after the original exposure to the specific antigen



Immunological Memory (Study Fig. 20-22)

☺ immune responses have memory for specific antigens that have triggered immune responses in the past

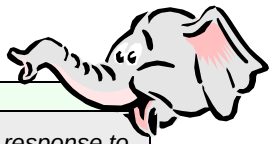
☺ immunological memory is due to the presence of long lasting antibodies and very long-lived lymphocytes that form during an initial exposure to an antigen

☺ immune responses, whether cell-mediated or antibody-mediated, are much quicker and more intense after a second or subsequent exposure to an antigen than after the first exposure
- this is because memory cells are already present after an initial exposure with an antigen and the cells can proliferate and differentiate into plasma cells or cytotoxic T cells within hours

primary response: After an initial exposure to an antigen, the production of antibodies or T cells may not be sufficient to prevent infection and the person comes down with symptoms of the disease.
However, cell-mediated and antibody-mediated immunity result in the formation of memory T cells and memory B cells. Memory cells are ready to respond if the immune system is exposed to the same antigen in the future.

secondary response: A subsequent exposure to the same antigen results in a larger and faster immune response.

Types of Immunity:



TYPE OF IMMUNITY	*HOW ACQUIRED*
ACTIVE: *person's own body produces antibodies or activated lymphocytes in response to exposure to antigens*	
Naturally Acquired Active	stimulated by natural exposure to pathogens or toxins
Artificially Acquired Active	immunization (vaccination) with attenuated (weakened) or killed pathogens or with toxoids (altered toxins)
PASSIVE: *antibodies or T lymphocytes are received from another source*	
Naturally Acquired Passive	fetus receives maternal antibodies via placental circulation
Artificially Acquired Passive	intravenous injection with antibodies or T lymphocytes for immediate protection

Immune Disorders (page 704)

Autoimmune Disorders

•the person produces antibodies against their own antigens ("self antigens")

• list examples of autoimmune diseases (bottom of p.704):

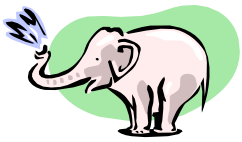
Allergies

• what are allergies?

• there are four categories of allergic reactions

- read about **immediate hypersensitivity** and **anaphylaxis** (see Fig. 20-26)

Stress And The Immune Response (starts on p. 705; you may find this interesting…!)



The End!