Chp. 7 Lymphatic System & Immunity
The interaction between microbes and humans?

- Microbes are very abundant in the environment and as well as in and on our bodies
- GOOD: We use microbes to make many foods and we even use them to make drugs
- Microbes are important as decomposers to recycle nutrients
- BAD: Some microbes cause disease in humans, we call these pathogens

7.1 Microbes, pathogens and you

Microbes are microscopic (bacteria, viruses, prions, & some fungi etc.) How do the sizes of our cells, bacteria and viruses compare?

What are bacteria?

- Prokaryotic cells
- Single-celled
- Almost all have a cell wall
- Have DNA in a single chromosome
- Have ribosomes
- Some have accessory rings of DNA called plasmids
What are specific structures and shapes of bacteria?

What are viruses?

- Small, non-living obligate parasites (not made of cells)
- Must reproduce inside of a host cell
- All viruses have an outer protein coat called a capsid and nucleic acid (RNA or DNA) inside
- Viruses are specific to which cell they will attach to and enter

What are prions?

- Infectious protein particles
- Cause degenerative disease of the nervous system
- Normal proteins change their shape
4 functions of the lymphatic system

- Lymphatic capillaries absorb excess tissue fluid and return it to the bloodstream
- Lymphatic capillaries (lacteals) in the small intestine absorb fats associated with proteins
- Works in the production, maintenance and distribution of lymphocytes in the body
- Helps in defense against pathogens

What are the components of the lymphatic system?

Lymphatic vessels

- One-way valve system that carries fluid called lymph
- Made of capillaries, vessels and ducts
- Function to return tissue fluid (includes water, solutes and cell products) to the bloodstream
- The larger vessels are similar in structure to veins and even have valves
### Classifying lymphatic organs

- **Primary**
  - Red bone marrow
  - Thymus gland

- **Secondary**
  - Lymph nodes and spleen

#### Primary lymphatic organs

- **Red bone marrow**
  - Site of blood cell production
  - More bones in children have red marrow and it decreases as we age
  - Some white blood cells mature here

- **Thymus gland**
  - Bilobed gland found in the thoracic cavity superior to the heart
  - Largest in children and shrinks as we age
  - Immature T lymphocytes move from the marrow to the thymus where they mature and 95% will stay

#### Secondary lymphatic organs

- **Lymph nodes**
  - Small, oval-shaped structures found along the lymphatic vessels filled with B cells, T cells, and macrophages
  - Common in the neck, armpit, and groin regions

- **Spleen**
  - In the upper left region of the abdominal cavity
  - Filled with white pulp containing lymphocytes and red pulp is involved with filtering the blood
What do the nonspecific defenses include?

- First line of defense:
  - Barriers to entry: physical and chemical

- Second line of defense:
  - Phagocytic white blood cells (neutrophils)
  - Inflammatory response
  - Protective proteins: complement and interferons

The first line of defense

- Physical barriers
  - Skin
  - Tears, saliva and urine physically flush out microbes
  - Mucous membranes line the respiratory, digestive, reproductive and urinary tracts
  - Resident bacteria/normal flora that inhabit the body use available nutrients and space thus preventing pathogens from taking up residence

- Chemical barriers
  - Secretions of the oil glands
  - Lysozyme found in saliva, tears and sweat
  - Acidic pH of the stomach and vagina

The second line of defense: Phagocytic white blood cells

- Includes neutrophils and macrophages
- Both leave circulation and move into tissue
- Cells that are important in the inflammatory response
The second line of defense: Inflammatory response

- Four hallmark symptoms are redness, heat, swelling, and pain.
- Histamine is released by mast cells, causing the capillaries to dilate and become more permeable to phagocytic white blood cells.
- Increased blood flow to an area increases the warmth that inhibits some pathogens.
- Increased blood flow also brings more white blood cells to an injured area, with neutrophils being the first scouts to kill pathogens.
- This response can be short-lived but if the neutrophils cannot control the damage, cytokines (chemicals) will call in more white blood cells including macrophages.

Summary of the inflammatory response

- Complement:
  - Group of blood plasma proteins.
  - Involved in the inflammatory response by binding to mast cells to release histamine.
  - Attract phagocytes to pathogens by binding.
  - Form a membrane attack complex that makes holes in some bacteria and viruses, causing them to burst.

- Interferons:
  - Proteins produced by virally infected cells sent out to warn neighboring healthy cells.
What do the specific defenses include?

- Third line of defense:
  - Helps protect us against specific pathogens when nonspecific defenses fail
  - Helps protect us against cancer
  - Depends on the action of B and T cells (remember that these are lymphocytes)

Characteristics of B cells

- Antibody-mediated immunity against pathogens
- Produced and mature in bone marrow
- Directly recognize antigen and then undergo clonal selection
- Clonal expansion produces antibody-secreting plasma cells as well as memory B cells

Antibody-mediated immunity by B cells
Structure of antibodies

- A Y-shaped protein
- The trunk of the Y is a constant region that determines the class of the antibody
- The end of the arms (Y) are the variable regions where specific antigens bind

What are the 5 classes of antibodies?

<table>
<thead>
<tr>
<th>Class</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td>IgG</td>
<td>Neutralizes toxins; involved in antibody-mediated immune response</td>
</tr>
<tr>
<td>IgM</td>
<td>Complement activator; involved in antibody-mediated immune response</td>
</tr>
<tr>
<td>IgA</td>
<td>Binds to bacteria, involved in mucosal immunity</td>
</tr>
<tr>
<td>IgE</td>
<td>Involved in allergic reactions, involved in IgE-mediated immune response</td>
</tr>
<tr>
<td>IgD</td>
<td>Involved in immune response against viruses and toxins</td>
</tr>
</tbody>
</table>

Characteristics of T cells

- Cell-mediated immunity against virus-infected cells and cancer cells
- Produced in bone marrow, mature in thymus
- Antigen must be presented in groove of an HLA molecule
- Cytotoxic T cells destroy nonself antigen-bearing cells
- Helper T cells secrete cytokines that control the immune response
Third line of defense: Cell-mediated immunity by T cells

- Each T cell has a unique receptor called a TCR that will recognize a piece of an antigen with the help of an antigen-presenting cell (APC).

- 1. An APC engulfs an antigen
   2. Breaks it down and presents it on its surface in association with a membrane protein called an MHC (in humans = HLA)
   3. Presents it to T cells in the lymph node or spleen—(Like a piece of it on outer flagpole)

- Then Clonal expansion will occur leading to mostly helper T cells, cytotoxic T cells and a few memory T cells

- After an infection has passed, helper and cytotoxic T cells undergo apoptosis leaving memory cells

7.4 Specific Defenses

Cell-mediated immunity by T cells

- Helper T cells:
  - Secrete cytokines that help many immune cells function

- Cytotoxic T cells:
  - Have vacuoles containing granzymes and perforins
  - Perforins punch holes in target cells followed by granzymes that cause the cell to undergo apoptosis

7.4 Specific Defenses

Helper and cytotoxic T cells
Immunity

- Is the ability to combat diseases and cancer
- Can be brought about naturally through an infection or artificially through medical intervention
- There are two types of immunity: active and passive

Examples of immunizations: a type of active immunity

Passive immunity

- An individual is given prepared antibodies against a particular antigen
- This type of immunity is short-lived
- This can happen naturally as antibodies are passed from mother to fetus or artificially via an injection of antibodies
HARMFUL REACTIONS

Allergies

• Hypersensitivities to harmless substances such as pollen, food or animal hair

• An immediate allergic response is caused by the IgE antibodies that attach to mast and basophils. When allergens attach to these IgE molecules histamine is released and we see allergy symptoms.

• A immediate allergic response that occurs when the allergen enters the bloodstream is anaphylactic shock in which the blood pressure drops and is life-threatening

• Delayed allergic responses are initiated by memory T cells such as seen with poison ivy

Disorders of the immune system

• Autoimmune diseases:
  – A disease in which cytotoxic T cells or antibodies attack the body’s own cells as if they were foreign
  – Examples: multiple sclerosis, lupus, myasthenia gravis and rheumatoid arthritis

• Immunodeficiency disease:
  – A disease in which the immune system is compromised and thus unable to defend the body against disease
  – Examples: AIDS and SCID

Tissue rejection

• This can occur when cytotoxic T cells respond to tissue that is not recognized as "self" tissue

• This can be controlled by giving patients immunosuppressive drugs and by transplanting organs that have the same MHC proteins in the donor and recipient

• Currently we are trying to grow organs in the lab that can be transplanted with less rejection