Bio11 schedule

- Lecture
  - Immune system
- Lab
  - This week: Diet analysis, bring a nutrition facts label!
  - Next week: Current events reports (10 pts)
- Extra credit (see my website)
  - 5 pts: Current events articles
  - 10 pts: Visit Body World exhibit;
  - Calculate your ecological footprint
  - 15 pts: Reports on HPV or genetic engineering

Ch 7 Immunity

Introduction

- Immune system
  - the body’s defenses against pathogens that produce disease
- 2 types of immunity
  - Nonspecific defenses
    - Provide general protection against invasion by a wide range of pathogens
    - Present at birth—innate
  - Specific defenses
    - Specific lymphocytes combat particular pathogens

Overview of the body’s defenses

<table>
<thead>
<tr>
<th>Non-specific defenses</th>
<th>Specific defenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>First line of defense:</td>
<td>Third line of defense:</td>
</tr>
<tr>
<td>External barriers</td>
<td>Immune system</td>
</tr>
<tr>
<td></td>
<td>The lymphatic system</td>
</tr>
<tr>
<td>Skin</td>
<td>Antibodies</td>
</tr>
<tr>
<td>Mucous membranes</td>
<td>Lymphocytes</td>
</tr>
<tr>
<td>Secretions at skin and mucous membranes</td>
<td></td>
</tr>
<tr>
<td>White blood cells</td>
<td>The inflammatory response</td>
</tr>
<tr>
<td>Defensive proteins</td>
<td></td>
</tr>
<tr>
<td>The immune system</td>
<td></td>
</tr>
</tbody>
</table>

Three lines of defense protect us from pathogens

The 1st line of defense

- Nonspecific Defenses
- A set of physical barriers and chemicals that prevent foreign invaders from getting inside our bodies

External Barriers

- The body has several physical barriers:
  - An outer layer of skin
  - Hair in the nostrils
  - Mucous membranes of the digestive and respiratory tracts
The 1st line of defense

- Cilia lining the upper respiratory tract propel trapped particles up and out

The 2nd line of defense

- Act when an invader penetrates the body's external barriers
- Nonspecific – combats all invading microbes
- Depend on white blood cells and defensive proteins.

Chemical defenses

- Sweat, saliva, and tears contain enzymes that kill bacteria.
- Glands produce oils and acids
- The acid pH of the stomach kills many bacteria

The 2nd line of defense

- When the external barriers fail, a set of nonspecific internal defenses stands ready – the second line of protection
- Antimicrobial proteins
  - Interferon
  - Complement
- WBCs: phagocytic cells and natural killer cells
- Inflammation
- Fever

Antimicrobial proteins—interferons (IFNs)

- Protect body against viral infection
- Cells infected by viruses produce interferon
- IFNs stimulate healthy cells to produce proteins that inhibit viral reproduction
Antimicrobial proteins— the complement system

- A group of ~20 proteins in blood plasma and cell membranes
- "Complement" proteins cause invading cells to lyse
  - Form a "membrane attack complex" that makes holes in some microbes
  - Causes the microbe to lyse

The 2nd line of defense: WBCs

- Natural Killer (NK) cells
  - Destroy infected body cells and cancerous cells
  - NK cells bind to infected cells
  - Release perforins that penetrate the plasma membrane of infected cells causing them to lyse

The 2nd line of defense: WBCs

- Phagocytes
  - Engulf microbes or other particles (by phagocytosis)
  - Phagocytes migrate to infected area by chemotaxis (attracted to chemicals released by invading microbes)

The 2nd line of defense: Inflammation

- Occurs when tissue is damaged
- Inflammation
  - an attempt to dispose of microbes
  - prevent their spread to other tissues
  - prepare the site for tissue repair
- 4 hallmark symptoms of the inflammatory response:
  - Redness
  - Pain
  - Swelling
  - Heat (warm to the touch)

What happens when you cut your finger?

- Phagocytes engulf bacteria
- Tissue heals

Fever

- Usually caused by infection from bacteria or viruses
- The high body temperature
  - inhibits some microbial growth
  - speeds up body reactions that aid repair
Recap:
Summary of Nonspecific Defenses
- First line of defense: external barriers
  - Skin
  - Mucous membranes
  - Secretions - inhibit growth of microbes

When external barriers fail—
The body’s second line of defense

Checkpoint
- What makes the 1st and 2nd lines of defense “nonspecific”?

The 3rd line of defense
- Three lines of defense protect us from pathogens

Specific Defenses
- The immune system
  - Consists of a large number of cells that work together to respond to a specific microbe or foreign invader.
- Two properties
  - Specificity for particular foreign molecules (antigens)
  - Memory for previously encountered antigens
    - The immune system can react more promptly to a second exposure to infection.

Definitions
- Antigens
  - Are foreign substances that trigger an immune response
  - Most are pathogens
- Antibodies
  - Are proteins found in blood plasma that attach to one particular kind of antigen and help counter its effects.
Antigens

- HIV virus
- Pollen
- Red blood cells

\( Y = \text{antibody} \)

Antibodies

- Y-shaped proteins that bind foreign molecules (antigens)
- Produced by a white blood cell called the B cell

**Figure 24.10**

Recognizing the Invaders

- Two kinds of lymphocytes
  - B cells
    - Secrete antibodies
    - Directed against bacteria and viruses
  - T cells
    - Helper T cells
    - Cytotoxic (or “killer”) T cells
    - Directed against intracellular pathogens, some cancer cells and tissue transplants

Two kinds of lymphocytes

- B cells
  - Develop in the bone marrow
- T cells
  - Become specialized in the thymus
- B cells and T cells are named based on where they mature

Responding to the Invaders

- The immune system stops infections by destroying antigen-bearing invaders.
- B cells secrete antibodies that inactivate foreign invaders
  - Antibody-mediated immunity
- T cells circulate in the blood and lymph, attacking infected body cells.
  - Cell-mediated immunity

B cells and antibody-mediated immunity

- Antibody immune response (No narration)
  - 0:53
  - [Watch Video](http://www.youtube.com/watch?v=lrYlZJiuf18)
**T cells and cell-mediated immunity**
- T cells respond to pathogens that have already entered body cells.
  - Cytotoxic T cells
    - Are the only T cells that actually kill other cells.
    - Kill virus-infected or cancer cells
  - Helper T cells
    - Regulate immune response by secreting chemicals (cytokines) that activate other immune cells

**The immune response**
- Cell-mediated immune response (attack on infected cells)
- Antibody-mediated immune response (secretion of antibodies)

**The immune response in action**
- How does our immune system respond when we get a cold?

**How does the body respond to a viral infection?**
- The common cold
  - A contagious viral disease of the upper respiratory tract
  - Primarily caused by rhinoviruses
  - The most common infectious disease in humans

**Cold viruses live only in the nose**
- The major entry point for the virus is the nose
- First line of defense – external barriers
  - Mucous membranes of the nose
  - From the nose, the virus is transported to the back of the nasopharynx
  - Cold viruses attach to cells lining the nasopharynx

**How a cold virus infection occurs**
- The virus attaches to a receptor located on the surface of nasal cells.
- After attaching to the receptor, the virus is taken into the cell, where it starts an infection.
How a viral infection occurs

- Virus binds to the plasma membrane
- The virus is taken into the cell where it starts an infection
- Viral RNA is integrated into the cell genome
- The infected cell ‘manufactures’ new virus
- The infected cell eventually ruptures and dies, releasing newly made virus

Nonspecific defenses

- Cold symptoms are due mainly to the body’s response to the infection.
- When a nasal cell is infected by a cold virus, the immune system responds by activating the inflammatory response
  - The immune system releases histamine that causes mucus secretion.
  - The production of interferon is an important host defense mechanism.
- A virus-infected cell produces interferon, which stimulates healthy cells to make antiviral proteins

Specific immune responses

- The host’s immune system effectively deals with the infection.
- Antibody-mediated response: the body begins producing specific antibodies that bind to the virus and prevent it from infecting cells.

Cell-mediated immune response

- Infected cells display viral antigens on their surface
- If a cytotoxic T cell recognizes a viral fragment there, it will destroy the infected cell
- Macrophages destroy the virus through phagocytosis and destroy infected cells to prevent further viral replication.

How does the body respond to a viral infection?

- **External barriers**
  - Skin, mucous membranes, secretions
- **The first responders**
  - Macrophages
- **Specific responses**
  - B cells produce antibodies to epitopes on virus
  - Helper T cells
  - Cytotoxic T cells attack virus-infected cells

AIDS

- AIDS is a worldwide epidemic that kills millions of people each year.
- HIV, the AIDS virus,
  - Attacks helper T cells
  - Cripples both antibody- and cell-mediated immunity.
Why is HIV so lethal?

Checkpoint

- Which of the following belong to the specific or nonspecific immune responses?
  - Natural killer cells
  - Complement proteins
  - Antibodies
  - Inflammation
  - Interferon
  - Cytotoxic T cells
  - Helper T cells

Checkpoint

- Which of the following best describes the difference in the way B cells and T cells deal with invaders?
  - B cells send out antibodies that attack invaders; T cells themselves do the attacking
  - T cells handle the 1st line of defense, B cells handle the 2nd
  - B cells are responsible for cell-mediated immunity; T cells for antibody-mediated immunity.

How do vaccinations work?

- Trigger the immune reaction, stimulating the body to defend itself.

Immunologic memory

- Interaction with an antigen activates B cells and T cells
- Activated B cells
  - Cells that secreted antibodies
  - Memory B cells that remain in the body and produce antibodies if that antigen enters the body again
- Memory T cells that respond to a second exposure to the antigen
Test your understanding

- What makes a secondary immune response faster than a primary immune response?

Self-recognition and self-tolerance

- To function properly, your T cells must have 2 traits:
  - They must be able to recognize self-MHC antigens
    - Self-recognition
  - But do not react to other self-proteins
    - Self-tolerance

How do immune cells recognize foreign or self?

- Self-antigens located in the plasma membrane of body cells
  - Unique to each person
  - Function: to help T cells recognize foreign or self
- Your T cells recognize your self-antigens and do not react
  - Self-tolerance

Autoimmune diseases

- Due to loss of self-tolerance
  - The immune system attacks the person’s own tissues
  - Examples
    - Type 1 diabetes - T cells attack the insulin-producing pancreatic beta cells
    - Multiple sclerosis (MS) - T cells attack myelin sheaths around axons of neurons

Graph or organ rejection

- Immune system recognizes the self proteins in the transplanted organ as foreign and mounts an immune response
  - Tissue typing (histocompatibility testing)
    - Match MHC proteins of donor and recipient
  - Why do organ transplant recipients receive immunosuppressive drugs?

Allergies

- Allergies
  - Are abnormal sensitivities to antigens in the environment.
- Allergens
  - Are antigens that cause allergies.
The symptoms of an allergy result from a two-stage reaction sequence

Stage 1
- Allergen binds to a B cell
- The B cell proliferates and secretes large amounts of antibodies to that allergen
- Some of the antibodies attach to mast cells
- Mast cells produce histamine that triggers the inflammatory response

Stage 2

Anaphylactic shock
- A life-threatening allergic reaction
- Some people are extremely sensitive to allergens
  - peanuts, shellfish, bee sting toxin
- Contact with these allergens causes a sudden release of histamine
- Blood vessels dilate abruptly → circulatory collapse
- The trachea and bronchi swell → suffocation
- Causes 1,500 deaths per year in the U.S.
- Can be counteracted with injections of epinephrine.

To help you understand the immune system
- Look over the lecture slides and read Ch. 8
- Focus on what we covered in lecture
- Answer questions #5-10 at the end of chapter 8