

Immunodeficiency Diseases

Enduring Understandings:

- Our environment contains millions upon millions of infectious microbes that can cause disease.
- If these diseases were allowed to grow unchecked, they could eventually be fatal. Despite that, most infections in healthy individuals are brief and leave little or no permanent damage because of the immune system.

Essential Questions:

- What is the immune system?
- How does it function?
- How does HIV weaken the immune system?

Notes to the Teacher:

This lesson provides a brief overview of how a normal immune system functions and then examines HIV as an example of an immunodeficiency disease. The first section taps students' prior knowledge to understand the innate immune system. The second section teaches vocabulary and concepts about specific immunities and helps students to understand how various cells respond to a disease. The final section discusses HIV/AIDS as a secondary immunodeficiency disease and introduces students to the mechanism of HIV.

Appendix C provides extensive information about the operation of the immune system. You should familiarize yourself thoroughly with this material before the lesson.

DURATION OF LESSON:

Approximately two 45-minute periods.

ASSESSMENT:

Participation in class discussions

Completion of adaptive immunity concept map



SCIENCE STANDARDS

Indicators addressed by this lesson:

STANDARD 5. Understands the structure and function of cells and organisms

LEVEL IV (9–12)

1. Knows the structures of different types of cell parts (e.g., cell wall; cell membrane; cytoplasm; cell organelles, such as the nucleus, chloroplast, mitochondrion, Golgi apparatus, vacuole) and the functions they perform (e.g., transport of materials, storage of genetic information, photosynthesis and respiration, synthesis of new molecules, waste disposal)
2. Understands the chemical reactions involved in cell functions (e.g., food molecules taken into cells are broken down to provide the chemical constituents needed to synthesize other molecules; enzymes facilitate the breakdown and synthesis of molecules)

HEALTH STANDARDS

Indicators addressed by this lesson:

STANDARD 8. Knows essential concepts for the prevention and control of disease

LEVEL IV (9–12)

1. Understands how the immune system functions to prevent or combat disease

Materials needed:

Fresh slices of bread
Moldy slices of bread
20 balloons (at least 2 colors)
Small- to medium-size blanket
Microscopes
Pond water
Sticky notes

HANDOUT 1: STUDENT NOTE ORGANIZER:

IMMUNODEFICIENCY

HANDOUT 2: IMMUNODEFICIENCY REVIEW

Procedure:

ACTIVITY 1: OVERVIEW OF IMMUNE SYSTEM — NON-SPECIFIC IMMUNITY

1. Show students a slice of fresh bread and explain that it represents a person with a normally functioning immune system. Next show a slice of moldy bread and explain this represents a person without a properly functioning immune system. Explain that without an immune system, we would simply be food for any number of microorganisms.
2. Ask students what their body's first line of defense is against disease. As students respond, record their answers on the board. Because most students don't usually consider the role of organs such as the skin and stomach in immunity, ask follow-up questions, such as how the stomach, skin, mouth, and nose can stop microbes. [See Appendix C for additional information on non-specific immunity.]

3. Explain to students that most humans are born with this nonspecific immunity, which is also referred to as innate immunity, because it is in place and fully functioning at birth.
4. Ask students what happens if the first line of defense fails, in order to initiate a discussion on the cellular and chemical components of the second line of defense and the phagocytes demonstration.
5. Using a drop of pond water on a slide under a microscope, show students how amoebas feed.
6. Demonstrate phagocytosis by using a balloon to represent the pathogen and a blanket to represent the phagocyte. Cover the balloon with the blanket to represent phagocytosis and then pop the balloon to show that a phagocyte will ingest and destroy the invader. Dump the balloon pieces out, just as a phagocyte will remove any residual material.
7. End the portion of the lesson on innate defenses by discussing inflammation.
8. Ask students what happens if their innate immunity is unable to stop the invasion. Have them explain the differences between the infantry of an army and its Special Forces. Explain that the infantry is analogous to the body's innate defenses and the Special Forces are analogous to the adaptive defenses. Similar to the military Special Forces, adaptive immune cells undergo extensive training to perform highly specialized tasks.

ACTIVITY 2: ADAPTIVE IMMUNITY

1. Distribute **HANDOUT 1: THE IMMUNE SYSTEM**. Tell students that this graphic organizer can be used to take notes on adaptive immunity as the lesson progresses.
2. Explain to students the roles that the components of the immune system play in protecting the body. [See Appendix C for additional information on adaptive immunity.]
3. To demonstrate how antibodies work, have four to six students come to the front to demonstrate the shape of an antibody. Direct them to put their arms in the air so that their bodies are in the shape of a Y. Explain that antibodies can attach or grab onto antigens. Bring out a bag of about 20 inflated balloons and shake them out over the students instructing them to grab as many as they can. Now make the following points:
 - a. Antibodies have only two combining sites (the student's hands); therefore anyone with more than two balloons should drop the extra ones.
 - b. If any students are holding two different-Coloured balloons, ask the rest of the class if that is possible. (Antibodies can combine with two antigens, but the antigens are identical, i.e., represented by the same color balloon). Have students exchange balloons as needed.
4. Arrange groups of 3 or 4 students with the same color balloons to form a lattice, each holding one balloon and connected to another student holding the other side of that balloon. Explain this is how agglutination works.

5. Use a pin to pop the balloons to demonstrate how the complement proteins poke holes in invaders that have been tagged with antibodies. Review phagocytosis, if you wish, by using a blanket to “eat up” the balloons.
6. Teach students an acronym to help them remember how antibodies work: PLAN, which stands for Precipitation, Lysis (via the complement), Agglutination, and Neutralization.
7. Discuss with students the role of T cells in cell-mediated immunity:
8. To demonstrate the role of Helper T cells, do the following exercise, step by step, reviewing the concepts at each step:
 - a. Have one student stand up to represent a Helper T cell. Give the student half of an index card that has been cut to resemble a jigsaw-puzzle piece. This card represents a Helper T cell with a surface protein.
 - b. Ask another student to represent a macrophage, another to represent a Cytotoxic T cell, and one other to represent a B cell.
 - c. Hold up the other half of the index card and announce that a foreign antigen has entered the body. Instruct the macrophage to “engulf” the antigen and present it to the Helper T cell.
 - d. Have several additional students join the Helper T cell to represent activation and cloning.
 - e. Have the Helper T cells verbally instruct the B cell to begin cloning and producing antibodies against the antigen. Have one or more students join the B cell.
 - f. Have another Helper T cell verbally instruct the Cytotoxic T cells to begin cloning and become active.
 - g. Next have the Helper T cells recruit the rest of the class (representing macrophages and Natural Killer cells) to join the fight.
 - h. Finally announce that the foreign antigens have been destroyed and have the students sit down.
 - i. Explain the role of the Suppressor T cell, which is responsible for suppressing T-cell and B-cell activity and stopping the immune response, once the antigen has been destroyed.

ACTIVITY 3: Immunodeficiencies

1. Define and describe immunodeficiency. [See Appendix C for additional information about immunodeficiency.]
2. Ask students: “If you were a pathogen that targeted some portion of the immune system, which portion of either the innate or adaptive immune system would you attack?” (Answers may vary. Help students to realize that attacking the Helper T cells will have a crippling impact on the immune system. People with defects or failures of the phagocytes or complement proteins are susceptible to recurring bacterial infections. People with any defects or failures of the T cells are susceptible to overwhelming, and often lethal, infections from microorganisms that most other people would develop resistance to.)
3. Lead a discussion on the HIV life cycle.
4. Explain the effects of HIV on the immune system:

- Repeat the Helper T cell demonstration with the same students. This time use a lollipop with a hard candy shell and chewy center to represent HIV. Put the lollipop in the Helper T cell's mouth to represent infection with the virus. The virus has essentially silenced the Helper T cells. Explain that the initial response to the virus is strong, but without the Helper T cells to amplify the response, HIV can easily stay ahead of the immune system. Point out that macrophages are also eventually targeted.

ACTIVITY 4: SUMMARY

- Distribute **HANDOUT 2: IMMUNODEFICIENCY REVIEW**.
- Have students work in pairs to fill in key words, using their notes from the class discussions.
- Check answers before students leave. An answer sheet for Handout 2 is provided.

EXTENSION ACTIVITIES:

- Have students research some other immunodeficiency diseases and their treatment and then create informational pamphlets based on their findings.
- Other areas for research are the effects of drugs on the immune system and potential future treatments for HIV.
- Assign an essay, asking students to briefly describe the role of Helper T cells and Cytotoxic T cells in normal cell-mediated immunity and then describe how HIV causes an immunodeficiency.

ADDITIONAL RESOURCES:

A. Print materials

Scientific American, July 2003, "In Search of AIDS-resistance Genes"

Scientific American, June 2006, "New Anti-HIV Drugs"

B. Internet resources

Newsweek article on the AIDS vaccine

<http://www.msnbc.msn.com/id/10268725/site/newsweek/>

Simulations and information on HIV

<http://www.pbs.org/wgbh/nova/aids/>

University of Arizona HIV Simulation.

<http://www.biology.arizona.edu/immunology/activities/AIDS2003/main.html>

NIH AIDS vaccine site

<http://www.niaid.nih.gov/hivvaccines/>

Article on immunodeficiencies from the American Academy of Family Physicians

<http://www.aafp.org/afp/20031115/2001.html>

HANDOUT 1 ▶ P. 1 Student Note Organizer: Immunodeficiency

I. What is a nonspecific immunity?

A. First line of defense

How does the skin provide immunity?

Examples of mucous membranes and how they provide immunity:

- 1.
- 2.
- 3.
- 4.

B. Second line of defense

How phagocytes work:

Location of phagocytes:

Function of Natural Killer cells:

Two important proteins and their function:

- 1.
- 2.

HANDOUT 1 ► P. 2

C. Inflammation

Causes:

Signs of inflammation:

II. What is Adaptive Immunity?

A. Antigens

Definition:

Types:

B. Cells

1. Lymphocytes:

Origin:

Immunocompetency locations:

T lymphocytes:

B lymphocytes:

HANDOUT 1 ► P. 3

2. Antigen presenting cells (APC)

Function:

Major Types:

C. Humeral response

1. B cells

Function:

Events after activation:

2. Vaccines

What they contain:

Role:

3. Antibodies

Target:

Function:

HANDOUT 1 ► P. 4

4. Cytotoxic T cells (display CD8 receptor)

Activation:

Primary targets:

Other targets:

How target cells are destroyed:

5. Helper T cells (display CD4 receptor)

Activation:

Primary function:

Other functions:

6. Suppressor T cells

Function:

HANDOUT 1 ► P. 5

III. Immunodeficiencies

Definition:

Causes:

HIV

Target cells:

Structure:

Method of infection:

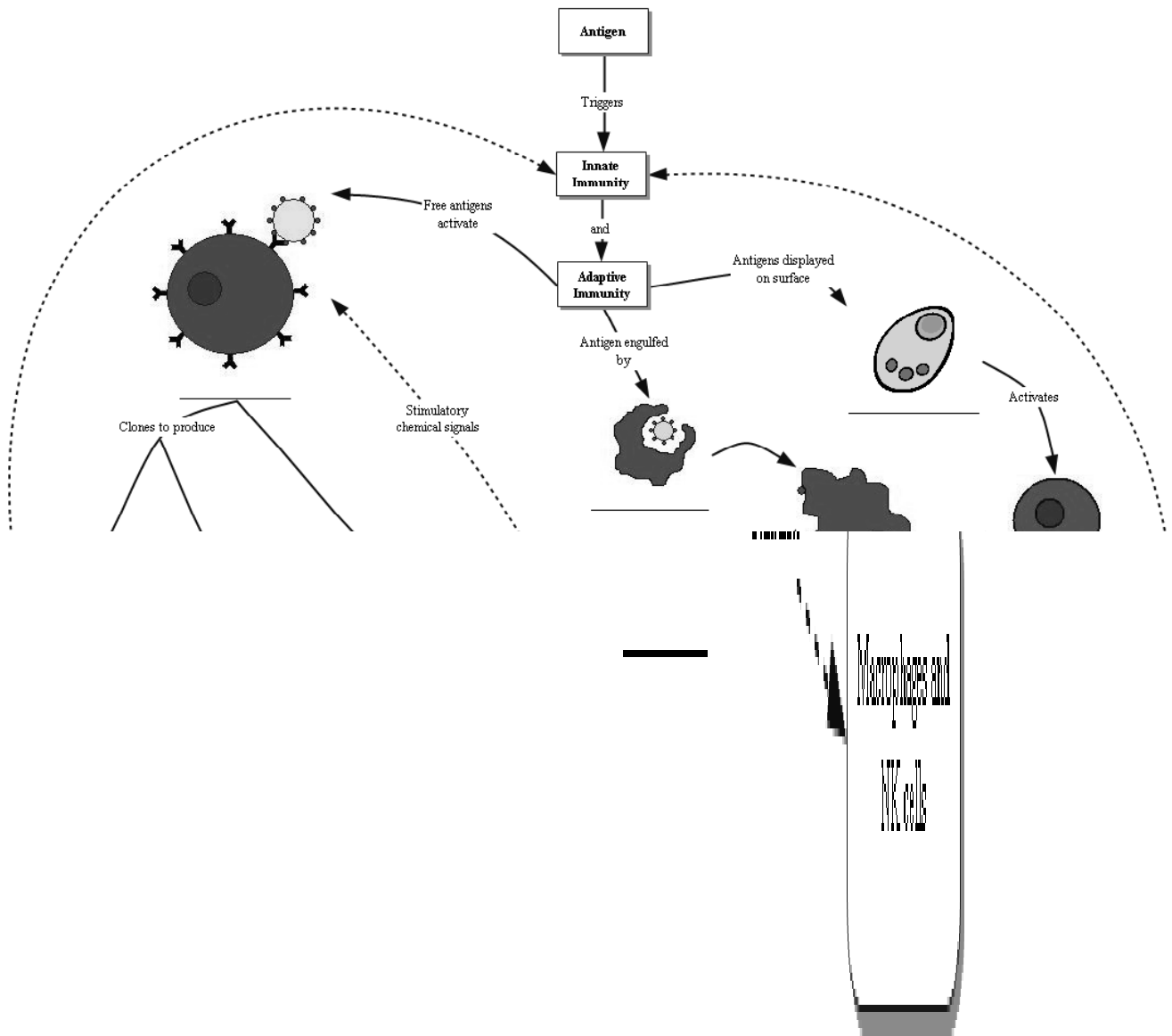
Effects on the immune system

Initial immune response:

Prolonged effect on the adaptive immune response:

HANDOUT 2 Immunodeficiency Review

INSTRUCTION: Try to fill in labels on all solid lines.



HANDOUT 2

Answer Sheet

