CHAPTER OUTLINE

1.1 Nonspecific Defenses
1.2 The Immune Response
1.3 Immune System Diseases
1.4 Environmental Problems and Human Health
1.5 Worksheet Answer Keys

The Immune System and Disease

Outline

Lesson 24.1: Nonspecific Defenses

24.1.1 First Line of Defense

- Mechanical Barriers
- Chemical Barriers
- Biological Barriers

24.1.2 Second Line of Defense

- Inflammatory Response
- Leukocytes
Lesson 24.2: Immune Response

24.2.1 Lymphatic System

- Structures of the Lymphatic System
- Lymphatic Vessels and Lymph
- Lymphocytes
- Antigen Recognition

24.2.2 Humoral Immune Response

- B Cell Activation
- Plasma Cells and Antibody Production
- Memory Cells

24.2.3 Cell-Mediated Immune Response

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- Regulatory T Cells

24.2.4 Immunity

- Active Immunity
- Passive Immunity

Lesson 24.3: Immune System Diseases

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24.3.3 Immunodeficiency
24.3.4 HIV and AIDS

- HIV Transmission
- HIV and the Immune System
- AIDS
- KQED: HIV Research: Beyond the Vaccine

Lesson 24.4: Environmental Problems and Human Health

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- How Cancer Occurs
- Cancer Treatment and Prevention

24.4.2 Air Pollution and Illness

- Outdoor Air Pollution
- Indoor Air Pollution

24.4.3 Bioterrorism
Pacing the Lessons

Use the Class Periods per Lesson table below as a guide for the time required to teach the lessons of this chapter.

**Table 1.1:**

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Number of Class Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.1 Nonspecific Defenses</td>
<td>1.0</td>
</tr>
<tr>
<td>24.2 Immune Response</td>
<td>2.0</td>
</tr>
<tr>
<td>24.3 Immune System Diseases</td>
<td>1.5</td>
</tr>
<tr>
<td>24.4 Environmental Problems and Human Health</td>
<td>1.0</td>
</tr>
</tbody>
</table>

- Class periods are assumed to be 60 minutes long.

Online Resources

See the following Web sites for appropriate laboratory activities:

1. In this virtual lab, students will gain a better understanding of antibodies by learning how they are used in medical diagnostics. (Lesson 24.2)

2. This lab demonstrates principles of antibody-antigen binding, the secondary immune response, cross reactivity, and complement fixation. (Lesson 24.2)

3. In this AP-level lab, students will learn the mechanisms of the immune system by focusing on gene variants that confer susceptibility to autoimmune disorders. (Lesson 24.3)

4. In this lab, students will role-play CDC team members preparing for a possible bioterrorist attack on a fictitious city. (Lesson 24.4)
   - [http://www.eduref.org/cgi-bin/printlessons.cgi/Virtual/Lessons/Science/Biology/BIO0204.html](http://www.eduref.org/cgi-bin/printlessons.cgi/Virtual/Lessons/Science/Biology/BIO0204.html)

These Web sites may also be helpful:

1. This URL is a directory of links to many useful immune system Web sites.

2. This Web site provides virtual immunology activities and tutorials.

3. Additional immunology classroom activities are described at this Web site.
4. This CDC Web site is a portal for information and data on HIV/AIDS.
   - http://www.cdc.gov/hiv/default.htm

5. You can access an air pollution curriculum for grades 7–12 at the URL below.
   - http://www.k12science.org/curriculum/airproj/index.html

6. This URL has several detailed tutorials on cancer.
1.1 Nonspecific Defenses

Key Concept

Barriers that keep out pathogens are the body’s first line of defense. They include mechanical, chemical, and biological barriers. The body’s second line of defense comes into play if pathogens manage to enter the body. It includes the inflammatory response and phagocytosis by nonspecific leukocytes.

Standards

- CA.9–12.LS.10.a; CA.9–12.IE.1.d
- NSES.9–12.A.1.6
- AAAS.9–12.6.C.1

Lesson Objectives

- Describe the barriers that keep most pathogens out of the human body.
- Explain how the inflammatory response and nonspecific leukocytes help fight pathogens that enter the body.

Lesson Vocabulary

- **inflammatory response**: nonspecific response the body first makes to tissue damage or infection
- **leukocyte**: white blood cell produced by bone marrow to fight infections
- **mucous membrane**: epithelial tissue that lines inner body surfaces and body openings and produces mucus
- **mucus**: slimy substance produced by mucous membranes that traps pathogens, particles, and debris
- **pathogen**: disease-causing agent, such as a bacterium, virus, fungus, or protozoan
- **phagocytosis**: process in which leukocytes engulf and break down pathogens and debris

Teaching Strategies

Introducing the Lesson

Have students play Immunopoly, a board game that can be downloaded from Houston’s Health Museum (see URL below). The game will introduce students to the components of the immune system and how healthy choices can enhance the body’s ability to fight off infections and stay healthy.

1.1. Nonspecific Defenses

Activity

Download the mini module on the inflammatory response at the URL below. Students will learn how and why the inflammatory response occurs by comparing the “chain of command” for immune cells to a military chain of command.

- http://peer.tamu.edu/LessonPlan.asp?id=139&file=lesson

Differentiated Instruction

Work with struggling students to create a simple flowchart that shows the series of “hurdles” pathogens must overcome to cause illness in the human body. LPR, ELL, SN

Enrichment

Suggest that students who need extra challenges play the game Immune Attack, which is available at the URL below. In the game, students will navigate a nanobot through a 3D environment of blood vessels and connective tissue in an attempt to save a patient by retraining nonfunctional immune cells. Along the way, students will explore biological processes that enable macrophages and neutrophils to detect and fight infections.

- http://www.fas.org/immuneattack/

Science Inquiry

Have students simulate the spread of an infectious disease in a population. The first URL below is the student worksheet for the activity. The second URL provides teacher notes. After the activity, discuss what students learned.

- http://serendip.brynmawr.edu/sci_edu/waldron/pdf/InfectiousDiseaseTeachPrep.pdf

Overcoming Misconceptions

Ask students to describe symptoms they think are caused by the cold virus. (They might mention stuffy nose, sore throat, and fever.) Tell the class that many disease symptoms are actually caused by the immune system fighting off pathogens, rather than by the pathogens themselves. For example, explain that a fever is part of the body’s second line of defense. It may help fight infection by slowing the growth of pathogens, increasing the metabolic rate of body cells, and stimulating phagocytosis.

Reinforce and Review

Lesson Worksheets

Copy and distribute the lesson worksheets in the CK-12 Biology Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.
Review Questions

Have students answer the Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.

Points to Consider

The body’s first and second lines of defense are the same regardless of the particular pathogen involved. The body’s third line of defense is different. It tailors the response to the specific pathogen.

- How do you think the immune system can identify specific pathogens?
  - (By their antigens.)

- How might a specific defense be different from a nonspecific defense? What mechanisms might be involved?
  - (Answers may vary. Encourage a diversity of responses.)
1.2 The Immune Response

Key Concept

The body’s third line of defense is the immune response. This involves the lymphatic system, which produces lymphocytes. Lymphocytes are leukocytes (B cells and T cells) that become activated by antigens. Activated B cells produce antibodies, and activated T cells destroy infected or cancerous cells. The immune response may result in immunity, or the ability to resist infection by a particular pathogen.

Standards

• CA.9–12.LS.10.b, c, d, f; CA.9–12.IE.1.d
• NSES.9–12.A.1.6
• AAAS.9–12.6.C.1; AAAS.9–12.8.F.4

Lesson Objectives

• Describe the lymphatic system and its roles in the immune response.
• List the steps that occur in a humoral immune response.
• Identify the roles of T cells in a cell-mediated immune response.
• Define immunity, and distinguish between active and passive immunity.

Lesson Vocabulary

• **active immunity**: ability to resist a pathogen that results when an immune response to the pathogen produces memory cells
• **antibody**: large, Y-shaped proteins produced by B cells that recognize and bind to antigens in a humoral immune response
• **B cell**: type of lymphocyte that fights infections by forming antibodies
• **cell-mediated immune response**: type of immune response in which T cells destroy cells that are infected with viruses
• **humoral immune response**: type of immune response in which B cells produce antibodies against antigens in blood and lymph
• **immune response**: specific defense against a particular pathogen
• **immunity**: ability to resist a pathogen due to memory lymphocytes or antibodies to the antigens the pathogen carries
• **immunization**: deliberate exposure of a person to a pathogen in order to provoke an immune response and the formation of memory cells specific to that pathogen
- **lymph**: fluid that leaks out of capillaries into spaces between cells and circulates in the vessels of the lymphatic system
- **lymphatic system**: system of the body consisting of organs, vessels, nodes, and lymph that produces lymphocytes and filters pathogens from body fluids
- **lymph node**: small structures located on lymphatic vessels where pathogens are filtered from lymph and destroyed by lymphocytes
- **lymphocyte**: type of leukocyte that is a key cell in the immune response to a specific pathogen
- **memory cell**: lymphocyte (B or T cell) that retains a “memory” of a specific pathogen after an infection is over and thus provides immunity to the pathogen
- **passive immunity**: type of immunity to a particular pathogen that results when antibodies are transferred to a person who has never been exposed to the pathogen
- **T cell**: type of lymphocyte involved in cell-mediated immunity in which cells infected with viruses are destroyed

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**Teaching Strategies**

### Introducing the Lesson

Show students the recommended vaccination schedule for infectious childhood diseases, such as measles, mumps, rubella, diphtheria, and tetanus (see URL below for sample schedules). Ask students if they know how vaccines prevent these diseases. (Accept all responses at this point.) Tell students they will learn how in this lesson.

- [http://www.cdc.gov/vaccines/recs/schedules/child-schedule.htm](http://www.cdc.gov/vaccines/recs/schedules/child-schedule.htm)

### Activity

Do the class activity described at the URL below. In the exercise, students will role-play the immune response.

- [http://www.aai.org/educating/using.htm](http://www.aai.org/educating/using.htm)

### Differentiated Instruction

Work with students to make a compare/contrast table of B cells and T cells (see sample Table 1.2).

<table>
<thead>
<tr>
<th>Type of Cells</th>
<th>Where They Mature</th>
<th>Forms They Take</th>
<th>What They Do</th>
</tr>
</thead>
<tbody>
<tr>
<td>B cells</td>
<td>bone marrow</td>
<td>(a) plasma</td>
<td>(a) produce antibodies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) memory</td>
<td>(b) provide immunity</td>
</tr>
<tr>
<td>T cells</td>
<td>thymus gland</td>
<td>(a) helper</td>
<td>(a) regulate B and T cells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) cytotoxic</td>
<td>(b) destroy infected, damaged, or cancerous cells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c) memory</td>
<td>(c) provide immunity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(d) regulatory</td>
<td>(d) end the immune response</td>
</tr>
</tbody>
</table>

**Table 1.2**: short caption
1.2. The Immune Response

Enrichment

Direct students who need extra challenges to the immunization activity at the URL below. They will use historical documents to learn how vaccines were developed and data on antibody production to understand how immunization prevents disease.

- [http://www.scientificprogram.org/biology/Granberry04.html](http://www.scientificprogram.org/biology/Granberry04.html)

Science Inquiry

Have groups of students do the inquiry activity at the URL below. In the activity, students will build a 3D model to represent molecular recognition in the immune response.

- [http://science.education.nih.gov/newsnapshots/TOC_Xeno/index/Science_Activity_1/science_activity_1.html](http://science.education.nih.gov/newsnapshots/TOC_Xeno/index/Science_Activity_1/science_activity_1.html)

Overcoming Misconceptions

Misconceptions about vaccines are common and potentially dangerous. Here are just two examples:

- Vaccine-preventable diseases have been virtually eliminated, so children no longer need to be vaccinated.
  - (Reality: Most of the diseases still exist in human populations. Without vaccinations, children are at risk of getting and spreading the diseases.)
- Vaccines cause autism.
  - (Reality: The single study that led to this myth was later shown to be fraudulent. Many other studies have found no link between vaccines and autism.)

Discuss why such misconceptions endanger health. For more vaccine misconceptions, see:

- [http://www.quackwatch.com/03HealthPromotion/immu/immu00.html](http://www.quackwatch.com/03HealthPromotion/immu/immu00.html)

Reinforce and Review

Lesson Worksheets

Copy and distribute the lesson worksheets in the *CK-12 Biology Workbook*. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Review Questions that are listed at the end of the lesson in their FlexBook.

- Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.
Points to Consider

Sometimes the immune system makes mistakes and things go wrong.

- What if the immune system responded to a harmless allergen as though it were a deadly pathogen? What might happen?
  - (It might make you sick.)
- What if the immune system responded to normal body cells as though they were foreign invaders? Would the immune system destroy the body cells?
  - (Answers may vary. Accept all reasonable responses.)
- What if pathogens attacked and destroyed cells of the immune system itself? Would the immune system still be able to defend the body?
  - (Students might predict that the immune system would be compromised so the body could no longer fight off other pathogens.)
1.3 Immune System Diseases

Key Concept

Allergies occur when the immune system makes an inflammatory response to a harmless antigen, called an allergen. Autoimmune diseases, such as type 1 diabetes, occur when the immune system fails to distinguish self from non-self and attacks the body’s own cells. In an immunodeficiency disease, such as HIV/AIDS, the immune system does not work normally, so it cannot adequately defend the body.

Standards

- CA.9–12.LS.10.e; CA.9–12.IE.1.d
- NSES.9–12.A.1.6; NSES.9–12.F.1.3
- AAAS.9–12.6.E.1, 4; AAAS.9–12.12.D.7
- McREL.9–12.12.4.20

Lesson Objectives

- Explain why allergies occur, and identify common allergens.
- Describe how autoimmune diseases affect the body.
- Define immunodeficiency, and list reasons for it.
- Explain how HIV is transmitted and how it causes AIDS.

Lesson Vocabulary

- **acquired immunodeficiency syndrome (AIDS)**: disorder characterized by frequent opportunistic infections that eventually develops in people who are infected with human immunodeficiency virus (HIV)
- **allergen**: any antigen that causes an allergy
- **allergy**: disease in which the immune system makes an inflammatory response to a harmless antigen
- **autoimmune disease**: type of disease, such as type 1 diabetes, in which the immune system attacks the body’s cells as though they were pathogens
- **human immunodeficiency virus (HIV)**: virus transmitted through body fluids that infects and destroys helper T cells and eventually causes acquired immunodeficiency syndrome (AIDS)
- **immunodeficiency**: inability of the immune system to fight off pathogens that a normal immune system would be able to resist
Teaching Strategies

Introducing the Lesson

Take a poll of the class. Ask how many students have allergies or know someone who does. Call on a few volunteers to share what they are allergic to (if they know) and how they treat their allergies (e.g., antihistamines, allergy shots, avoidance of allergens). Tell students they will learn more about allergies and other immune system disorders when they read this lesson.

Activity

Have students do the coloring activity at the URL below. It will help them understand the structure of HIV and how it infects T cells.


Differentiated Instruction

Tell students to make a KWL chart for the lesson, where K = Know, W = Want to Know, and L = Learned. Students should fill in the K and W columns before reading the lesson and the L column after reading the lesson.

Enrichment

Interested students can research the medical and scientific literature for evidence for and against the molecular mimicry hypothesis of autoimmunity (see URLs below). Ask the students to choose sides and debate the issue in front of the class. Take a class vote on which side presented the most convincing evidence and arguments.

- http://www.mult-sclerosis.org/MolecularMimicry.html
- http://en.wikipedia.org/wiki/Molecular_mimicry

Science Inquiry

Have pairs of students research autoimmune diseases by doing the cooperative learning activity at the URL below. Make sure each pair of students chooses a different autoimmune disease to investigate but researches the same set of questions. Allow class time for groups to share what they learn in a PowerPoint presentation.

- http://www.scientificteacherprogram.org/biology/mjoseph201.html

Overcoming Misconceptions

Misconceptions about HIV/AIDS are very common. For their own health’s sake, make sure your students know the facts. Assign the articles at the URLs below and then discuss them with the class.

- http://en.wikipedia.org/wiki/Misconceptions_about_HIV_and_AIDS
Reinforce and Review

Lesson Worksheets

Copy and distribute the lesson worksheets in the CK-12 Biology Workbook. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

Review Questions

Have students answer the Review Questions that are listed at the end of the lesson in their FlexBook.

• Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.

Points to Consider

Pathogens such as HIV are not the only cause of human disease. Many other things in our environment can also make us sick.

• Can you think of other environmental factors that negatively affect human health? What about pollutants in the environment? What are their possible health effects?
  – (Sample answer: Pollutants in the air can cause respiratory diseases.)
• Viruses cause some types of cancer, but cancer is more often caused by other environmental dangers. What environmental factors might increase the risk of cancer? Do you know what causes skin cancer, for example, or lung cancer?
  – (Sample answer: UV light causes skin cancer, and smoking causes lung cancer.)
1.4 Environmental Problems and Human Health

Key Concept

A carcinogen is anything that causes cancer. Most carcinogens produce mutations in genes that control the cell cycle. Both outdoor and indoor air may contain pollutants that can cause human illness and death. Bioterrorism is the intentional release or spread of agents of disease.

Standards

- CA.9–12.LS.4.c; CA.9–12.IE.1.d
- NSES.9–12.A.1.6; NSES.9–12.F.1.1, 2, 3; NSES.9–12.F.4.1, 3; NSES.9–12.F.5.2, 4
- AAAS.9–12.5.C.6; AAAS.9–12.6.E.2

Lesson Objectives

- Describe how carcinogens cause cancer and how cancer can be treated or prevented.
- Identify causes of air pollution and its effects on human health.
- Explain how bioterrorism threatens human health.

Lesson Vocabulary

- **Air Quality Index (AQI)**: assessment of the levels of pollutants in the outdoor air that is based on their human health effects
- **bioterrorism**: intentional release or spread of agents of disease
- **carcinogen**: anything that can cause cancer

Teaching Strategies

Introducing the Lesson

Introduce environmental health problems by asking a few students to go to the URL below and find the current air quality index (AQI) for their location. Explain what the AQI measures, and have students compare the value for their location with the AQI chart (Figure 24.19 in the FlexBook and reproduced below). Ask the class to predict how pollutants in the air might affect health. Tell them they will learn how when they read this lesson.

Demonstration

Demonstrate particulates in outdoor or indoor air. Show students a new and a used (dirty) air filter from a car (outdoor air) or furnace (indoor air). Give them a chance to compare the two air filters. Then discuss where particulates in the air come from and how they affect human health.

Differentiated Instruction

Have students make a main ideas/details chart as they read the lesson. On the left side of a sheet of paper, they should list the main ideas, leaving several blank lines between each idea. Tell them to identify one main idea for each heading in the lesson. On the right side of the paper, they should list supporting details for each main idea.

Enrichment

Students who seek enrichment can investigate the role of clinical trials in the development of cancer therapies. They should start with the URL below. Ask the students to summarize what they learn in an oral report to the class.


Science Inquiry

Have students analyze the data from the “Cancer in U.S. Adults” table (Table 24.6 in FlexBook, reproduced as Table 1.3).
### Table 1.3: Cancers in U.S. Adults

<table>
<thead>
<tr>
<th>Gender</th>
<th>Most Common Types of Cancer after Skin Cancer (% of all cancers)</th>
<th>Most Common Causes of Cancer Deaths (% of all cancer deaths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>prostate cancer (33%), lung cancer (13%)</td>
<td>lung cancer (31%), prostate cancer (10%)</td>
</tr>
<tr>
<td>Females</td>
<td>breast cancer (32%), lung cancer (12%)</td>
<td>lung cancer (27%), breast cancer (15%)</td>
</tr>
</tbody>
</table>

- **Ask:** What does the graph show? (Lung cancer causes more cancer deaths in males and females, but prostate cancer in males and breast cancer in females are more common.)
- **Ask:** Why do you think more deaths are caused by lung cancer, given that breast and prostate cancer are more common? (Sample answer: Lung cancer might be harder to detect or treat than breast and prostate cancer.)

### Health Connection

Describe routine screening tests for relatively common cancers, such as mammograms (breast cancer), Pap smears (cervical cancer), and colonoscopies (colon cancer). Discuss why early detection of cancer saves lives.

### Reinforce and Review

#### Lesson Worksheets

Copy and distribute the lesson worksheets in the *CK-12 Biology Workbook*. Ask students to complete the worksheets alone or in pairs as a review of lesson content.

#### Review Questions

Have students answer the Review Questions that are listed at the end of the lesson in their FlexBook.

- **Sample answers to these questions will be provided upon request. Please send an email to teachers-requests@ck12.org to request sample answers.**

### Points to Consider

High levels of certain hormones can increase the risk of some types of cancer. For example, high levels of estrogen can increase the risk of breast cancer. Estrogen is a sex hormone.

- What are sex hormones? How do sex hormones normally affect the body?
  - (Sex hormones are chemical messengers produced mainly by the gonads. They normally control sexual development and reproduction.)
- Do you think sex hormones might differ in males and females? Why?
  - (The main male sex hormone is testosterone. The main female sex hormone is estrogen. The hormones are produced by different organs and have different functions.)
1.5 Worksheet Answer Keys

- The worksheet answer keys are available upon request. Please send an email to teachers-requests@ck12.org to request the worksheet answer keys.