

2015

Using BiInteractive.org  
Resources to Teach:

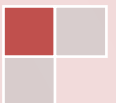
# Immunology

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**Last Update: Winter 2015**



# Using BioInteractive.org Resources to Teach: *IMMUNOLOGY*

<b>Table of Contents:</b>	<b>Page</b>
From the Author	3
Introduction	4
Part I: Course Curriculum Connections	
AP Biology	5
2-year College “Principles of Biology”	5
Advanced Genetics and Biotechnology	5
Honors Biology	5
Health	6
Part II: BioInteractive.org Immunology Resources including Access Instructions	
Immunology	7
HIV and Immunology	8
HIV Drug Development and Immune Response	9
ELISA, HIV, and Immunology	10
CCR5 Coreceptor Mutation and HIV	11
Vaccine Development and HIV Evolution	12
Dengue Fever and Immunology	13
Part III: Sample Lesson Plans/Schedule	
Immunology (Advanced)	15
Immunology (Basic)	19
Immunology as a Part of Cell Signaling	22
Immunology as a Part of Viruses/HIV/AIDS	26
Immunology as a Part of Infectious Diseases/HIV/AIDS	29
Part IV: Curriculum Standards	
National Standards	33
Ohio State Standards and Benchmarks	34

## From the Author

With the pace of current research, the biological sciences change incredibly fast, particularly in the fields of molecular genetics, disease, and cellular biology, making me keenly aware that I must keep myself and my students abreast of cutting-edge research. Therefore, as a veteran biology teacher, I am constantly looking for resources that include up-to-date research, help my students process material, reinforce textbook material, and stimulate discussions and explorations of current topics in biology. For these reasons, I routinely utilize the Howard Hughes Medical Institute's (HHMI's) BioInteractive website and Holiday Lectures on Science DVDs in my classroom to highlight and strengthen my day-to-day coverage of material.

The BioInteractive and Holiday Lectures on Science resources are accurate, user-friendly, free of charge, and readily accessible, making them easy to implement in the classroom. The video clips, animations, and interactive “click-and-learn” activities enhance my formal lecture material, helping students better understand and visualize the subject matter. In addition, the classroom activities and virtual lab series offer excellent lessons and laboratory simulations.

The longer I teach the more I realize the importance of the research process as it relates to all of my students developing the problem-solving skills needed in all aspects of life. The BioInteractive virtual labs illustrate the process of science, the significance of controls, the importance of laboratory repetition, and the notion that “science doesn't work every time.” The students progress through a simulation's protocol, consistently being referred to background information, terminology, and quizzes to enhance their understanding. As they proceed through the steps, the students can make mistakes which are not conveyed at the time but come to light as the results are “published” at the conclusion of the simulation. This is a valuable lesson in accuracy, scientific integrity, and reality.

I highly recommend the Holiday Lectures on Science DVDs and the BioInteractive online resources. These resources have greatly enhanced my teaching methods, my students' ability to understand the material, and our shared knowledge about current findings in biology.

This teacher guide will help you navigate and organize the vast immunology-specific BioInteractive resources. Please do not hesitate to contact me with any questions or suggestions.

Most sincerely,

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## Introduction

The amount of resources accessible to teachers from various organizations and the Internet can be overwhelming. Furthermore, finding the time to process these resources and develop them into solid classroom-ready activities and lessons is difficult. This guide provides teacher-ready curriculum ideas utilizing Howard Hughes Medical Institute (HHMI) resources, including the BioInteractive website features and the **Holiday Lectures on Science** DVDs, to enhance classroom instruction on immunology, viruses, and disease.

**Part I** of this guide outlines curriculum objectives of various courses to illustrate the connections between immunology and several general curricula at various levels of instruction, including first-year high school biology, health, genetics, and biotechnology; AP Biology; and 2-year college biology.

**Part II** presents HHMI resources specific to immunology. These resources include animations, video clips, a virtual laboratory, and lectures. This section offers details on computer and DVD access, time lengths, and summaries of each immunology resource.

Whether you teach immunology as a separate body system, as part of cellular communication, or in relation to viruses and infectious diseases, **Part III** illustrates various sample lesson plans with correlated HHMI resources. These resources are meant to be suggestions only; numerous other HHMI resources related to this topic can be substituted. These sample plans provide a springboard to develop teacher and classroom-specific sessions, because they will help you sort through the vast resources available.

**Part IV** illustrates national and state standards to which these resources and lessons connect.

## Part I: Course Curriculum Connections

### AP Biology

- Characteristics and Structures of Life
  - Recognize various cell organelles; describe their functions and the relationship of organelles within the cell.
  - Predict the relationship between the composition of various organelles in a cell and that cell's function.
  - Describe the structure of cell membranes and how they relate to the different transport mechanisms.
  - Describe how the maintenance of a relatively stable internal environment is required for the continuation of life, and explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of pathogens.
- Classification and Organismal Biology
  - Explain why specialized cells and structures are useful to plants and animals.
  - Compare and contrast the structure and function of vertebrate tissues, organs, and organ systems.
- Diversity and Interdependence of Life
  - Relate diversity and adaptation to structures and functions of living organisms at various levels of organization.
- Historical Perspectives and Scientific Revolutions
  - Trace the historical development of a biological theory or idea.
  - Describe advances in life sciences that have important, long-lasting effects on science and society.

### Two-Year College “Principles of Biology”

- Describe the basic structural and functional organization of cells.
- Identify the stages of cell reproduction in the eukaryotic cell cycle and compare and contrast principal events in mitosis, meiosis, and cell differentiation.
- Describe and explain the fundamental concepts of molecular genetics.

### Advanced Genetics and Biotechnology

- Genetics of Immunity
  - The Importance of Cell Surfaces
  - The Human Immune System
  - Abnormal Immunity
  - Altering Immune Function
  - A Genomic View of Immunity: The Pathogens Perspective

### Honors Biology (first-year high school biology course)

- Characteristics and Structure of Life
  - Compare the structure, function, and interrelatedness of cell organelles in eukaryotic cells.
  - Explain the characteristics of life as indicated by cellular processes, including homeostasis, transportation of molecules, synthesis of new molecules, and disposal of wastes.
  - Summarize the general processes of cell division and differentiation, explain why specialized cells are useful to organisms, and explain that complex multicellular organisms are formed as highly organized arrangements of differentiated cells.

- Explain that living cells are the basic unit of structure and function of all living things and are different from viruses.
- Classification of Life
  - Identify structures and functions of organs in various vertebrate body systems.
- Diversity and Interdependence of Life
  - Explain that living organisms use matter and energy to synthesize a variety of organic molecules to drive life processes.
  - Relate diversity and adaptation to structures and their functions in living organisms.
- Historical Perspectives and Scientific Revolutions
  - Use historical examples to explain how new ideas are limited by the context in which they are conceived.
  - Describe advances in life science that have important long-lasting effects on science and society.
  - Analyze and investigate emerging scientific issues.

### **Health**

- Understand personal responsibility for health behaviors and the relationship between health behaviors and prevention of illness.
- Explain the interrelationships between the dimensions of health, health behaviors, external factors on health, and ways to prevent illness throughout the life span.
- Describe advances in medicine and the prevention and control of health problems.
- Explain disease transmission, prevention, and control.
- Analyze and select behaviors that prevent or minimize the risk of diseases by understanding symptoms, causes, patterns of transmission, and prevention of communicable diseases.
- Understand how the functions of different body systems are interrelated.

## Part II: BioInteractive.org Immunology Resources and Access Instructions

Immunology					
Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Click & Learn	<a href="#">Cells of the Immune System</a> <i>Resource title on DVD: Immunology Primer</i>	This minilesson covers the basics of the human immunological response and includes embedded lecture video clips. (11 slides)	HS.LS1.A	2.D.3, 2.D.4, 3.D.2	1.3, 6.3, 11.1
Lecture	<a href="#">Lecture 1: From Outbreak to Epidemic, Ch. 14</a>	Cells of the immune system. (19:13–19:54)	HS.LS1.A	2.D.3, 2.D.4, 3.D.2	6.3, 11.1
Lecture	<a href="#">Lecture 1: From Outbreak to Epidemic, Ch. 15</a>	Antigen-presenting cells and helper T cells. (19:54–20:45)	HS.LS1.A	2.D.3, 2.D.4, 3.D.2	6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 17</a>	Helper T cells orchestrate the immune response. (22:32–24:03)	HS.LS1.A	2.B.2, 2.D.3, 2.D.4, 3.D.2	1.3, 6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 24</a>	Humoral immunity and antigen binding. (33:06–34:03)	HS.LS1.A	2.D.3, 2.D.4, 3.D.2	6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 27</a>	Mechanism of cytotoxic T lymphocytes (CTLs). (37:16–38:51)	HS.LS1.A	2.D.3, 2.D.4, 3.D.2	1.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 31</a>	How helper T cells orchestrate an immune response. (44:34–45:07)	HS.LS1.A	2.D.3, 2.D.4, 3.D.2	6.3, 11.1
Animation	<a href="#">Antigen Presentation and CTL</a>	Animation shows how a cell that is infected by a virus triggers cytotoxic T cells to kill the virus-infected cell before the virus replicates and spreads. (2 min. 34 sec.)	HS.LS1.A	2.B.1, 2.D.3, 2.D.4, 3.C.3, 3.D.2, 3.D.3, 4.A.1, 4.B.1	1.3, 1.5, 6.3, 11.1
Video Clip	<a href="#">CTL (Cytotoxic T Lymphocyte) Killing a Target Cell</a>	This video clip shows actual video microscopy of a cytotoxic T lymphocyte in action. (1 min. 16 sec.)	HS.LS1.A	3.D.2, 2.D.3, 2.D.4	1.4, 11.1
HIV and Immunology					
Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2009)
Animation	<a href="#">HIV Life Cycle</a>	This animation illustrates how HIV infects a cell and replicates itself using reverse transcriptase and the host's cellular machinery. (4 min. 52 sec.)	HS.LS1.A	2.B.1, 2.B.3, 2.D.3, 2.D.4, 3.A.1, 3.C.3, 4.A.1, 4.A.2, 4.B.1, 4.C.1	1.3, 6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 23</a>	Is the immune system trying to keep HIV in check? (31:52–33:06)	HS.LS1.A	2.D.3, 2.D.4	6.3, 11.1

Use HHMI Resources to Teach: Immunology

Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 25</a>	Antibodies neutralize HIV by binding to its surface proteins. (34:03–35:19)	HS.LS1.A	2.B.1, 2.D.3, 2.D.4, 4.B.1	1.3, 6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 32</a>	By eliminating helper T cells, HIV disables the immune response. (45:07–47:23)	HS.LS1.A	2.B.1, 2.D.3, 2.D.4, 3.D.2	6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 33</a>	Summary: Conclusions of HIV and the immune response. (47:23–49:22)	HS.LS1.A	2.D.3, 3.D.2, 2.D.4	6.3, 11.1

### HIV Drug Development and Immune Response

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2009)
Animation	<a href="#">AZT Blocks Reverse Transcriptase</a>	This animation reviews reverse transcription and then explains how AZT works to block this process. It also explains how AZT is similar to thymine nucleotides, and it describes how mutated reverse transcriptase bypasses the AZT blockage. (1 min. 46 sec.)	HS.LS1.A	3.A.1, 3.C.3, 4.A.1, 4.B.1, 4.C.1.	2.6, 6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 6</a>	AZT: The first antiretroviral used to fight HIV. (7:43–8:49)	HS.LS1.A	3.A.1, 3.C.3, 4.A.1	2.6, 6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 7</a>	AZT's mechanism of action. (8:49–9:33)	HS.LS1.A	3.A.1, 3.C.3, 4.A.1, 4.B.1, 4.C.1.	2.6, 6.3
Animation	<a href="#">Protease Inhibitors</a>	This animation visually demonstrates how protease inhibitors prevent maturation of viral proteins inside HIV particles. (1 min. 6 sec.)	HS.LS1.A	3.C.3, 4.B.1, 4.C.1	2.5, 6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 4</a>	Antiretroviral therapy can halt progression to AIDS. (4:23–5:52)	HS.LS1.A	2.D.4, 3.C.3	6.3

### ELISA, HIV, and Immunology

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2009)
Lecture	<a href="#">Lecture 1: From Outbreak to Epidemic, Ch. 29</a>	Antibodies to HIV found in infected people. (40:28–41:27)	HS.LS1.A	2.D.3, 2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 1: From Outbreak to Epidemic, Ch. 30 and 31</a>	Development of an antibody-based test for HIV. (41:27–43:02) <i>These two chapters discuss the development of an antibody-based test for HIV and how the ELISA test works.</i>	HS.LS1.A	2.D.4, 4.B.1	1.5, 6.3, B.4



Video Clip	<a href="#">Demo: Rapid AIDS Virus Test</a>	This video clip demonstrates a live introduction to an antibody-based ELISA for detecting HIV. (7 min. 40 sec.)	HS.LS1.A	2.D.4, 4.B.1	1.5, 6.3, B.4
Lecture	<a href="#">Lecture 1: From Outbreak to Epidemic, Ch. 33</a>	HIV infection precedes AIDS symptoms by years. (Helper T cell loss). (43:51–44:30)	---	2.D.3	6.3
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 9</a>	Why HIV tests show no infection during acute phase. (11:27–12:24)	HS.LS.1	2.D.3, 2.D.4	6.3
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 10</a>	Development of an antibody response. (12:24–13:28)	HS.LS.1	2.D.3, 2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 11</a>	Measuring HIV RNA detects high HIV levels during acute infection. (13:28–15:18)	HS.LS.1	2.D.3, 2.D.4, 3.A.1	6.3, 11.1
Lecture	<a href="#">Lecture 2: AIDS and the HIV Life Cycle, Ch. 12</a>	HIV RNA can be detected before antibodies to HIV. (15:18–16:53)	HS.LS.1	2.D.3, 2.D.4	6.3
Virtual Lab	<a href="#">Immunology Virtual Lab</a>	This virtual laboratory will demonstrate how the enzyme-linked immunosorbent assay (ELISA) is carried out and some of the key experimental problems that may be encountered. Students will learn about the assay procedure and the equipment and materials that are needed. By completing this exercise, students will gain a better understanding of experimental design, key concepts in immunological reactions, and interpretation of data.	HS.LS.1	2.D.4, 3.D.2, 4.B.1	1.5, 6.3, B.4

### CCR5 Coreceptor Mutation and HIV

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2009)
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 18</a>	People who have mutant CCR5 coreceptors avoid infection. (19:01–20:31)	HS.LS.1, HS.LS3.B	2.D.4, 3.C.1, 4.B.1	1.3, 5.2, 6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 20</a>	Q&A: Is the CCR5 inhibitor drug working well? (21:16–21:53)	---	2.D.4	6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 23</a>	Q&A: How common is the CCR5 mutation? (22:59–23:23)	HS.LS.1, HS.LS3.B	3.C.1	5.2
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 25</a>	Q&A: Do CCR5 mutations have an effect on people? (24:18–24:48)	HS.LS.1, HS.LS3.B	3.C.1	5.2, 6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 26</a>	Q&A: Is caution needed with ART due to HIV mutations? (24:48–26:05)	HS.LS.1, HS.LS3.B	2.D.3, 2.D.4, 3.C.3	6.3

Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 27</a>	Q&A: Can you take CCR5 inhibitor without other drugs? (25:30–26:05)	---	2.D.4	6.3
Lecture	<a href="#">Lecture 3: Drugs and HIV Evolution, Ch. 41</a>	Mother-to-child HIV transmission is preventable. (41:54–45:14)	HS.ETS1.B	2.D.3, 2.D.4	6.3
<b>Vaccine Development and HIV Evolution</b>					
Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2009)
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 6</a>	How vaccines work (5:52–7:00)	HS.LS.1	2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 7</a>	Antibody-inducing vaccines provide immunity. (7:00–7:45)	HS.LS.1	2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 9</a>	Vaccination primes the immune system for future exposure. (8:51–10:17)	HS.LS.1	2.D.3, 2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 13</a>	HIV mutation leads to staggering diversity in HIV genome. (14:37–16:29)	HS.LS3.B, HS.LS4.A	3.C.3	5.4, 6.3
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 15</a>	HIV mutation means antibodies are always a step behind. (17:41–18:48)	HS.LS3.B, HS.LS4.A	2.D.3, 2.D.4, 3.C.3	1.3, 5.4, 6.3
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 17–19</a>	Is using cytotoxic T lymphocytes (CTLs) an option? (19:22–24:10) <i>These three chapters address the idea of targeting other cellular components rather than focusing on antibodies to help fight HIV</i>	HS.LS3.B, HS.LS1.A	2.D.3, 2.D.4, 3.A.1, 3.C.3, 3.D.2, 4.B.1, 4.C.1	1.3, 6.3, 11.1
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 21</a>	Summary: Overview of HIV experimental conclusions. (26:43–27:24)	HS.LS1.A, HS.LS3.B	2.D.3, 2.D.4, 3.A.1, 3.C.3, 4.B.1, 4.C.1	1.3, 5.4, 6.3, 11.1,
Lecture	<a href="#">Lecture 4: Vaccines and HIV Evolution, Ch. 38</a>	Summary: Viral mutations are a huge challenge to vaccine and drug development. (49:43–51:35)	HS.LS1.A, HS.LS3.B, HS.LS4.A	3.A.1, 3.C.3	5.4, 11.1
<b>Dengue Fever and Immunology</b>					
Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2009)
Lecture	<a href="#">Lecture 1: Dengue Fever: Breaking Epidemic Cycles, Ch. 5</a>	What is dengue fever? (7:28–8:55)	HS.ETS1.A	2.D.3, 3.C.3	6.3
Lecture	<a href="#">Lecture 1: Dengue Fever: Breaking Epidemic Cycles, Ch. 13</a>	The immune response and severe dengue. (15:11–16:52)	HS.ETS1.A, HS.LS1.A, HS.LS3.B	2.D.3, 3.C.3, 3.D.2,	6.3
Lecture	<a href="#">Lecture 2: The Virus Hunter's Toolkit, Ch. 13</a>	Antibodies can recognize specific viruses. (18:36–21:40)	HS.LS1.A	2.D.3, 2.D.4, 3.C.3, 3.D.2	6.3, 11.1, B.4

Lecture	<a href="#">Lecture 2: The Virus Hunter's Toolkit, Ch. 16</a>	Q&A: What kind of antigens do viruses have? (25:03–25:45)	HS.LS1.A	2.D.4	6.3
Lecture	<a href="#">Lecture 2: The Virus Hunter's Toolkit, Ch. 17</a>	Q&A: Where do secondary antibodies come from? (25:45–26:48)	HS.LS1.A	2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 4</a>	Immune system as potential foe. (4:25–6:29)	HS.LS3.B	2.D.3, 2.D.4, 3.C.3	6.3, 11.1
Animation	<a href="#">Dengue Virus Enters a Cell</a>	Infection begins when the dengue virus uses receptors on an immune cell's surface to gain entry and release its genome. (1 min. 24 sec.)	HS.LS1.A	2.B.2, 2.D.4, 3.C.3	1.3, 1.4, 2.6, 6.3
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 6</a>	Antibodies neutralize viruses and tag them for destruction. (8:02–10:50)	HS.LS1.A	2.B.2, 2.D.3, 2.D.4, 3.C.3, 4.A.2, 4.B.1	1.3, 1.4, 2.6, 6.3, 11.1
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 7</a>	Antibody-dependent enhancement (ADE) of disease symptoms. (10:50–12:12)	HS.LS1.A	2.B.2, 2.D.3, 2.D.4, 3.C.3	1.3, 1.4, 2.6, 6.3, 11.1
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 8</a>	ADE leads to physiological changes that cause severe dengue. (12:12–12:55)	HS.LS1.A	2.D.3, 2.D.4, 3.C.3, 4.A.4	6.2, 6.3, 11.1
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 9</a>	Maternal antibodies can cause ADE in infants. (12:55–13:59)	HS.LS1.A	2.D.3, 2.D.4	6.3, 11.1
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 10-13</a>	Engineering a mouse model for dengue research. (13:59–21:27)	HS.ETS1.A, HS.LS1.A	2.D.3, 2.D.4	6.3, 11.1, B.4
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 14-16</a>	Modified antibody can prevent ADE in vitro. (21:57–22:54)	HS.ETS1.A, HS.LS1.A	2.D.3, 2.D.4, 4.B.1	6.3, 11.1, B.4
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 18</a>	Q&A: Can the modified antibodies be used as a vaccine? (27:08–28:04)	HS.ETS1.A, HS.LS1.A	2.D.4	6.3, 11.1, B.4
Lecture	<a href="#">Lecture 3: Fighting Viruses in the Lab and Beyond, Ch. 19</a>	Q&A: Can injected antibodies compromise you against other serotypes? (28:04–28:56)	HS.LS1.A	2.D.4	6.3, 11.1

## Part III: Sample Lesson Plans/Schedule


### Immunology (Advanced)

Day	Lesson Goals	HHMI Suggested Resources
1	<p><i>A summary of each day's lesson is provided with a brief description and key concepts. (Lessons are based on a 55-minute daily class period.)</i></p> <p><b>Lesson Part I</b> Provide a brief introduction to the immune system including:</p> <ul style="list-style-type: none"> <li>• General definition of the immune system</li> <li>• Summary of the first, second, and third lines of defense in the human immune system</li> </ul> <p><b>Lesson Part II</b> Provide a brief overview of the nonspecific human immune responses, which include:</p> <ul style="list-style-type: none"> <li>• First line of defense (skin, mucous membranes, and secretions)</li> <li>• Second line of defense (phagocytosis, phagocytic white blood cells, antimicrobial proteins, and the inflammatory response)</li> </ul> <p><b>Lesson Part III</b> Provide an introduction to the concept of helper T cells and antigen presentation. The key concepts are:</p> <ul style="list-style-type: none"> <li>• Macrophage (APC) phagocytosis of pathogen</li> <li>• MHC class II antigen presentation</li> <li>• Helper T cell (T<sub>H</sub>) with T-cell receptor and CD4 activation</li> <li>• Release of interleukin 2 (IL-2) and cytokines</li> </ul>	<p><i>Provided is a list of HHMI resources for each lesson correlated with the specific part of the lesson and topic. (These are meant to be suggestions only; numerous other related HHMI resources can be used.)</i></p> <p><b>Lesson Part III</b> Immunology Primer</p>
2	<p><b>Lesson Part I</b> Provide a brief review of Lesson Day 1, Part III: Helper T cells and antigen presentation</p>	<p><b>Lesson Part I</b> AIDS Lecture 1 Chapter 14: Cells of the Immune System Immunology Primer, including video clips: Slide 3: Intro to B and T Cells Slide 6: Antigen-Presenting Cells Slide 8: Cell-Mediated Immunity</p>

Use HHMI Resources to Teach: Immunology

	<p><b>Lesson Part II</b> Present the specifics of the <b>cell-mediated immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Intracellular pathogen defense system</li> <li>• Infected cell presents antigen with MHC class I</li> <li>• Cytotoxic T lymphocytes (CTLs) with T-cell receptor and CD8 activated by IL-2 from T<sub>H</sub></li> <li>• Activated CTLs give rise to memory T cells</li> <li>• Activated CTLs discharge perforin, causing cellular lysis of an infected cell</li> </ul>	<p><b>Lesson Part II</b> Animation: Antigen Presentation and CTL Video Clip: CTLs Killing a Target Cell AIDS Lecture 4 Chapter 17: Is Using CTLs an Option? Chapter 18: HIV variability disrupts antigen presentation in CTLs Chapter 19: Additional reasons for failure of CTLs to respond</p>
<p><b>3</b></p>	<p><b>Lesson Part I</b> Provide a brief review of Lesson Day 1, Part III: Helper T cells and antigen presentation</p> <p><b>Lesson Part II</b> Present the specifics of the <b>Humoral Immune Response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Extracellular pathogen defense system</li> <li>• Activation of B cells by IL-2 from T<sub>H</sub></li> <li>• B cells proliferate</li> <li>• B cells differentiate into memory B cells and plasma cells</li> <li>• Plasma cells secrete antibodies</li> <li>• Antibodies bind to antigen and make them easy targets for phagocytes and the complement system</li> </ul> <p><b>Lesson Part III</b> Provide a brief review of cell-mediated immune response (Day 2) and humoral immune response (Day 3)</p>	<p><b>Lesson Part II</b> Immunology Primer, including video clip: Slide 4: Humoral immunity and antibody structure AIDS Lecture 2 Chapter 24: Humoral immunity and antigen binding AIDS Lecture 4 Chapter 7: Antibody-inducing vaccines provide immunity Immunology Primer, including video clip: Slide 5: Antibody development with HIV as an example AIDS Lecture 1 Chapter 29: Antibodies to HIV found in infected people Viral Outbreak Lecture 1 Chapter 13: The immune response and severe dengue Viral Outbreak Lecture 2 Chapter 13: Antibodies can recognize specific viruses Viral Outbreak Lecture 3 Chapters 4–9: Immune system as potential foe</p> <p><b>Lesson Part III</b> Immunology Primer, including video clip: Slide 9: Humoral vs. cell-mediated immunity</p>

<p><b>4</b></p>	<p><b>Lesson</b> This lesson spotlights the topic of <i>HIV/AIDS and Immunology</i>. The lesson is divided into parts as listed on the following page:</p> <p><b>Part 1</b> Life Cycle of HIV</p> <p><b>Part 2</b> HIV and Helper T Cell Decline</p> <p><b>Part 3</b> HIV and Immunology</p> <p><b>Part 4</b> How AZT and protease treatments wor</p> <p><b>Part 5</b> Genetic Mutation (CCR5)</p> <p><b>Part 6</b> Overview of the challenges to developing a vaccine for HIV/AIDS</p>	<p><b>Lesson Review</b> Immunology Primer, including Video Clip: Slide 8: Cell-Mediated Immunity</p> <p><b>Part 1</b> Animation: U.S. AIDS Epidemic Animation: HIV Life Cycle AIDS Lecture 1 Chapter 33: HIV infection precedes AIDS symptoms by years</p> <p><b>Part 2</b> AIDS Lecture 2 Chapter 17: Helper T cells orchestrate the immune response Chapter 24: Humoral immunity and antigen binding</p> <p><b>Part 3</b> AIDS Lecture 4 Chapter 21: Summary of HIV and CTLs</p> <p><b>Part 4</b> AIDS Lecture 3 Chapter 4: Antiretroviral therapy can halt progression to AIDS Chapter 6: AZT: The first antiretroviral used to fight AIDS Animation: AZT Blocks Reverse Transcriptase Animation: Protease Inhibitor</p> <p><b>Part 5</b> AIDS Lecture 3 Chapter 18: People who have mutant CCR5 coreceptors avoid infection Chapter 20: Students' questions (Chapters 23, 25, 26, 27)</p> <p><b>Part 6</b> AIDS Lecture 4 Chapter 38: Summary of HIV, vaccines and current research Video Clip: Rapid AIDS virus test (This video clip is useful for introducing the basic concepts of an ELISA for Day 5 Activity and Day 6 and 7 Laboratory.)</p>
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5	<p><b>Activity:</b> HHMI Immunology Virtual Lab</p> <p><i>This virtual activity requires computers with either CD-ROM disk drives or Internet access.</i></p>	<p>HHMI Virtual Laboratory Series: Immunology Lab</p> 
6-7	<p><b>Lab:</b> ELISA Protocol</p> <p>This ELISA (enzyme-linked immunosorbent assay) lab activity helps students understand how HIV is detected in a lab setting . This type of lab is available commercially from several biological supply companies, and an HIV “storyline” can be developed for the activity so students can develop an understanding of testing for HIV.</p>	

### Immunology (Basic)

Day	Lesson Goals	HHMI Suggested Resources
1	<p><b>Lesson Part I</b> Provide a brief introduction to the immune system including:</p> <ul style="list-style-type: none"> <li>• General definition of the immune system</li> <li>• Summary of the first, second, and third lines of defense in the human immune system</li> </ul> <p><b>Lesson Part II</b> Provide a brief overview of the nonspecific human immune responses, which include:</p> <ul style="list-style-type: none"> <li>• First line of defense (skin, mucous membranes, and secretions)</li> </ul>	<p><b>HHMI Suggested Resources</b></p> <p><i>Provided is a list of HHMI resources for each lesson correlated with the specific part of the lesson and topic. (These are meant to be suggestions only; numerous other related HHMI resources can be used.)</i></p> <p><b>Lesson Part III</b> Immunology Primer</p>

	<ul style="list-style-type: none"> <li>• Second line of defense (phagocytosis, phagocytic white blood cells, and the inflammatory response)</li> </ul> <p><b>Lesson Part III</b> Provide an introduction to the concept of helper T cells and antigen presentation. The key concepts are:</p> <ul style="list-style-type: none"> <li>• Macrophage (APC) phagocytosis of pathogen</li> <li>• Antigen presentation</li> <li>• Helper T cell (<math>T_H</math>) activation</li> <li>• Release of chemical signals to various immunological cells</li> </ul>	
2	<p><b>Lesson Part I</b> Provide a brief review of Lesson Day 1, Part III: Helper T cells and antigen presentation</p> <p><b>Lesson Part II</b> Present the specifics of the <b>cell-mediated immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Intracellular pathogen defense system</li> <li>• Infected cell presents antigen</li> <li>• Cytotoxic T cells (CTLs) activated</li> <li>• Activated CTLs give rise to memory T cells</li> <li>• Activated CTLs cause cellular lysis of an infected cell</li> </ul> <p><b>Lesson Part III</b> Present the specifics of the <b>humoral (antibody-mediated) immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Extracellular pathogen defense system</li> <li>• Activation of B cells by <math>T_H</math></li> <li>• B cells proliferate and differentiate into memory B cells and plasma cells</li> <li>• Plasma cells secrete antibodies</li> <li>• Antibodies bind to antigen and make them easy targets for phagocytes</li> </ul>	<p><b>Lesson Part I</b> AIDS Lecture 1 Chapter 14: Cells of the Immune System Immunology Primer, including Video Clips: Slide 3: Intro to B and T Cells Slide 6: Antigen-Presenting Cells Slide 8: Cell-Mediated Immunity</p> <p><b>Lesson Part II</b> Animation: Antigen Presentation and CTL Video Clip: CTL Killing a Target Cell AIDS Lecture 4: Chapter 17: Is using CTLs an option? Chapter 18: HIV variability disrupts antigen presentation in CTLs</p> <p><b>Lesson Part III</b> Immunology Primer, including video clip: Slide 4: Humoral Immunity and Antibody Structure AIDS Lecture 2 Chapter 24: Humoral immunity and antigen binding Immunology Primer, including video clip: Slide 5: Antibody Development with HIV as an Example Viral Outbreak Lecture 1</p>



	<p><b>Lesson Part IV</b> Provide a brief review of cell-mediated immune response and humoral immune response</p>	<p>Chapter 13: The immune response and severe dengue Viral Outbreak Lecture 2 Chapter 13: Antibodies can recognize specific viruses <b>Lesson Part IV</b> Immunology Primer, including video clip: Slide 9: Humoral vs. Cell-Mediated Immunity</p>
<p><b>3</b></p>	<p><b>Lesson</b> This lesson spotlights the topic of <i>HIV/AIDS and Immunology</i>. The lesson is divided into parts as listed below:</p> <p><b>Part 1</b> Life Cycle of HIV</p> <p><b>Part 2</b> HIV and Helper T Cell Decline</p> <p><b>Part 3</b> HIV and Immunology</p> <p><b>Part 4</b> How AZT and Protease Treatments Work</p> <p><b>Part 5</b> Genetic Mutation (CCR5)</p> <p><b>Part 6</b> Overview of the Challenges to Developing a Vaccine for HIV/AIDS</p>	<p><b>Lesson Review</b> Immunology Primer, including video clip: Slide 8: Cell-Mediated Immunity Slide 9: Humoral vs. Cell-Mediated Immunity</p> <p><b>Part 1</b> Animation: U.S. AIDS Epidemic Animation: HIV Life Cycle AIDS Lecture 1 Chapter 33: HIV infection precedes AIDS symptoms by years</p> <p><b>Part 2</b> AIDS Lecture 2 Chapter 17: Helper T cells orchestrate the immune response Chapter 24: Humoral immunity and antigen binding</p> <p><b>Part 3</b> AIDS Lecture 4 Chapter 21: Summary of HIV and CTLs</p> <p><b>Part 4</b> Animation: AZT Blocks Reverse Transcriptase Animation: Protease Inhibitor</p> <p><b>Part 5</b> AIDS Lecture 3 Chapter 18: People who have mutant CCR5 coreceptors avoid infection</p> <p><b>Part 6</b> AIDS Lecture 4 Chapter 38: Summary of HIV, vaccines, and current research Video Clip: Rapid AIDS Virus Test (This video clip is useful for</p>


		introducing the basic concepts of an ELISA for Day 4 Activity and Day 5 Laboratory.)
4	<b>Activity:</b> HHMI Immunology Virtual Lab <i>This virtual activity requires computers with either CD-ROM disk drives or Internet access.</i>	HHMI Virtual Laboratory Series: Immunology Lab
5	<b>Lab:</b> ELISA Protocol This ELISA (enzyme-linked immunosorbent assay) lab activity helps students understand how HIV is detected in a lab setting. This type of lab is available commercially from several biological supply companies, and an HIV “storyline” can be developed for the activity so students can develop an understanding of testing for HIV.	

### Immunology as a Part of Cell Signaling (Advanced)

Day	Lesson Goals	HHMI Suggested Resources
	<i>A summary of each day’s lesson is provided with a brief description and key concepts. (Lessons are based on a 55-minute daily class period.)</i>	<i>Provided is a list of HHMI resources for each lesson correlated with the specific part of the lesson and topic. (These are meant to be suggestions only; numerous other related HHMI resources can be used.)</i>
1	<b>Lesson</b> Provide a detailed account of <b>cell communication</b> , which includes the following key concepts: <ul style="list-style-type: none"> <li>• An overview of cell signaling</li> <li>• Signal reception and the initiation of transduction</li> <li>• Signal transduction pathways</li> <li>• Cellular responses to signals</li> </ul>	
2	<b>Lesson</b> Present the specifics of <b>signal transduction pathways</b> with specific examples. This lesson includes the following key concepts: <ul style="list-style-type: none"> <li>• Pathways relay signals</li> <li>• Protein phosphorylation is a common mode of regulation in cells</li> <li>• Second messengers are key components of signaling</li> <li>• In response to a signal, a cell may regulate activities in the cytoplasm or</li> </ul>	<b>Lesson</b> Animation: Signal Molecules Trigger Transcription Factors*  Animation: Molecular Mechanism of Synaptic Function* (*Access to these animations:

	<p>transcription in the nucleus</p> <ul style="list-style-type: none"> <li>• Signaling pathways amplify and specify the cell's response</li> <li>• Examples of pathways</li> </ul>	<p><i>Website → Animations → Neuroscience 2008 DVD Neuroscience → Disk 1 → Animations)</i>  Animation: Newt Limb Regeneration**  Animation: Cytoplasmic Factors**  (**Access to these animations:  <i>Website → Animations → Stem Cells 2006 DVD Stem Cells → Disk 1 → Animations)</i></p>
3	<p><b>Lesson Part I</b> Provide a brief overview of helper T cells and antigen presentation. The key concepts are:</p> <ul style="list-style-type: none"> <li>• Macrophage (APC) phagocytosis of pathogen</li> <li>• Antigen presentation</li> <li>• Helper T cell activation</li> <li>• Release of chemical signals to various immunological cells</li> </ul> <p><b>Lesson Part II</b> Present the specifics of the <b>cell-mediated immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Intracellular pathogen defense system</li> <li>• Infected cell presents antigen with MHC Class I</li> <li>• Cytotoxic T lymphocytes (CTLs) with T-cell receptors and CD8s activated by IL-2 from T<sub>H</sub></li> <li>• Activated CTLs give rise to memory T cells</li> <li>• Activated CTLs discharge perforin, causing cellular lysis of an infected cell</li> </ul>	<p><b>Lesson Part I</b> AIDS Lecture 1 Chapter 14: Cells of the immune system Immunology Primer, including video clips: Slide 3: Intro to B and T Cells Slide 6: Antigen-Presenting Cells Slide 8: Cell-Mediated Immunity</p> <p><b>Lesson Part II</b> Animation: Antigen Presentation and CTL Video Clip: CTLs Killing a Target Cell AIDS Lecture 4 Chapter 17: Is using CTLs an option? Chapter 18: HIV variability disrupts antigen presentation in CTLs Chapter 19: Additional reasons for failure of CTLs to respond</p>
4	<p><b>Lesson Part I</b> Provide a brief review of Lesson Day 3, Part I: Helper T cells and Antigen Presentation</p> <p><b>Lesson Part II</b> Present the specifics of the <b>humoral (antibody-mediated) immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Extracellular pathogen defense system</li> <li>• Activation of B cells by IL-2 from T<sub>H</sub></li> <li>• B cells proliferate</li> <li>• B cells differentiate into memory B cells and plasma cells</li> <li>• Plasma cells secrete antibodies</li> <li>• Antibodies bind to antigen and make them easy targets for phagocytes and the</li> </ul>	<p><b>Lesson Part II</b> Immunology Primer, including video clip: Slide 4: Humoral Immunity and Antibody Structure AIDS Lecture 2 Chapter 24: Humoral immunity and antigen binding AIDS Lecture 4 Chapter 7: Antibody-inducing vaccines provide immunity Immunology Primer, including video clip: Slide 5: Antibody development with HIV as an example</p>


	<p>complement system</p> <p><b>Lesson Part III</b> Provide a brief review of cell-mediated immune response (Day 3) and humoral immune response</p>	<p>AIDS Lecture 2 Chapter 25: Antibodies neutralize HIV by binding to its surface proteins</p> <p>AIDS Lecture 1 Chapter 29: Antibodies to HIV found in infected people</p> <p><b>Lesson Part III</b> Immunology Primer, including video clip: Slide 9: Humoral vs. Cell-Mediated Immunity</p>
<p>5</p>	<p><b>Lesson</b> This lesson spotlights the topic of <i>HIV/AIDS and Immunology</i>. The lesson is divided into the following parts:</p> <p><b>Part 1</b> Life Cycle of HIV</p> <p><b>Part 2</b> HIV and Helper T Cell Decline</p> <p><b>Part 3</b> HIV and Immunology</p> <p><b>Part 4</b> How AZT and Protease Treatments Work</p> <p><b>Part 5</b> Genetic Mutation (CCR5)</p>	<p><b>Lesson Review</b> Immunology Primer, including video clip: Slide 8: Cell-Mediated Immunity</p> <p><b>Part 1</b> Animation: U.S. AIDS Epidemic Animation: HIV Life Cycle AIDS Lecture 1 Chapter 33: HIV infection precedes AIDS symptoms by years</p> <p><b>Part 2</b> AIDS Lecture 2 Chapter 17: Helper T cells orchestrate the immune response Chapter 24: Humoral immunity and antigen binding</p> <p><b>Part 3</b> AIDS Lecture 4 Chapter 21: Summary of HIV and CTLs</p> <p><b>Part 4</b> AIDS Lecture 3 Chapter 4: Antiretroviral therapy can halt progression to AIDS Chapter 6: AZT: The first antiretroviral used to fight AIDS Animation: AZT Blocks Reverse Transcriptase Animation: Protease Inhibitor</p> <p><b>Part 5</b> AIDS Lecture 3 Chapter 18: People who have mutant CCR5 coreceptors avoid infection Chapter 20: Students' Questions (Chapters 23, 25, 26, 27)</p>

	<p><b>Part 6</b> Overview of the Challenges of Developing a Vaccine for HIV/AIDS</p>	<p><b>Part 6</b> AIDS Lecture 4 Chapter 38: Summary of HIV, vaccines, and current research Video Clip: Rapid AIDS Virus Test (This video clip is useful for introducing the basic concepts of an ELISA for Day 6 Activity and Day 7 Laboratory.)</p>
6	<p><b>Activity:</b> HHMI Immunology Virtual Lab</p> <p><i>This virtual activity requires computers with either CD-ROM disk drives or Internet access.</i></p>	<p>HHMI Virtual Laboratory Series: Immunology Lab</p> 
7	<p><b>Lab:</b> ELISA Protocol</p> <p>This ELISA (enzyme-linked immunosorbent assay) lab activity helps students understand how HIV is detected in a lab setting. This type of lab is available commercially from several biological supply companies, and an HIV “storyline” can be developed for the activity so students can develop an understanding of testing for HIV.</p>	
8–11	<p><b>Lesson: Cell Signaling Poster Projects</b></p> <p>These projects engage students in 2 days of research and 2 days of poster presentations on specific examples of cell signaling that occur in various organisms. More details of these projects can be accessed by contacting the author directly via the email address provided (page 3).</p>	

## Immunology as a Part of Viruses

Day	Lesson Goals	HHMI Suggested Resources
1	<p><b>Lesson:</b> Biology of Viruses</p> <p>This lesson provides the details of the science of viruses including the following key concepts:</p> <ul style="list-style-type: none"> <li>• Genetics of viruses</li> <li>• Virus dependence on a host cell</li> <li>• Lytic and lysogenic cycles</li> <li>• Diversity of animal viruses relating to infection and reproduction</li> <li>• Causes and prevention of viral disease in animals</li> <li>• Emerging viruses</li> <li>• Viruses and cancer</li> </ul>	<p><b>HHMI Suggested Resources</b></p> <p><i>Provided is a list of HHMI resources for each lesson correlated with the specific part of the lesson and topic. (These are meant to be suggestions only; numerous other related HHMI resources can be used.)</i></p> <p><b>Lesson</b></p> <p>DVD → Disk 1 → Feature 2 → What is a retrovirus?            Website → Interactive → Click and Learn → What is a retrovirus?</p>
2	<p><b>Lesson:</b> HIV/AIDS and Dengue Fever</p> <p>This lesson focuses on HIV and AIDS, including the following key concepts:</p> <ul style="list-style-type: none"> <li>• Life Cycle of HIV</li> <li>• Progression of HIV to AIDS</li> <li>• Symptoms of HIV</li> <li>• Transmission of HIV</li> </ul> <p>This lesson also focuses on dengue fever including the following:</p> <ul style="list-style-type: none"> <li>• Life cycle of dengue</li> <li>• Dengue virus entry to a cell</li> <li>• Re-emergence of dengue fever</li> <li>• Structure of the dengue virus</li> <li>• Current direction of research</li> </ul>	<p><b>Lesson</b></p> <p>Animation: U.S. AIDS Epidemic            Animation: HIV Life Cycle            Video Clip: First AIDS Patient            AIDS Lecture 1                Chapter 13: AIDS defined                Chapter 28: HIV: the retrovirus that causes AIDS                Chapter 33: HIV infection precedes AIDS symptoms by years                Chapter 34: Modes of HIV transmission            AIDS Lecture 2                Chapter 8: Symptoms of HIV acute viral infection            Video Clip: HIV Origins in Africa            AIDS Lecture 1                Chapter 36: Global HIV/AIDS estimates</p>

		<p>Animation: Structure of the Dengue Virus  Animation: Dengue Virus Life Cycle  Animation: Dengue Virus Enters a Cell  Animation: Dengue Fever Re-Emergence in the Americas  Viral Outbreak Lecture 1  Chapter 5: What is dengue fever?  Chapter 13: The immune response and severe dengue  Viral Outbreak Lecture 3  Chapters 4–9: Immune system as potential foe  Chapters 14–16: Antibody-dependent enhancement research</p>
<p><b>3</b></p>	<p><b>Lesson</b>  This lesson spotlights the topic of <i>HIV/AIDS and Immunology</i>. The lesson is divided into parts as listed below:</p> <p><b>Part 1</b>  HIV and Helper T Cell Decline</p> <p><b>Part 2</b>  HIV and Immunology</p> <p><b>Part 3</b>  How AZT and Protease Treatments Work</p>	<p><b>Lesson Review</b>  Immunology Primer, including video clip:  Slide 8: Cell-Mediated Immunity  Animation: HIV Life Cycle</p> <p><b>Part 1</b>  AIDS Lecture 2  Chapter 17: Helper T cells orchestrate the immune response  Chapter 24: Humoral immunity and antigen binding  Chapter 32: By eliminating helper T cells, HIV disables the immune response</p> <p><b>Part 2</b>  AIDS Lecture 2  Chapter 25: Antibodies neutralize HIV by binding to its surface proteins  AIDS Lecture 4  Chapter 21: Summary of HIV and CTLs</p> <p><b>Part 3</b>  AIDS Lecture 3  Chapter 4: Antiretroviral therapy can halt progression to AIDS  Chapter 6: AZT: The first antiretroviral used to fight AIDS  Animation: AZT Blocks Reverse Transcriptase  Animation: Protease Inhibitor</p>

	<p><b>Part 4:</b> Genetic Mutation (CCR5)</p> <p><b>Part 5</b> Overview of the Challenges in Developing a Vaccine for HIV/AIDS</p>	<p><b>Part 4:</b> AIDS Lecture 3 Chapter 18: People who have mutant CCR5 coreceptors avoid infection Chapter 20: Students' Questionsn (Chapters 23, 25, 26, 27)</p> <p><b>Part 5</b> AIDS Lecture 2 Chapter 37: Why can't we use antibodies to HIV as a vaccine? Chapter 38: Could you make drugs to attack HIV's protease or integrase?</p> <p>AIDS Lecture 4 Chapter 38: Summary of HIV, vaccines, and current research</p> <p>Video Clip: Rapid AIDS Virus Test (This video clip is useful for introducing the basic concepts of an ELISA for Day 4 Activity and Day 5 and 6 Laboratory.)</p>
<p><b>4</b></p>	<p><b>Activity:</b> HHMI Immunology Virtual Lab</p> <p><i>This virtual activity requires computers with either CD-ROM disk drives or Internet access.</i></p>	<p>HHMI Virtual Laboratory Series: Immunology Lab</p> 
<p><b>5-6</b></p>	<p><b>Lab:</b> ELISA Protocol</p> <p>This ELISA (enzyme-linked immunosorbent assay) activity helps students understand how HIV is detected in a lab setting. This type of lab is available commercially from several biological supply companies, and an HIV "storyline" can be developed for the activity so students can develop an understanding of testing for HIV.</p>	




## Immunology as a Part of Infectious Diseases

Day	Lesson Goals	HHMI Suggested Resources
1	<p><b>Lesson:</b> The Biology of Infectious Disease</p> <p>This lesson provides details of the science of viruses, including the following key concepts:</p> <ul style="list-style-type: none"> <li>• Definition of an infectious disease</li> <li>• Modes of transmission of various diseases</li> <li>• Examples of infectious diseases with related symptoms, modes of infection, and progression</li> </ul>	
2–5	<p><b>Lesson:</b> Infectious Disease Poster Projects</p> <p>These projects engage students in 2 days of research and 2 days of poster presentations regarding specific infectious diseases that occur in humans. More details of these projects can be accessed by contacting the author directly via email provided (page 3).</p>	
6	<p><b>Lesson Part I</b></p> <p>Provide a brief overview of helper T cells and antigen presentation. The key concepts are:</p> <ul style="list-style-type: none"> <li>• Macrophage (APC) phagocytosis of pathogen</li> <li>• Antigen presentation</li> <li>• Helper T cell activation</li> <li>• Release of chemical signals to various immunological cells</li> </ul> <p><b>Lesson Part II</b></p> <p>Present the specifics of the <b>cell-mediated immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>• Intracellular pathogen defense system</li> <li>• Infected cell presents antigen</li> <li>• Cytotoxic T lymphocytes (CTLs) activation</li> </ul>	<p><b>Lesson Part I</b></p> <p>AIDS Lecture 1</p> <p>Chapter 14: Cells of the Immune System</p> <p>Immunology Primer, including video clips:</p> <p>Slide 3: Intro to B and T Cells</p> <p>Slide 6: Antigen-Presenting Cells</p> <p>Slide 8: Cell-Mediated Immunity</p> <p><b>Lesson Part II</b></p> <p>Animation: Antigen Presentation and CTL</p> <p>Video Clip: CTLs Killing a Target Cell</p> <p>AIDS Lecture 4:</p> <p>Chapter 17: Is using CTLs an option?</p>

	<ul style="list-style-type: none"> <li>Activated CTLs give rise to memory T cells</li> <li>Activated CTLs cause cellular lysis of infected cell</li> </ul> <p><b>Lesson Part III</b> Present the specifics of the <b>humoral (antibody mediated) immune response</b>, which include the following key concepts:</p> <ul style="list-style-type: none"> <li>Extracellular pathogen defense system</li> <li>Activation of B cells by T<sub>H</sub></li> <li>B cells proliferate and differentiate into memory B cells and plasma cells</li> <li>Plasma cells secrete antibodies</li> <li>Antibodies bind to antigen and make them easy targets for phagocytes</li> </ul> <p><b>Lesson Part IV</b> Provide a brief review of cell-mediated immune response and humoral immune response</p>	<p>Chapter 18: HIV variability disrupts antigen presentation in CTLs</p> <p><b>Lesson Part III</b> Immunology Primer, including video clip: Slide 4: Humoral Immunity and Antibody Structure AIDS Lecture 2 Chapter 24: Humoral immunity and antigen binding Immunology Primer, including video clip: Slide 5: Antibody Development with HIV as an Example Viral Outbreak Lecture 1 Chapter 13: The immune response and severe dengue Viral Outbreak Lecture 2 Chapter 13: Antibodies can recognize specific viruses</p> <p><b>Lesson Part IV</b> Immunology Primer, including video clip: Slide 9: Humoral vs. Cell-Mediated Immunity</p>
7	<p><b>Lesson: HIV/AIDS and Dengue Fever</b> This lesson focuses on HIV and AIDS, including the following key concepts:</p> <ul style="list-style-type: none"> <li>Life cycle of HIV</li> <li>Progression of HIV to AIDS</li> <li>Symptoms of HIV</li> <li>Transmission of HIV</li> </ul> <p>This lesson also focuses on dengue fever, specifically:</p> <ul style="list-style-type: none"> <li>Life cycle of dengue</li> <li>Dengue virus entry to a cell</li> <li>Re-emergence of dengue fever</li> <li>Structure of the dengue virus</li> <li>Current direction of research</li> </ul>	<p><b>Lesson</b> Animation: U.S. AIDS Epidemic Animation: HIV Life Cycle Video Clip: First AIDS Patient AIDS Lecture 1 Chapter 13: AIDS Defined Chapter 28: HIV: the retrovirus that causes AIDS Chapter 33: HIV infection precedes AIDS symptoms by years Chapter 34: Modes of HIV transmission AIDS Lecture 2: Chapter 8: Symptoms of HIV acute viral infection Video Clip: HIV Origins in Africa AIDS Lecture 1 Chapter 36: Global HIV/AIDS estimates Animation: Structure of the Dengue Virus Animation: Dengue Virus Life Cycle Animation: Dengue Virus Enters a Cell Animation: Dengue Fever Re-Emergence in the Americas</p>

		<p>Viral Outbreak Lecture 1  Chapter 5: What is dengue fever?  Chapter 13: The immune response and severe dengue</p> <p>Viral Outbreak Lecture 3  Chapters 4–9: Immune system as potential foe  Chapters 14–16: Antibody-dependent enhancement research</p>
<p><b>8</b></p>	<p><b>Lesson</b>  This lesson spotlights the topic of <i>HIV/AIDS and Immunology</i>. The lesson is divided into the following parts:</p> <p><b>Part 1</b>  HIV and Helper T Cell Decline</p> <p><b>Part 2</b>  HIV and Immunology</p> <p><b>Part 3</b>  How AZT and Protease Treatments Work</p> <p><b>Part 4</b>  Genetic Mutation (CCR5)</p>	<p><b>Lesson Review</b>  Immunology Primer, including video clip:  Slide 8: Cell-Mediated Immunity  Animation: HIV Life Cycle</p> <p><b>Part 1</b>  AIDS Lecture 2  Chapter 17: Helper T cells orchestrate the immune response  Chapter 24: Humoral immunity and antigen binding  Chapter 32: By eliminating helper T cells, HIV disables the immune response</p> <p><b>Part 2</b>  AIDS Lecture 2  Chapter 25: Antibodies neutralize HIV by binding to its surface proteins</p> <p>AIDS Lecture 4  Chapter 21: Summary of HIV and CTLs</p> <p><b>Part 3</b>  AIDS Lecture 3  Chapter 4: Antiretroviral therapy can halt progression to AIDS  Chapter 6: AZT: The first antiretroviral used to fight AIDS  Animation: AZT Blocks Reverse Transcriptase  Animation: Protease Inhibitor</p> <p><b>Part 4</b>  AIDS Lecture 3  Chapter 18: People who have mutant CCR5 coreceptors avoid infection  Chapter 20: Students' Questions (Chapters 23, 25, 26, 27)</p>

	<p><b>Part 5</b> Overview of the challenges of developing a vaccine for HIV/AIDS</p>	<p><b>Part 5</b> AIDS Lecture 2 Chapter 37: Why can't we use antibodies to HIV as a vaccine? Chapter 38: Could you make drugs to attack HIV's protease or integrase? AIDS Lecture 4 Chapter 38: Summary of HIV, vaccines, and current research Video Clip: Rapid AIDS Virus Test (This video clip is useful for introducing the basic concepts of an ELISA for Day 9 Activity and Day 10 Laboratory.)</p>
<p><b>9</b></p>	<p><b>Activity:</b> HHMI Immunology Virtual Lab</p> <p><i>This virtual activity requires computers with either CD-ROM disk drives or Internet access.</i></p>	<p>HHMI Virtual Laboratory Series: Immunology Lab</p> 
<p><b>10</b></p>	<p><b>Lab:</b> ELISA Protocol</p> <p>This ELISA (enzyme-linked immunosorbent assay) lab activity helps students understand how HIV is detected in a lab setting. This type of lab is available commercially from several biological supply companies, and an HIV “storyline” can be developed for the activity so students can develop an understanding of testing for HIV.</p>	

## Part IV: Curriculum Standards

### National Standards

#### 1. The Cell

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out cell functions such as energy production, transport of molecules, waste disposal, synthesis of new molecules, and storage of genetic material.
- Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.
- Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.
- Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues, and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.

#### 2. The Behavior of Organisms

- Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.
- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses can be either innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments; therefore, their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

#### 3. Personal and Community Health

- The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted.

#### 4. Science and Technology in Local, National, and Global Challenges

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
- Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.
- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.
- Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and who gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions such as "What can happen?," "What are the odds?" and "How do scientists and engineers know what will happen?"

## **Ohio State Standards and Benchmarks**

### 1. Life Science

- Explain that cells are the basic unit of structure and function of living organisms; that once life originated, all cells came from pre-existing cells, and that there are a variety of cell types.
- Explain the characteristics of life as indicated by cellular processes, and describe the process of cell division and development.
- Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of life sciences.
- Explain how processes at the cellular level affect the functions and characteristics of an organism.
- Explain the interconnectedness of the components of a natural system.
- Explain how the molecular basis of life and the principles of genetics determine inheritance.

### 2. Science and Technology

- Explain that science and technology are interdependent; each drives the other.
- Predict how human choices today will determine the quality and quantity of life on Earth.

### 3. Scientific Inquiry

- Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

### 4. Scientific Ways of Knowing

- Explain how scientific inquiry is guided by knowledge, observations, ideas, and questions.
- Describe the ethical practices and guidelines in which science operates.
- Recognize that scientific literacy is part of being a knowledgeable citizen.
- Explain how ethical considerations shape scientific endeavors.
- Explain how societal issues and considerations affect the progress of science and technology.