

Unit 1: Lesson 3 –The Adaptive Immune System

LESSON QUESTIONS

- What are the key features and processes of the adaptive immune system?
- How does the adaptive immune system differ from the innate immune system?

LESSON OBJECTIVES

- Define glossary terms related to the adaptive immune system.
- Create a concept map of the adaptive immune system.
- Create analogies to illustrate features and processes of the adaptive immune system.

OVERVIEW

In this lesson, students learn about the adaptive immune system, which provides an antigen-specific response. Students explore glossary terms associated with the adaptive immune system. They define cells, molecules and processes of the adaptive immune system and then create a concept map that describes how the adaptive immune system works.

LENGTH

Three 45-minute sessions

GLOSSARY TERMS

antibody, antigen, antigen-presenting cells (APCs), B cells, cytokines, dendritic cells, macrophages, neutralize, proliferation, protein, T cells

STANDARDS

- **Next Generation Science Standards**
 - HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
 - HS-LS1-2.2.1 Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

- HS-LS1-2.4.1 Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.
 - HS-LS1-2.LS1.A.1 Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
 - HS-LS1-2.LS1.A.2 Feedback mechanisms maintain a living system’s internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.
- **Common Core State Standards**
 - RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.
 - RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
 - WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
 - WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
 - WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

MATERIALS

- Student worksheet:
https://vaccinemakers.org/sites/default/files/lessons/HS.student%20worksheet.unit1_lesson3_FINAL.pdf
- Student activity sheets:

- Function of the Adaptive Immune System (Activity 1):
<https://vaccinemakers.org/sites/default/files/lessons/HS.activity%201.unit1.lesson3.Function%20of%20Adaptive%20Immune%20System%20FINAL.pdf>
 - Components of the Adaptive Immune System (Activity 2):
https://vaccinemakers.org/sites/default/files/lessons/HS.activity%202.unit1.lesson3.Components%20of%20Adaptive%20Immune%20System_FINAL.pdf
 - Illustrating the Adaptive Immune System (Activity 3):
https://vaccinemakers.org/sites/default/files/lessons/HS.activity%203.unit1.lesson3.Illustrating%20the%20Adaptive%20Immune%20System_FINAL.pdf
- Computer with internet access

BACKGROUND FOR TEACHER

The adaptive immune system provides the body with a specific response to antigens. This targeted response contrasts with the generalized response of the innate immune system. (Unit 1 Lesson 2 covers the innate immune system.) When a pathogen invades the body, it is detected by antigen-presenting cells (APCs), such as macrophages and dendritic cells. These APCs display pieces of the pathogen, known as antigens, on their cell surface as a means of alerting and engaging other immune system cells, such as T cells. Some T cells attack or neutralize the pathogen directly, while others help to “train” B cells. Activated B cells produce antibodies, which either neutralize the pathogen by preventing it from entering cells or flagging it for destruction. Some B cells survive long after infection to serve as “memory” for the adaptive immune system. These memory-based responses are faster and more efficient at stopping future infections with the same pathogen. The adaptation of the immune system to new challenges is the basis of vaccination. (Unit 2 covers the relationship between vaccination and the immune system.) In this lesson, students use a concept map to understand this complex system. Rather than trying to recall the many details, students should focus on understanding the basic principles of the adaptive immune system.

TEACHER NOTES

Students should understand the difference between the general response produced by the innate immune system and the pathogen-specific response of the adaptive immune system. If you did not recently cover the innate immune system in class, you may want to show the animation *The Innate Immune System* (<https://vimeo.com/227178345>).

LESSON RESOURCES

- Lesson animations:
 - *The Adaptive Immune System* <https://vimeo.com/227178817>
 - *How do Antibodies Work?* <https://vimeo.com/227176366>

- Lesson glossary:
https://vaccinemakers.org/sites/default/files/resources/HS.lesson%20glossary.unity.lesson3_FINAL.pdf
- Reading passage, *Killer Cells, Memory Cells: A Brief Introduction to the Adaptive Immune System*,
https://vaccinemakers.org/sites/default/files/resources/HS.reading%20passage.unity.lesson3_FINAL.pdf
- Additional resources that may be useful:
 - Trivia quizzes related to the lesson animations, *Kahoot!*,
www.vaccinemakers.org/trivia
 - Comprehensive human immune system overview, VEC,
<https://www.chop.edu/centers-programs/vaccine-education-center/human-immune-system>
 - Immune system information, with sections on immune system function and location, NIH, <https://www.niaid.nih.gov/research/immune-system-overview>
 - Basic information on immune system function, How Stuff Works.com,
<http://science.howstuffworks.com/life/human-biology/immune-system2.htm>

ENGAGE

1. Ask students to list three serious diseases they have heard about. For each, students should write one or two sentences to describe how they think these diseases can be prevented.
2. On your whiteboard, list and tally responses. Ultimately, count how many students mentioned vaccines or vaccination in their descriptions.
3. Explain to students that they will learn about the adaptive immune system, which is the basis for vaccination.

EXPLORE

1. Working in small groups, students discuss how they think vaccination works. If needed, prompt students by reminding them that vaccination is also called immunization.
2. Lead students to understand that the principle of vaccination is to “prime” the adaptive immune system.
3. Students read the reading passage, *Killer Cells, Memory Cells: A Brief Introduction to the Adaptive Immune System*.
4. Students watch the animation, *The Adaptive Immune System*.
5. Students explore glossary terms related to the features and functioning of the adaptive immune system.
6. Students complete the vocabulary table in their worksheets.

7. Students watch the animation, *How do Antibodies Work?*
8. Students work in pairs or small groups to research online resources to learn about the adaptive immune system. The goal of the exploration is to develop a simple model that explains the function of the adaptive immune system's components.

EXPLAIN

1. Working in groups, students create a graphic organizer such as a flowchart or concept map that models the adaptive immune system using the activity sheet *Function of the Adaptive Immune System (Activity 1)*.
2. Groups discuss their models with other groups.
3. Hold a class discussion to address any questions or misconceptions. If needed, guide students with prompt questions:
 - a. How representative is your model of the real immune system?
 - b. Are some parts of the immune system more important than others?
 - c. Why is an adaptive immune system needed if we have an innate immune system?
4. Working individually, students write a short passage to explain the difference between the innate and adaptive immune system.
5. Working individually, students complete the tables and labeling of the concept map on the activity sheet, *The Components of the Adaptive Immune System (Activity 2)*.
6. Students describe differences between their activity sheet concept map and their original flowchart or concept map from the *Functions of the Adaptive Immune System* activity sheet (Activity 1).

ELABORATE

1. Students choose a major component of the adaptive immune system to explore in more detail:
 - a. Antibodies
 - b. Antigen-presenting cells
 - c. B cells
 - d. T cells
 - e. Cytokines
2. Students write a short passage describing their selected component's role in the adaptive immune system.
3. Students characterize their component as part of a feedback system (negative or positive).

EVALUATE

1. Students work in pairs or small groups to create a multimedia resource (story, skit, webpage, video script, etc.) using the activity sheet, “Illustrating the Adaptive Immune System” (Activity 3). The resource should use a metaphor to explain the features and functioning of the adaptive immune system in the way that the reading passage uses a castle analogy. Students should be encouraged not to use the castle example.
2. Students identify aspects of their metaphor that symbolize or relate to immune system components.
3. Working individually, students complete the multiple-choice and short answer questions in the student worksheet.

RUBRIC: STUDENT WORKSHEET

Vocabulary table

- Refer to the lesson glossary for correct definitions of the components of the innate immune system.

Multiple Choice

1. B cells are formed in bone marrow. (B)
2. T cells mature in the thymus. (A)
3. An antibody is a protein. (D)
4. Proliferation is rapid multiplication of immune system cells. (A)

Short Answer

1. Describe the importance of the role of APCs.

Antigen-presenting cells activate T cells and B cells. This activation begins the adaptive immune system response.

2. Which classes of cells involved in the *adaptive* immune response release cytokines?

- T cells release cytokines to alert other immune system cells.

3. Describe the function of cytokines in the immune system.

- Answers will vary. The key concept is that cytokines are used by the immune system to communicate.

4. Describe the two main functions of antibodies.

- Antibodies attach to pathogens to neutralize them or serve as an alert to other cells looking to destroy the pathogen.

5. What parts of the adaptive immune system are involved in immunological memory?

- T cells and B cells are involved in immunological memory. They monitor and protect the body from future infections by the same pathogen.

6. Why is immunological memory beneficial?

- Immunological memory provides the basis for responding more quickly to future encounters with the same antigen.

RUBRIC - ACTIVITY 1: Function of the Adaptive Immune System

- Graphical models should indicate students' understanding of the function of each of the adaptive immune system components.

RUBRIC - ACTIVITY 2: The Components of the Adaptive Immune System

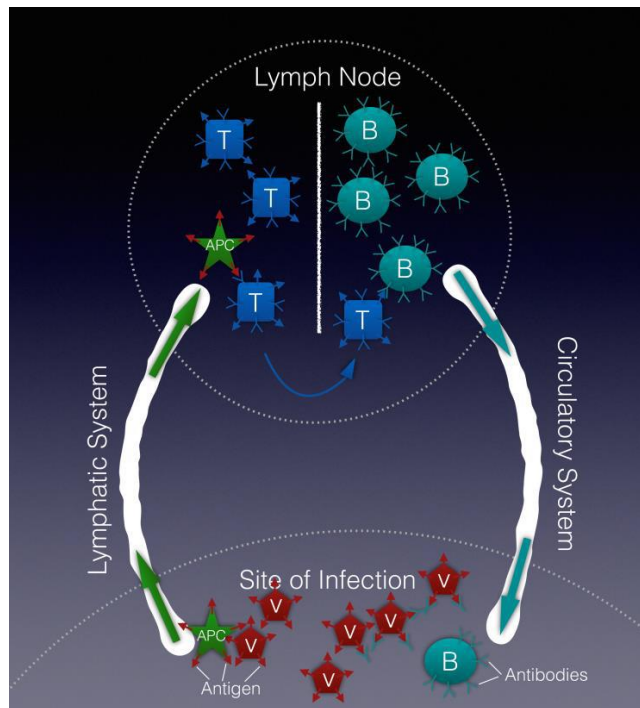
Completed table- adaptive immune system components that carry out specific functions.

Function	Component(s)
Fight infection	antibodies, T cells, cytokines
Communicate information about infection	antigen-presenting cells, T cells, cytokines
Establish immunological memory	B cells, T cells
Create antibodies to fight infection	B cells

Completed table - descriptions of how adaptive immune system components function to fight infection.

Component	Function to fight infection
Antibodies	<ul style="list-style-type: none"> Mark pathogens for destruction by phagocytes and complement proteins. Neutralize pathogens so they cannot attach to cells.
T cells	<ul style="list-style-type: none"> Release factors that can induce programmed death of a target cell. Killer T cell: lyses cells that have antigens that are recognized by the T cell on their surface. Helper T cells: release cytokines to stimulate other immune system components. Memory T cells: remember antigen to protect against future infections.
B cells	<ul style="list-style-type: none"> Serve as antigen-presenting cells. Produce antibodies specific to the antigen. Become memory B cells to rapidly neutralize future infections by the same antigen.
Antigen-presenting cells	<ul style="list-style-type: none"> Capture and process antigen during infections, then display antigen to activate T and B cells.
Cytokines	<ul style="list-style-type: none"> Modulate immune responses.

Labeled concept map of the components of the adaptive immune system.



RUBRIC - ACTIVITY 3: Illustrating the Adaptive Immune System

Sample metaphor - A castle or other building being defended by an invader:

Antigen - invader

Antibody - cannon, gun, other weapon; flare

B cell - weapon operator

T cell - troop commander

Antigen-presenting cell – intelligence specialist

Cytokine - communications specialist