Unit 1: Lesson 2 – The Innate Immune System

LESSON QUESTIONS

- What are the key features and processes of the innate immune system?
- How can the innate immune system be modeled?

LESSON OBJECTIVES

- Define glossary terms related to the innate immune system.
- Identify features of the innate immune system that respond to antigens.
- Analyze the castle and moat model as an analogy for the innate immune system.

OVERVIEW

In this lesson, students learn about the body's first line of defense—the innate immune system. Students explore glossary terms associated with the innate immune system. They conduct an activity that models the barriers of the innate immune system and analyze data from the activity. In an optional activity, students describe the symptoms and the innate immune response given a specific scenario that introduces pathogens into the body.

LENGTH

Three 45-minute sessions

GLOSSARY TERMS

complement system, cytokines, edema, inflammatory response, macrophages, mucous membranes, natural killer (NK) cells, neutrophils, pathogen-associated molecular patterns (PAMPs), phagocytosis

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.

- **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.
    - HSS.IC.A Understand and evaluate random processes underlying statistical experiments.

- HSS.IC.B Make inferences and justify conclusions from sample surveys, experiments, and observational studies.

- HSS.ID.A Summarize, represent, and interpret data on a single count or measurement variable.

MATERIALS

- Student worksheet: https://vaccinemakers.org/sites/default/files/lessons/HS.student%20worksheet.unit1_.lesson2.FINAL_.pdf
- Computer with internet access

- For Activity 1, each group will need:
  - Activity 1 sheet: https://vaccinemakers.org/sites/default/files/lessons/HS.activity1.%20Castle%20of%20the%20Body.unit1_.lesson2.FINAL_.pdf
  - Shoebox without lid
  - 10 marbles
  - Craft knife or scissors
  - 10 1½" foam balls
  - 10 ping pong balls
  - Masking tape

- For Activity 2, each group will need:
  - Activity 2 sheet: https://vaccinemakers.org/sites/default/files/lessons/HS.activity%202.How%20Does%20Innate%20Immune%20System%20Work.unit1_.lesson2.FINAL_.pdf

BACKGROUND FOR TEACHER

The innate immune system is the body's first line of defense. The key concept for students is that the innate immune system is a generalized defense system, as opposed to the specific defenses provided by the adaptive immune system. (The adaptive immune system is covered in Unit 1, Lesson 3.) Innate immune system defenses include passive barriers, such as the skin and mucous membranes, as well as active cellular and biochemical responses. The castle and moat analogy is a good model for the innate immune system's barriers to pathogens. In this lesson, students conduct an activity that allows them to quantitatively analyze the castle and moat model. The goal is for students to understand how the model is analogous to the innate immune system. They should also be able to explain how the model differs from the real system.

TEACHER NOTES

You may wish to divide the lesson so that Engage and Explore are completed in the first 45-minute session, completing the remainder of the lesson in the next two sessions.

LESSON RESOURCES

- Lesson Animation:
  - *The Innate Immune System* https://vimeo.com/227178345

- Lesson glossary: https://vaccinemakers.org/sites/default/files/resources/HS.lesson%20glossary.unit1_.lesson2.FINAL_0.pdf

- Additional resources that may be helpful:
  - Comprehensive human immune system overview, VEC, https://www.chop.edu/vaccine-education-center/human-immune-system
  - Animation Expedition #4 - The First Line of Defense: The Innate Immune System, https://vaccinemakers.org/news-events/animation-expedition-4-first-line-defense-innate-immune-system
  - Trivia quiz related to the lesson animation, *Kahoot!,* www.vaccinemakers.org/trivia
  - Infectious Diseases and Fevers Q&A sheet, VEC, https://www.chop.edu/sites/default/files/vaccine-education-center-infectious-diseases-fevers.pdf
  - *How Do Cells Defend Against Foreign DNA*, Animation, VEC, https://vimeo.com/1045119029
  - Basic information on immune system function, How Stuff Works.com, https://health.howstuffworks.com/human-body/systems/immune/immune-system.htm#pt2

ENGAGE

1. Ask students to list in their notebooks fun games they have played that simulate defending castles or similar scenarios. Students can also list stories or books they have read about castles.
2. Students work in pairs to brainstorm and then write a list of castle defenses and methods of attack.
3. Students write a passage on why castles are not used in modern warfare.

EXPLORE

1. Students explore online sources and the lesson glossary to complete the vocabulary table in their worksheets.
2. Students watch the animation, *The Innate Immune System*. If time allows, or to reinforce the concepts in the animation, students can complete the quiz on *Kahoot!* related to this animation or complete the "Check Your Understanding Questions" in the article, "Animation Expedition #4 - The First Line of Defense: The Innate Immune System"
3. Working in small groups or pairs, students complete the "Castle of the Body" activity (Activity 1). Ensure students record their data accurately.
4. Students tally the scores. Combine student data to tally an overall class score.
5. Students calculate the percentages and averages of the data from the activity.
6. Students discuss whether the attack or defense was more successful.

EXPLAIN

1. Students complete the first three questions in their Activity 1 packets.
2. Students describe differences observed between the results for each trial.
3. Students hypothesize why they observed differences.
4. Students explain why this activity is a model for the immune system.

ELABORATE

1. Working in small groups, students create a list of ways to get more of the balls or marbles into the box. These could include different-sized projectiles or launching the balls with a rubber band.
2. Students repeat the activity using different materials to represent various kinds of pathogens. Students calculate statistics (mean, range) from the data collected during the activity.

EVALUATE

1. Students work in pairs or small groups to create a resource that demonstrates understanding of the innate immune system. Example assignments include:
    - Make a 30-second television commercial.
    - Design an ad for a magazine.
    - Write a newspaper article.
    - Create a web page (blog, wiki, etc.).
    - Perform a skit.
    - Create a slide presentation.

Make sure that students include at least one of the following points about the innate immune system in their resource:

- The innate immune response is non-specific.
- The innate immune response is our first line of defense.
- The innate immune response is successful in averting most infections.

EXTENSION

Activity 2 presents students with scenarios that would cause the innate immune system to be activated. Working in groups or individually, students brainstorm symptoms that they might experience in the scenario. For each symptom, students should write or think about the following:

- What part of the innate immune system contributes to the symptom?
- The effects or results of each innate immune system response

RUBRIC: STUDENT WORKSHEET

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

RUBRIC - ACTIVITY 1: Castle of the Body

1. Describe the differences you observed between the results for each trial.

    - Answers will vary, but students should notice that different types of balls were more likely or less likely to get stuck on the tape, bounce off the castle walls, or make it into the castle.

2. What is your hypothesis to explain the differences you observed between the results for each trial?

    - Hypotheses should include factors such as differences between the size and weight of the balls, the size of castle opening, the stickiness and width of the masking tape and variations related to how fast or far the balls rolled.

3. How does this activity represent the human body and the immune system?

    - Students should be able to explain that the sides of the cardboard box are like the body's skin, the sticky tape around the box is like the body's mucous membranes and the balls are like pathogens trying to gain entrance to the body.

4. Working in a small group, create a list of ways to get more of the balls or marbles into the box. Then create a list of ways to stop more of the balls or marbles from getting into the box. If time allows, repeat the activity using different materials to represent various kinds of pathogens. Record your data and calculate percentages as before. Record the effectiveness of the technique and summarize your results and conclusions.

5. Within your group, discuss how your activity represents the immune system's interaction with pathogens to protect the body.

    - For questions 4 and 5, students should extend the activity, exploring ways to change the "pathogen" to make it more likely to gain entrance and exploring ways to fortify the box to discourage entrance. These observations will serve as scaffolding when introducing the concepts presented in Unit 2 lesson 1: Development of Disease and Infection, which focuses on how pathogens change to continue infecting people.

RUBRIC - ACTIVITY 2: How Does the Innate Immune System Work?

Scenario	Q1. Symptoms	Q2. Innate system contributing to symptom	Q3. Effect of innate immune responses
Splinter after skateboarding accident	Punctured skin, splinter breaches skin, introducing pathogens into body	Macrophages below the skin activated	• Macrophages eliminate pathogens and activate other parts of the immune response. • Blood vessels dilate. Blood flow slows so immune cells can leave the blood and enter tissue near wound. • Cytokines clot blood in tissue so pathogens cannot cause wider infection. • NK cells help fight infection. • Inflammatory response promotes repair of damaged tissue. • Pathogens identified due to PAMPs, therefore targeted by immune cells.
	Pain	Inflammatory response	
	Red		
	Warm to touch		
	Pus	Dead neutrophils Plasma containing complement	
	Bleeding when splinter removed	Cytokines	

Scenario	Q1. Symptoms	Q2. Innate system contributing to symptom	Q3. Effect of innate immune responses
Sick after eating out	Upset stomach or nausea	Movement of stomach or intestine trying to eliminate pathogen	• Mucus in gastrointestinal tract traps pathogens. • Low pH stomach acid kills some bacteria. • Anti-bacterial peptides in digestive tract act as barrier to infection. • If pathogen crosses epithelial and mucosal barrier of digestive tract, macrophages, cytokines, and neutrophils activate.
	Vomiting	Induced by the innate response to eliminate pathogen	
	Diarrhea		
	Chills or fever		

Scenario	Q1. Symptoms	Q2. Innate system contributing to symptom	Q3. Effect of innate immune responses
Pimple before class pictures	Raised skin	Inflammatory response	• Blood vessels dilate. Blood flow slows so immune cells can leave the blood and enter tissue near pimple. • Cytokines clot blood in tissue so pathogens cannot cause wider infection. • NK cells help fight infection. • The inflammatory response will promote repair of damaged tissue. • Pathogens may be recognized by PAMPs so that immune cells are signaled to their presence.
	Red		
	Sore		
	Pus	Dead neutrophils Plasma containing complement	

Scenario	Q1. Symptoms	Q2. Innate system contributing to symptom	Q3. Effect of innate immune responses
Getting coughed on in class	Sore throat	Inflammatory response	• Macrophages eliminate pathogens and activate other parts of the immune response. • Blood vessels dilate. Blood flow slows so neutrophils and other immune cells can leave the blood and enter lung tissue. • NK cells help fight infection. Inflammatory response promotes repair of damaged tissue. • Pathogens identified due to PAMPs, therefore targeted by immune cells. • Airways swell as a result of inflammation.
	Red throat		
	Cough	Cough	
	Runny nose	Mucus	
	Mucus production during cough	Cilia in respiratory tract move mucus up to throat Pathogens killed in the digestive tract	
	Fever	Inflammatory response	