How Our Immune System and Vaccines Protect Us From Diseases

Name: _____

Date: _____

Student Worksheet—*Answer Key*

Engage

1. While watching the videos and discussing the different types of immune responses, make notes about what you learned about the innate immune response below.

    a. Innate immune response:

    Notes will vary. They might include:

    - *Is the first line of defense against pathogens. It either destroys all the pathogens or holds them off long enough for the adaptive immune system to kick in.*
    - *Happens very quickly after a pathogen attack.*
    - *Includes the skin and mucous membranes, as well as innate immune cells.*
    - *Includes special white blood cells called phagocytes that recognize and destroy invading pathogens.*
    - *Is non-specific; innate immune cells can recognize and destroy a wide range of pathogens but cannot distinguish between them.*

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b. Fill in the blanks below using the words from the word bank. A word can be used more than once.

Word Bank
Mucous membranes, non-specific, pathogens, phagocytes, quickly, skin

The **innate immune system** is our first line of defense against *pathogens*. It includes physical barriers such as the *skin* and *mucous membranes* that prevent *pathogens* from entering our bodies. If they breach these physical barriers, special white blood cells called *phagocytes* attack the invading microbes and destroy them. Their specific pattern-recognition receptors allow them to tell foreign intruders apart from body cells. Innate immune cells respond very *quickly* but are *non-specific*, which means they can recognize and destroy a wide range of *pathogens* but cannot distinguish between them.

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2. While watching the videos and discussing the different types of immune responses, make notes about what you learned about the adaptive immune response below.

   a. Adaptive immune response:

   Notes will vary. They might include:

   - *Is the second line of defense against pathogens.*
   - *Is much slower than the innate immune response.*
   - *Is triggered by innate immune cells.*
   - *The key players of the adaptive immune response are T cells and B cells.*
   - *B cells produce antibodies, the immune system's ultimate weapon against pathogens.*
   - *Antibodies have antigen-binding sites that target a specific antigen. Once antibodies bind to an antigen, the pathogen is flagged for destruction.*
   - *During a primary immune response, the adaptive immune system creates memory cells. Memory cells are long-lived B cells and T cells that can remember a specific antigen in case the immune system encounters it again in the future.*

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b. Fill in the blanks below using the words from the word bank. A word can be used more than once.

Word Bank
Antibody (antibodies), antigen(s), antigen-binding sites, B cell(s), innate immune cell(s), long-lived, memory cells, pathogens, primary, second, slower, specific, T cell(s)

The **adaptive immune** system is the *second* line of defense against *pathogens* and is much *slower* than the innate immune response. It is activated by *innate immune cells*. The key players of the adaptive immune response are *B cells* and *T cells*. A critical part of the adaptive immune system are *antibodies*. These y-shaped proteins are produced by *B cells* and are the ultimate defense weapon against pathogens. The variable regions at both tips of the Y contain *antigen-binding sites* that are tailored to identify a specific *antigen*. *Antigens* and *antibodies* work like a lock and key mechanism. This makes the adaptive immune response *specific*, which means it can target one pathogen. The first time the adaptive immune system faces a pathogen, also called the *primary* immune response, *memory cells* are produced. *Memory cells* are adaptive immune cells that are *long-lived* and can remember a specific antigen in case the immune system encounters it again in the future.

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Explore

Part 1: Antigen-Antibody Matching

1. Carefully look at the antigen and antibody cards. Write down your observations below.

   Student answers will vary. They should have noticed:

   - *The y-shaped structure of the antibodies.*
   - *The different variable regions (antigen-binding sites) of the antibodies.*
   - *The different shapes and antigen symbols of the pathogens.*
   - *That each antibody matches only one of the pathogens (antigens).*

2. Make notes about what you have learned about the structure and function of antibodies below.

   Student answers will vary. They might include:

   - *Antibodies are y-shaped proteins with a constant region and a variable region. Antigen-binding sites exist at the tips of the variable region.*
   - *Antibodies are specific and only match one antigen. Antibodies and antigens work like a lock and key mechanism.*
   - *Antibodies bind to their matching antigen and flag it for destruction.*

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Part 2: Vaccine Factory

1. In your own words, describe what a vaccine is and how it works.

   Student answers will vary. They might include:

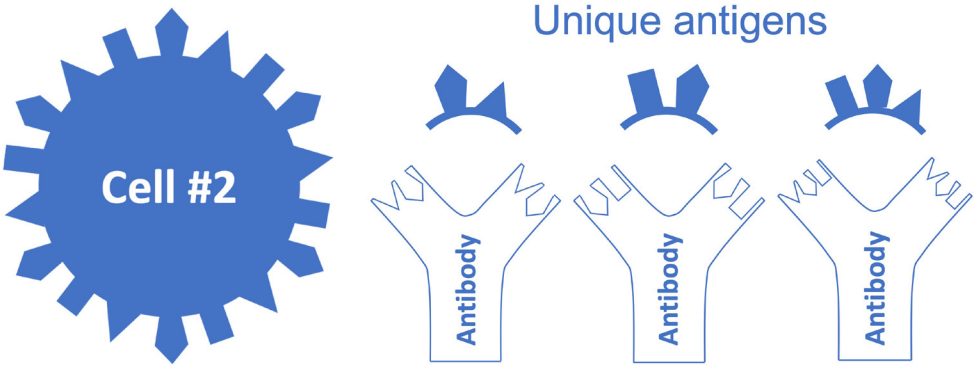
   - *Vaccines present the body with a pathogen's antigen(s) without making the individual sick. This is typically done in one of several ways:*
     - *A vaccine that has weakened or otherwise inactive forms of the pathogen*
     - *A vaccine that is made up of the pathogen's antigens*
     - *A vaccine, like the COVID mRNA vaccines, that instructs the body to make the pathogen's antigens, which it then produces antibodies against*
   - *All types of vaccines trigger a primary immune response against that pathogen and thus help our body make antibodies that recognize and destroy the disease-causing pathogen once there is a real pathogen attack.*
   - *Some vaccines, like the flu vaccine, need to be refreshed regularly due to antigenic drift.*

2. Which cell number is your disease-causing pathogen:

   Cell # *depends on the note the student group received.*

3. Draw the specific antigen(s) that you have selected for your vaccine below.

   The selected antigen(s) depend on the cell number the students received. One example that shows possible unique antigens for cell #2 and their corresponding antibodies is shown below.



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4. Make a drawing of your vaccine-induced antibody below.

   The antibodies depend on the cell number the students received. One example that shows possible unique antigens for cell #2 and their corresponding antibodies is shown with question 3.

Part 3: Antigenic Drift

1. Which cell number is your mutated disease-causing pathogen or your new pathogen variant:

   Cell # *depends on the new note the student group received.*

2. Would your mutated pathogen variant be able to escape your vaccine-induced antibodies from part 2? Explain why or why not below.

   Most likely, the mutated pathogen will be able to escape the vaccine-induced antibodies. The unique antigens selected earlier targeting this specific pathogen are not identical in the pathogen variant. This means the vaccine-induced antibodies will not be able to bind to the new pathogen variant.

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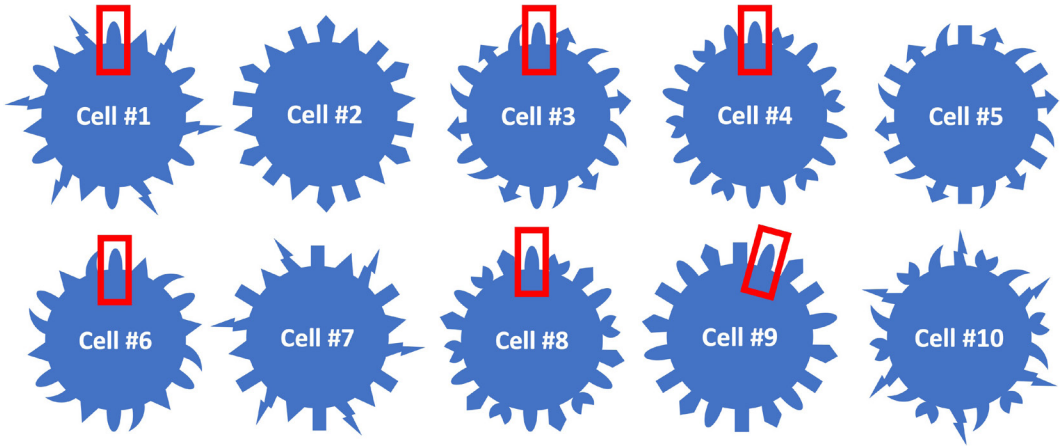
Vaccine Adjustment Activity

Each cell of the vaccine factory card set now represents a mutated variant of the same pathogen. You will find that some of the pathogen variants have similar antigens while others are different. Your task is to develop an adjusted vaccine that can target as many pathogen variants as possible.

1. Draw your adjusted antigen(s) below.

   Student answers will vary. One possible solution is shown below.



2. Draw your adjusted vaccine-induced antibody below.

   Student answers will vary depending on what their adjusted antigens look like. The vaccine-induced antibody matching the above antigen example is shown below.

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3. Explain in your own words why you chose these antigen(s) for your adjusted vaccine.

   Student answers will vary. They should argue that the antigen they chose is present in many of the pathogen variants and thus makes a good vaccine target.

4. How many of the pathogen variants does your adjusted vaccine target?

   Student answers will vary depending on what their adjusted vaccine looks like. The adjusted vaccine example above can target six pathogen variants simultaneously.

Reflect

1. Write down any questions that you still have about our immune system, antibodies, vaccines, or other topics covered in this lesson.

   Student answers will vary.