Acting Out the Immune Response

An Activity for the Middle School Life Science Classroom

by

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I. Overview

Concepts covered in this activity are innate and adaptive (learned) immunity by acting out the nonspecific and then specific response of the immune system toward an invading pathogen. The topics to be covered in this activity are: the first line of defense with the skin, inflammation, macrophage response, T helper cell response, cytokine messaging, B cell response and antibody recognition of antigen, antibody and memory cell production, and T killer cell destruction of the antigen.

The goal of this activity is to have a class of middle school aged students act out the immune response to bacteria and viruses in order to better understand how it works. Each student will have a given role in this activity, and props will be provided. By having a role in the immune response it personalizes the actions of the immune system and gives students insight as to how their body fights disease.

II. Science Background

In the human body, there are multiple lines of defense in order to fight infection. The first line of defense is the skin. The skin acts a physical barrier to any foreign invading pathogens, or disease causing agents. Such agents could include a wide variety of pathogens such as viruses, bacteria, protozoa, fungi, venom, or parasites. If one of these pathogens does enter the body, it is met by a host of other defenses. The pathogen is fought in a specific way depending on what type it is.

One form of defense the immune system offers is called the innate response. The innate response is carried out by phagocytic cells that ingest foreign invaders and digest them in order to destroy them. This form of response is considered to be “non-specific” because there is no exact recognition factor between the invading pathogen, and the phagocytic cell.

Another form of defense is called the adaptive immune response because in this response, the immune system specifically recognizes individual pathogens. In this case, a molecule that the body produces called antibody recognizes a particular molecule on the surface of a pathogen called an antigen. Antibodies are produced by white blood cells called B lymphocytes. Once an antibody has recognized an antigen, B and T lymphocytes help launch a full attack on the pathogen.

There are different types of T lymphocytes that carry out differing functions. Some T lymphocytes interact with phagocytes to help destroy pathogens, while others attack virus ridden body cells directly. Still another type of T lymphocyte stimulates B lymphocytes to produce large amounts of antibody specific to the pathogen being attacked so that the antibody can mark the pathogen for T cell recognition and destruction.

B lymphocytes mainly produce large amounts of antibody, and can also produce memory cells. Memory cells stay in the blood stream and will produce mass amounts of antibody for a specific antigen if the body is presented with it a second time.

Specific antibody recognition of antigen is crucial in the body's ability to combat a pathogen. The body cannot rely solely on non-specific recognition and destruction of pathogens by phagocytes alone. It needs to use a specific targeted response in order to fight infection.

III. Student Outcomes

Content material will include a class demonstration of the immune response as well as discussion to follow. From this activity students will learn the lines of defense the body has including: the skin, macrophages, T cells, B cells, antibodies, and the ability to create memory cells. They will also learn the function of each line of defense as well as its role in fighting foreign invaders. Each student role in the activity will demonstrate a segment of the immune response.

IV. Learning Objectives

The students will be able to:

1. Demonstrate by acting out:
    - How pathogens enter the body.
    - The role of macrophages in destroying pathogens.
    - The role of T helper cells in the immune response.
    - The messenger role of cytokines.
    - B cell activation and antibody recognition of antigen.
    - The role of T killer cells.
    - The production of antibody by B cells.
    - The production of memory cells.
2. Describe the overall process of the immune response.
3. Distinguish between innate and acquired (learned) immunity.
4. Describe how vaccination prevents a pathogen from causing illness. (optional)

V. Time Requirement

This activity may be played out in one class period and processed in another, or it may be played out in steps and processed in between each step. Either way, it will take two to three 45 minute class periods.

It may be most useful to break the activity into separate steps and to provide the students with a step-by-step question guide that will lead them through the process. This way, breaks can be taken in between each portion of the process, and the class can discuss what has happened in each step before answering the guiding questions on their sheet. Then, the whole process can be run through again with no interruption.

VI. Advance Preparation and Materials

In order to prepare, you will need a script. This will help you to lead students through their roles. A sample one will be provided here. You may hand out copies of the script, or read and guide the students yourself for the first round through. Students should also have a description of what their role is so when the time comes they can explain what function their role is performing. Their description may be pasted onto the back of their prop.

Props for each student will also be needed. For a class of twenty four, you will need cut outs of the following objects:

- Five bacteria cells with the same specific antigen on each cell surface.
- One set of non-white blood cell blood components. Cut outs of platelets, plasma, and red blood cells.
- . Two to three cut outs of macrophages.
- Multiple antigen shaped cut-outs that the macrophage will present to the T helper cells.
- One T helper (Th) cell with a T helper receptor on its surface that matches the shape of the antigen pieces presented by the macrophage.
- One T cytotoxic (Tc) cell with a T cell receptor on its surface to recognize virus fragments.
- One virally infected cell with virus fragments on its surface to match the Tc cell receptor.
- One cytokine messenger.
- Four B cell cut-outs with antibodies, three that don't match the antigen, and one that does.
- Three cut outs of matching unattached antibodies that match the antigen.
- Four new memory B cells with antibodies that match the antigen.
- One or more virus cut-outs.
- One or more virally infected body cells with virus fragments on the cell membrane.

By color coding each category of cut-outs, students will have an easier time visually remembering the process.

Each cut-out should also have the name of the object on the front as well as a description of its function on the back.

These numbers of props and roles can be adjusted depending on personal need and class size. The props may be made from construction paper cut-outs.

VII. Student Prior Knowledge and Skills

The students should have a general introduction to the immune system including its parts, and its function. Since the activity focuses on the function of each of the major parts of the immune system, it is not necessary to give the function of each part prior to doing the activity.

Vocabulary that students should be familiar with prior to the activity includes: antigen, antibody, bacteria, B cells, macrophages, pathogens, T cells, and viruses. Vocabulary that will be introduced in the activity includes: cytokine, inflammation, memory cells, T helper cells, and T killer cells.

VIII. What is Expected From Students

Students will be expected to participate in the activity, answer the guiding questions that take them through the activity, and participate in discussion of the activity. Students will also be expected at the end of the unit to display their knowledge in one of the three ways discussed in the assessment section of this paper.

In assessing students, depending on the form of assessment, special accommodations may be made for individuals by providing a word bank for the assignment as well as giving the option to use pictures to support any written work.

IX. Anticipated Results

The anticipated results for this activity would be for each student to be able to demonstrate knowledge of the concepts of basic immune response covered in this activity by using writing, pictures, or manipulation of objects.

X. Classroom Discussion

The following questions are sample questions to be given to students to use as a guide through the activity as well as for discussion after the activity.

1. What is the first line of defense that an invading pathogen must cross?
2. What is the purpose of inflammation?
3. What is a macrophage, and what are two of its roles in the immune response?
4. Once a T cell recognizes a piece of the pathogen what does it do to get the attention of the B cells?
5. What is a cytokine?

6. Once B cells arrive on the scene, what is on the pathogen that will help the B cells recognize it?
7. What structure is on the B cells that helps them recognize the pathogen?
8. What must happen between the B cell and the pathogen in order for the B cells to help out?
9. What are two things that B cells do when the pathogen is "recognized"?
10. What is the role of T killer cells?
11. What is the role of B memory cells?
12. What part of this immune response was an innate response?
13. What part of this immune response was a learned response?
14. Please write out below in short steps what has happened in the activity. When you are finished, take turns and describe these steps to a partner. Make any corrections you need to make.

XI. Possible Assessment

There are many possible modes of assessment for this activity. One possible mode of assessment would be to require that the students write an individual essay describing what they acted out together in class. The essay could include pictures to help support written work.

Another assessment could be to ask each student individually to use the props from the activity to describe what happens in the immune response. Other sets of these props could be provided to groups of students for practice of the immune response prior to quizzing.

A third assessment could be a group assessment having the students as a group develop a poster, story, map, rap, song, poem, metaphor, or presentation of choice to indicate their knowledge of the topic.

Concept maps may be used as well to diagram the immune response.

THE ACTIVITY

XII. Rationale: For Students

The reason for doing this activity is for you to be able to act out and then describe how your body fights pathogens such as viruses and bacteria that you come into contact with every day. In this activity, each of you will play a part of the immune system in fighting a pathogen. The classroom represents the body, and the classroom door represents the protective covering, the skin.

One day you were out planting in your garden when OUCH!!! you got stuck with an old nail in the soil. You ran inside to rinse the wound, but the nail had pushed some bacteria into your skin and it entered your bloodstream. What did your immune system do about this?

Note: You may change the story so that it is a different pathogen such as a cold virus invading a body cell. However, the way the virus is fought is slightly different. This is why in the following section both macrophages and T killer cells are involved in the destruction of the pathogen. See bottom of next section for further explanation.

XIII. Materials and Procedure

Hand out all the props to the students, and designate areas for each student or group of students to stand. Then begin reading the script.

BACTERIAL INFECTION

1. The bacteria has entered the body through the skin! Students with bacteria roles enter through the door.

2. Inflammation occurs and the blood rushes to the area of infection in order to help fight it. The T helper cell, macrophages and other blood components rush to where the bacteria is.

3. The macrophages gobble up some of the bacteria, but can't get it all. They need help! Only two of the bacteria cells are destroyed. (A discussion of phagocytosis could take place prior to the activity so that students can explain how these bacteria are being "gobbled up".) Or, an explanation of phagocytosis could be placed on the information card on the back of the macrophage cut-out for students to refer to while acting out the process.

4. The macrophages show the T helper cell the parts of the bacteria that it ate up.

5. Now that the T helper cell knows there is a problem, it sends a messenger, the cytokine to get the B cells. The cytokine goes over to where the B cells are waiting and calls for them to help.

6. The B cells rush to the scene, but only the B cell with the matching antibody can really help. The others have to go find another infection to fight.

7. When a match is found, the B cell makes multiple copies of the antibody it has on its surface. Antibodies appear at the scene.

8. The antibodies attach themselves to the antigens that are present on the bacteria cells.

9. Once the antibodies are attached to the antigens on the bacteria cell, the messenger is then sent to get more macrophages.

10. The macrophages find the bacteria with the antibodies attached to them and (not so violently) put to death the bacteria cells by way of phagocytosis.

11. Meanwhile, the B cell that recognized the antigen is replicating and making memory cells with the same antibody on them so that if this bacteria comes back they can recognize it more quickly and destroy it.

VIRAL INFECTION

1. A virus enters the body through a mucus membrane. A student with a virus card walks through the door of the classroom.

2. The virus enters a body cell by puncturing its cell membrane. Student with virus card describes this process which is written on the back of the card.

3. The virus begins to replicate inside the cell. The student with the infected cell may describe how this happens. This process should be written on the back of the body cell card.

4. Fragments of the virus are presented on the body cell membrane.

5. A passing T cytotoxic cell does not recognize the fragment as being a part of the body and binds to the fragment with its receptor.

6. The T cytotoxic cell then releases toxin that causes holes to form in the cells membrane, and the cell lyses. This process is described by the Tc cell.

7. After the cell explodes, virus fragments are recognized by a B cell with a matching antibody.

8. The B cell makes multiple antibodies that match the virus fragments and bind to the fragments and deactivate them.

9. Macrophages then recognize these tagged viruses with antibody as being something that needs to be cleaned up, and ingest them.

10. B memory cells are then made in case the virus returns, there will be a stronger response of B cells with matching antigens against the virus.

XIV. Discussion

Please see section X. Classroom Discussion, for discussion questions. Another useful discussion after this activity would be that of vaccination. You could call the invading bacteria tetanus, and then discuss how vaccines such as the tetanus shot actually inject some of the antigen either a small amount or an un-harmful strain into the body so that B memory cells are created to recognize and de-activate the antigen when and if it does enter the body.

XV. Credits

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Informational Sources:

Immunology Fourth Edition, Roitt, Bradstoff, and Male. Copyright 1996, Mosby, Times Mirror International Publishers Limited. Barcelona, Spain.