Acting Out Immunity: A Simulation of a Complicated Concept

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The activities of the immune system are quite complex and abstract for the average high school biology student to understand. Yet the immune system is of major importance to us all. The Acquired Immune Deficiency Syndrome (AIDS) epidemic has grasped the imagination of the world. Autoimmune conditions such as multiple sclerosis strike much of our population. And what student is not touched in some fashion by allergies? Daily battles that take place in the human body that protect us from infection and cancer constitute a phenomenon of grave significance.

In order to facilitate student comprehension and retention of these complicated processes, we have designed a lecture and play in which the students themselves become the elements of the immune system. Of course the facets of the immune response are simplified, but we feel that the basic core of knowledge is there in a very useful form.

Objectives

Upon completion of this unit the students will be able to:

1. Name the major cellular and humoral components of the immune system.
2. Understand the specificity of antibodies.
3. List the functions of the major cell types of the immune system.
4. Understand the functions of cytokines in the immune system.
5. List the sequence of events of cellular response to antigens.
6. Apply their knowledge of the immune system to AIDS.

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Outline

1. The instructor will discuss the major components of the immune system and their functions (one class period.)
2. The instructor will demonstrate the desired activity by talking one group of students through the model. (This step takes about 10 minutes.)
3. In teams, the students will act out the major events of the immune response, each playing an assigned part. (This occupies the remainder of the class period after Step 2.)
4. The students will answer the question set about the immune system.

Background Information Sources

Many references are available that you may use to become familiar with this subject. The September Issue of *Scientific American*, 1993, is devoted to the immune system. This is a good general review for the instructor preparing to teach this subject.

There are a number of texts available as well. A quick look in a university bookstore will show you the range. One useful little volume is *Introducing Immunity* (2nd ed.) by Staines, Brostoff and James. It is small—only 142 pages—and has excellent illustrations.

We recommend *Science News*, a weekly publication that often has articles on the latest happenings in immunity to keep you up-to-date. It is accurate and well-written. We often have our students read articles from this magazine since it is not loaded with jargon and is succinct.

In addition, the June 1986 issue of *National Geographic* contains an article about immunity that has some wonderful microscope pictures of immunity in action and diagrams. It is well worth a look even though it is somewhat dated. References are provided at the end of the article.

Lecture Outline

1. An antigen (e.g. a virus) enters the body after overcoming the body's first nonspecific defenses such as the acids of the stomach, the protective wall of the skin, or the mucous membranes.
2. A macrophage engulfs the virus nonspecifically.
3. The macrophage then "digests" the virus and displays peptides (short "protein chains") from the antigen on its own surface.
4. Helper T-lymphocytes (helper T-cells or CD4 cells) carrying the antigen binding sites specific for that antigen detect the macrophage and lock onto the foreign peptide.
5. The population of that type of helper T-cell increases in blood and tissue fluid due to cytokines (hormones) from the original macrophage.
6. Helper T-cells activate killer T-lymphocytes (killer T-cells or CD8 cells) and B-lymphocytes (B-cells) to react to the specific antigen.
7. Helper T-cells cause killer T-cells and B-cells as well as themselves to proliferate in response to other cytokines.
8. B-cells differentiate into short-lived plasma B-cells that secrete antibodies (proteins that inactivate specific antigens) and into long-lived memory B-cells that have the potential to respond to the same antigen quickly after subsequent exposure.
9. Macrophages engulf inactivated viruses.

10. Killer T-cells puncture cell membranes of cells hosting the virus.
11. T-cells and plasma B-cells die off after the virus is gone.
12. Memory B-cells live long and can mount a quick attack if reinfection takes place.

The Players

- Viruses (at least 6)
- Macrophages with bed sheet (1–3)
- Helper T-cells (6)
- Killer T-cells (3)
- Narrator (1)
- Plasma B-cells (3)
- Memory B-cells (3)
- Body cells (1–3)
- Evaluators (3)

Props

- M&M candies, one-pound bag
- Bed sheet (1 per team)
- Viral antigen labels (See Figure 1):
  Square shaped (2)
  Polygon shaped (2)
  Circle shaped (2)
- Antibody models (toy handcuffs with square-, polygon- or circle-shaped template attached with pipe cleaner) (3) (See Figure 2.)[1]
- Killer T-cell labels shaped like square, polygon or circle (3) (See Figure 2.)
- Water pistol for T-cell (3)[1]
- Macrophage cell labels (1–3) (See Figure 3.)
- Helper T-cell labels (6) (See Figure 4.)
- Body cell labels (1–3) (See Figure 5.)
- Killer T-cell labels (3) (See Figure 6.)
- Memory B-cell labels (3) (See Figure 7.)
- Plasma B-cell labels (3) (See Figure 8.)
- Copy of the student narrator guide (1 per team)

Instructor Guide

There will be two or three teams, depending on class size. A class of 26–30 can accommodate three teams. Each team will have the ability to fight a specific foreign protein.

The instructor will demonstrate the correct procedure for the immune response by serving as narrator for one team of students while the other mem-

[1] Toy handcuffs and water pistols can be obtained (cheaply) at the party favor section of your local variety store.

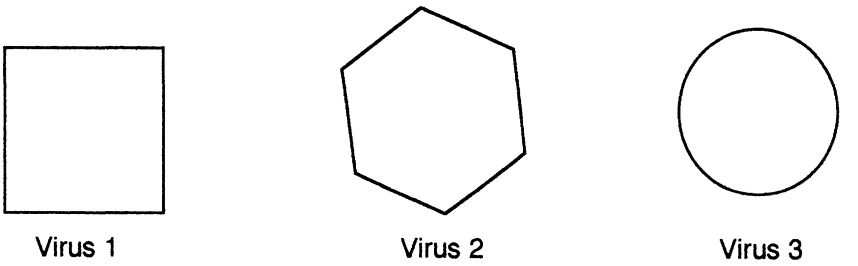

Figure 1. Viral antigens.

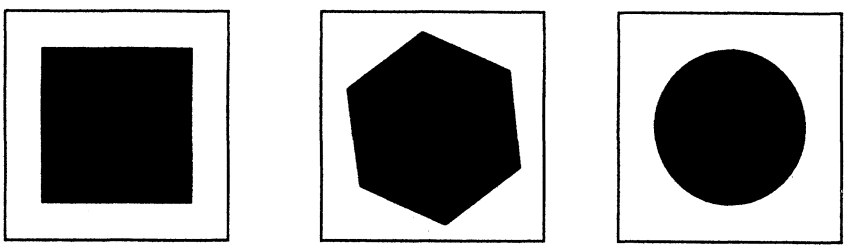

Figure 2. Antibody templates and T-cell receptors.

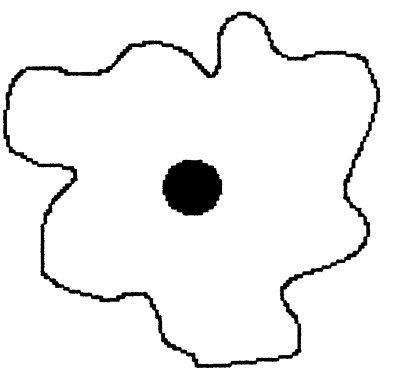

Figure 3. Macrophage cell.

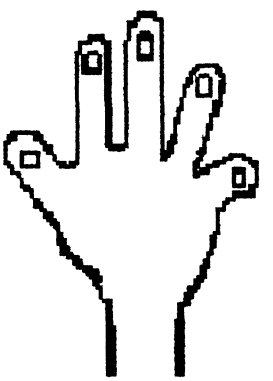

Figure 4. Helper T-cell.

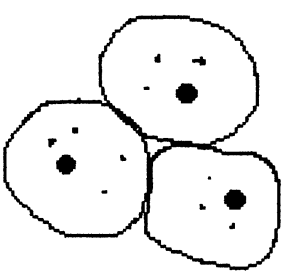

Figure 5. Body cell.

Figure 6. Killer T-cell.

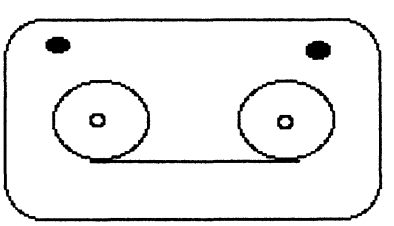

Figure 7. Memory B-cell.

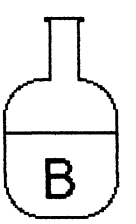

Figure 8. Plasma B-cell.

bers of the class watch. Then each student will receive a label indicating his/her assignment on a team. An observer/evaluator will be assigned to each team to assess that teams' correct progress through the immune response. The observer/evaluator will record the teams' progress on a data sheet without giving advice. The observer/evaluator may be asked to give an oral critique of the teams' performances.

After team assignments are made and props are provided, allow the teams to practice. It is a good idea to hold on to the candy and water pistols until the official performance.

When the teams are ready, they perform the play. Afterward the observer/evaluator critiques the teams' efforts.

Time permitting after the evaluation phase, the team can do a repeat performance. This would add practice and ensure students are learning the correct sequence of the immune system's responses.

Student Narrator Guide

Student narrator reads or paraphrases Steps 1–12 as students carry out the actions.

1. A virus invades a body cell. Inside that cell it commandeers the cell machinery and makes replicas of itself. The virus enters a body cell (under the bed sheet) and five viruses emerge.
2. A macrophage engulfs a virus and "digests" it. The macrophage displays pieces of the antigen proteins on its surface. (Circle, polygon or square labels can be displayed.)
3. A helper T-cell detects this marker and recognizes that it is foreign.
4. The macrophage gives cytokines (candy) to the helper T-cell and it proliferates.
5. The helper T-cells give off cytokines (candy) that stimulate B-cells and killer T-cells to proliferate.
6. Helper T-cells also cause B-cells and killer T-cells to recognize the invading virus. (Narrator gives students copies of the antibody and killer T-cell receptors.)
7. B-cells differentiate to plasma and memory B-cells.
8. Plasma B-cells produce an antibody. The antibody matches the viral antigen and attaches to the viruses making them clump so that the macrophage can engulf them more easily. (Narrator handcuffs viruses and macrophage surrounds them with the sheet.)
9. Killer T-cells match the template with the viral antigen and kill the virus with toxins (water pistol). The virus dissolves. This step repeats until the last virus is killed.
10. Infection over, all the T-cells and B-cells die except for the memory B-cells.
11. Memory cells wait for more invaders.
12. A sixth virus with one of the original antigens comes on the scene. (What do memory B-cells do?)

Using This Activity with Classes

The detail as to what students should do for the 12 steps has been kept sketchy on purpose. This gives the students the chance to be creative. As they work through the problem of depicting these events, they will question you as to whether or not certain events are correctly represented by their proposed activities. At this point you can teach them the details. This is where you have a chance to dispel the fallacies.

We have tried this activity with classes and it works well with 11th and 12th graders. It generates a high degree of interest and seems to increase student understanding. It helps to inform the students prior to the performance that they will be allowed to use some props that can be misused. If a team grade is awarded, the students seem to police themselves.

To further encourage the students to be on their best behavior, you could choose the "best" group to give a command performance. In this case they would perform, for the entire class, the extension (see below).

Of course individual instructors will find ways to modify this activity according to his/her student needs or situation.

Extension

Have one of the groups simulate an immune system that has AIDS. In this case the T-cells are inactivated. Allow the selected team to discuss what would happen in such a case and then to perform their interpretation for the class.

Topics for Discussion

1. Name at least three of the first lines of defense that viruses must penetrate in order to initiate the immune response.
2. How are macrophages different from T-cells and B-cells in the types of antigens to which they react?
3. What does the candy passed to the various cells represent?
4. What did the handcuffs represent? (Answer: agglutination antibodies.)
5. How did the T-helper cells know that the body had been invaded?
6. What did the squirt guns represent? (Cytotoxins)
7. What did the tape player on some B-cell labels represent?
8. Which cell types orchestrate the immune response? (Helper T-cells)
9. How many types of viruses can one antibody disable?
10. Why do we keep immunity for a long time after an infection is over?
11. What stopped the immune activity?
12. What if the B-cells and T-cells didn't die quickly?
13. Sometimes the immune system reacts to certain parts of the body as if it were foreign. What would happen if the immune system attacked the insulating myelin sheath around nerve cells in the central nervous system?
14. Name two other antigens besides viruses.
15. The AIDS virus attacks the helper T-cells. Explain how the immune response would be affected if these cells were in short supply.
16. Why is it said that people don't die directly from AIDS?

References

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