**A System of Many Hats: Immune Response**

**-Play/Modeling Activity**

**Overview:**

This activity will be a simulation of what happens when a pathogen enters the body.

**Learning Objectives:**

1. Students experience what the different parts of the immune system do
2. Summarize what may happen when a pathogen enters the body

**Background:**

An immune response involves events that unfold both locally, at the site of an infection, and at more distant sites, such as nearby lymph nodes. We can see the integration of the different parts of the immune response if we follow the course of a typical infection. Most pathogens are kept outside of the body by epithelial barriers, such as the epidermis and layers of cells that line hollow organs and glands, and are crossed only when there is an injury or tissue damage.

After an injury, bacteria/virus cross the epidermis and establish an infection in the underlying tissue. Phagocytic cells in the tissues, such as macrophages and neutrophils, engulf the pathogen. Certain immune cells like macrophages and dendritic cells have special toll-like receptors (TLRs) that recognize distinctive molecules from bacteria and viruses (e.g. lipopolysaccharide from bacterial cell walls). When they recognize something non-self (antigen) they signal the release of inflamatory cytokines.

Dendritic cells, another type of phagocytic cell, leave the site of infection and migrate to a nearby lymph node. The dendritic cells are collected in a draining lymph node (one or ones nearest the stie of infection), where they present pieces of the antigen to activate T cells, which in turn activate B cells to secrete antibody that specifically recognize the antigen. Effector T cells and antibody molecules return to the circulation, headed back to the site of infection.

In the meantime, tissue damage has triggered an inflammatory response at the infection site. Mast cells release histamine from their histamine granules into the surrounding tissue. Histamine diffuses into the capillaries, causing them to dilate and become leaky. As plasma leaks into the tissue, the area swells – this process is what causes inflammation. In damaged or infected tissue, complement proteins and other chemicals also attract phagocytes into the area, which engulf and digest dead cells and bacteria.

When effector T cells and antibody molecules reach the infection site, CD4 T cells activate macrophages to become killing machines, while antibodies bind to the antigens on the pathogen, both to recruit complement proteins to lyse bacteria directly and to opsonize them (mark for ingestion by phagocytes). In the case of a viral infection, dendritic cells activate CD8 T cells that kill any infected cells.

Note: activation of naïve B and T cells results in the production of effector cells, which go to work right away, and memory cells, which can survive in a functionally inactive state for many years after the antigen is eliminated. Memory cells mediate a rapid and enhanced (recall) response to second and subsequent exposures to antigens (this is what you are aiming for when you vaccinate someone).

**See Garland Science Animation** → [The Immune Response](http://www.garlandscience.com/garlandscience_resources/resource_detail.jsf?landing=student&resource_id=9780815342434_CH11_QTM01)

**Time required:**

40-60 min depending on the discussion

**Materials:**

construction paper

staplers

string

markers

tape

printed and cut out cards

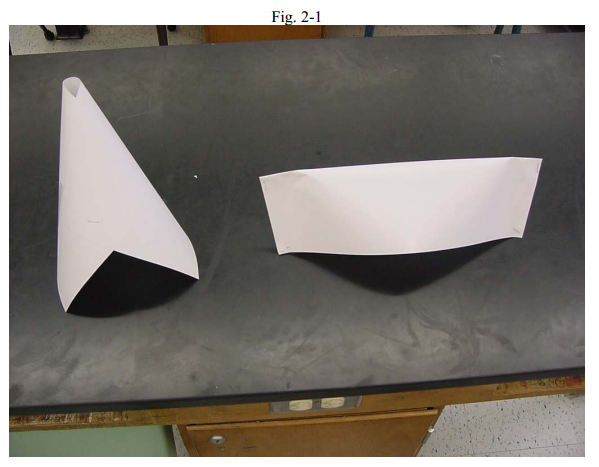
* Print out cards and signs (“Infected” and “R.I.P.”), cut them up, and separate.
* Also Print “Infection Site” and “Lymph Node” signs.
* Antigens and Antibodies are represented by paper hats. These can be made using:
  + White paper and distinguished by symbols (students can use markers to make them different)

**–OR–**

* + Differently-colored paper (e.g. red for antigen (bad), green for antibody (good), etc.)

**–OR–**

* + Antigen hats can be party hats with elastic to help them stay on better, and the antibodies must be created out of paper to match the shape
  + Some options for the Antigen/Antibody paper hats are shown below



**Setup:**

* Classroom wall with a door leading to the hallway – simulates skin
* Open door – symbolizes a cut
* “Infection Site” sign should be placed by a door. “Lymph Node” sign should be placed in the opposite corner.
* Desk near the infection site should be used to hold a supply of antigen hats and “Infected” signs. Each time the pathogen wants to infect a cell, they should pick up one hat and one sign before going over to a Body cell. (This will help slow down the rate of infection).
* The dendritic cell or macrophage traveling to the lymph node will weave in between rows of desks/tables – lymph vessels
* On a desk in the lymph node area place supplies (paper, staplers, markers, etc.) for making antibodies. The naïve T and B cells also stand near this desk.
* All students will receive a card with their role on it (see below) and must follow the card.

|  |  |  |
| --- | --- | --- |
| **Immune Cell/molecule** | **# of Students** | **Summary of Roles** |
| Macrophage | 1 | One will kill a bacteria, and present antigens from it to T cell in lymph node. This will activate T cells which in turn will stimulate specific B-cells to produce antibody. It will then return to the area of infection. |
| 1 | The other will kill bacteria in the area unless directed by a T cell. |
| Pathogen  (Bacteria) | 2 | Stand next to body cell, give an “Infected” sign, and count to 25 (TIME CAN BE CHANGED TO MAKE THE INFECTION HAPPEN MORE QUICKLY). When time is up, give an antigen hat to body cell to represent cell has died and more bacteria has emerged. |
| Antigen | Have  10-12 pre-made | This is a paper hat worn by pathogen. |
| B Cell | 2 | Make paper antibodies the fit the antigens (ideally – same hat shape but different color or marking). These hats will be made in the lymph node and the “Antibody” will be passed along to students who will carry them to the infection site. |
| T Cell | 2 | This is activated by macrophages. As a result of this activation  One T cell will become a Helper T and stimulate macrophages (at the site of infection) by giving it a supply of “RIP” cards.  Another will become a Killer T cell and kill virally infected cells. |
| Antibody | 2-4 | Students will carry antibodies made by B cells to the infection site to bind with antigen, (since paper antibodies can’t carry themselves). |
| Body Cell | Remaining Students | Play along.  Some will be infected and killed by the pathogen. |
| Memory Cells |  | May want to mention naïve T and B cells also differentiate into memory cells that can initiate a more rapid response if subsequent exposure to a pathogen occurs. Put Antigen hat in a file folder to represent this. |

* Read the Role Cards to gain a better understanding of what each student will do. *READ CAREFULLY—*Macrophage and T cell cards have different descriptions
* Assign each Macrophage an area along the “skin” wall. The one Macrophage with a “★” on the card should be placed closest to the door. All other Macrophages must stay in their area unless recruited by a Helper T cell. Give out a few “RIP” signs to each Macrophage.
* All B cells, T cells, and Antibodies start in the “Lymph Node” area
* Body cells should spread out evenly among the Macrophages
* Pathogen (Bacteria) will start outside the classroom and be invited in on cue.

**Pathogen (e.g. bacteria)**

**Door**

**BC**

**Mac**

**BC**

**BC**

**BC**

**BC**

**BC**

**Mac**

**Mac ★**

**BC**

**BC**

**BC**

**Desk hats/ signs**

**Bs**

**Abs**

**Ts**

**Lymph**

**Node**

Some rules to remember:

* To infect a cell …
  + Pathogen stands next to a cell and gives the cell an “Infected” sign.
  + Count to 25.
  + After this time, put a hat on the cell—they have now become a pathogen!
* Pathogens cannot be eaten by a macrophage if inside a cell (i.e macrophages can’t touch them if they are counting after infection)
* Pathogens can only be eaten if they have been hatted with an antibody (except for the first one). Macrophage can then give an “R.I.P” sign to kill it.

**Simulating the Immune System**

To minimize chaos the first time around, walk the students through simulation using scenes. Students only move when referred to or directed by teacher. This way, everyone can focus on the series of events that unfold.

Some events in the scenario may be discussed, instead of acting it out (e.g. inflammatory response is happening simultaneously during Scene 2).

**Scene 1 (Infection Site)**

1. Person gets a cut; pathogens (e.g. bacteria) enter.
2. One macrophage recognizes the pathogen as foreign and eats it. *(Put an “RIP” sign on this bacteria).* The Macrophage takes the antigen from this bacteria to the lymph node to activate T and B cells.
3. In the meantime, the other bacteria is able to infect AND kill at least one body cell.
4. If the pathogen is a virus it specifically infects its target cells (ones that have a receptor for the virus). The death of these cells leads to release of new virus and fragments of the virus. This is picked up by macrophages and used to activate T cells in the lymph node.

**Scene 2 (Lymph Node)**

1. The macrophage presents the antigen to the T cells, which activates them (*the macrophage goes back to the infection site*).
2. T cells then activate B cells, which begin making lots of antibodies that are specific to the antigen.
3. Antibodies and activated T cells travel to infection site.
4. In the meantime, the other bacteria is able to infect AND kill at least one body cell.

**Scene 3 (Infection Site)**

1. Antibodies bind to bacterial antigen, marking it for destruction by macrophages. In the case of a viral infection the infected cells are marked for desctruction by Killer T cells.
2. Helper T cells stimulate macrophages to kill pathogens that are outside of their area.
3. In the meantime, the pathogens are each able to infect only one cell.
4. Macrophages eat the pathogens tagged with Antibodies (when not inside a cell).
5. Killer T cells destroy any cells that have become infected with pathogenic virus.

Allow students to switch roles and attempt to walk each other through the scenario again and put in the context of any pathogen. Discuss/role-play possible outcomes if the pathogens are bacterial, viral, or parasitic.

**Closure:** Create a concept map or flow chart about the immune response (application of knowledge).

**You are a Macrophage!**

Macrophages will eat pathogens if recognized as foreign. After digestion, this special immune cell can present antigen to T cells, which in turn triggers an immune response.

Viruses are safe once inside a cell. Kill a virus in your area, and then go to the lymph node with the antigen to present it to a T cell. Then, return to your area to kill more viruses (must now have an Antibody hat on to kill them).

**You are a Macrophage!**

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Kill the pathogens in your area if they have an Antibody hat on. The pathogen is safe once inside a cell. You may move to another site if told to do so (recruited) by a T cell.

**You are a Pathogen!**

The immune system can recognize bacteria, viruses, and parasites by their antigens. These antibody generators include capsule proteins, flagella, and toxin.

To infect a Body Cell, stand next to one, give it an “Infected” sign, count to 25, and then hat them. The cell now becomes another virus.

**You are an Antibody!**

An antibody is protein produced by Plasma B cells that can specifically bind to foreign substances (antigens).

Once you receive the antibody from a B cell, travel to the site of infection and “bind” with your specific antigen. Go back to get more antibodies if needed.

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Body cells can be susceptible to many infections without the protection provided by the immune system.

You are to cooperate with the other cells during this simulation (e.g. allow pathogens to hat you, no objections!). Carefully observe what is happening.

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**You are a B Cell!**

Once activated, B cells are responsible for making antibodies to a specific antigen that has entered the body.

Use the materials provided to make antibodies that specifically fit the antigen. Then send them to the infection site to take action (to do this, give your antibody to a student labelled antibody).

**You are a T Cell!**

Once presented with an antigen by a macrophage, T cells initiate a tailored immune response to the specific pathogen.

First, activate B cells—show them the antigen and tell them to start making antibodies. Then, head to the infection site to either make macrophages more efficient (give them more “R.I.P.” signs to use) or kill infected cells (Killer T) (give any “Infected” cell a “R.I.P.” sign).

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**R.I.P.**

**Infected**

**Infected**

**Infected**

**Infected**

**Infected**

**Infected**

**Infected**

**Infected**

**Infection**

**Site**

**Lymph**

**Node**