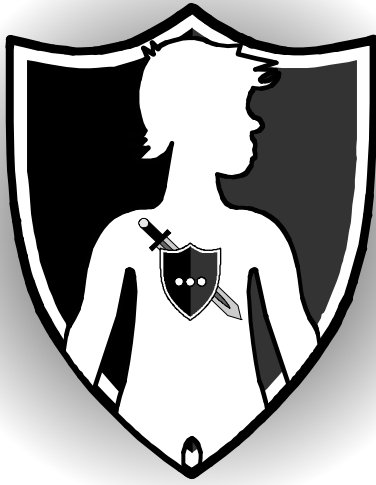


Activity on the IMMUNE SYSTEM:



The Body Fights Back

In this activity, the students will use a hands-on approach to learn about the immune system and how it fights off pathogens that invade the body. They use play dough to model the steps of the body battling several pathogens.

Background

The immune system, charged with the mission of protecting the body against attack, is the ultimate fighting machine. In fact, it helps to picture the immune system's efforts to keep the body healthy as a war against several enemies—the invading pathogens. **Viruses** and some types of **bacteria** are the common pathogens that the body must fight off, but **fungi**, **protists**, **helminthes** (worms), and **prions** can also invade the body.

The body's defense department doesn't have a single general leading the battle. Instead, its immune response is orchestrated by a variety of cells, organs, and organ systems. The **LYMPHATIC SYSTEM**, which includes a network of vessels and associated organs, plays a key role in defending the body. **LYMPH NODES** are densely packed areas of tissue that become swollen and sore in various areas of our bodies when they are working to filter out pathogens. The tonsils, thymus, and spleen also fight infection in the body. The circulatory system helps transport other important defenders, the white blood cells, around the body also.

LINES OF DEFENSE

The body can send troops to fight this battle on three different levels called the **FIRST**, **SECOND**, and third lines of defense. Many invaders are stopped by this first line of defense!

First Line. The soldiers in the **first lines of defense** are **NON-SPECIFIC**. They try to fight off anything they recognize as foreign to the body. For instance:

- the **skin** forms a barrier to keep pathogens out;
- **sweat** has enzymes that help prevent the growth of harmful bacteria;
- the **cilia** and **mucous** that lines the nose trap some invaders and move them toward the throat where they are swallowed;
- The **strong acids in the stomach** kill some bacteria and viruses that have been trapped in the mucous.

Second Line. If the first line of defenders fail, the second line of defense, called the **inflammatory response**, takes over. This is also a **NON-SPECIFIC RESPONSE** since the immune cells involved fight off *anything* they recognize as foreign. When tissue is damaged by injury or infection, the inflammatory response causes the area to become red and inflamed. Blood flow to the area increases, which brings **white blood cells**, which are also called **leucocytes**, (**loo-kuh-sites**) to the scene. There are several types of white blood cells, but only one is the non-specific “cell eater” variety that can roam around tissues seeking invaders. This type of white blood cell is called a **phagocyte** (**fag-uh-site**). Phagocytes surround and engulf pathogens and other unwanted materials. The pus found in an infected area is made up of dead phagocytes. (The term **macrophage** is sometimes used to refer to these pathogen-eating cells. A macrophage is the largest type of phagocytic cell and can engulf hundreds of bacteria at a time.) Sometimes the body develops a fever; this increases blood flow and speeds up the action of the phagocytes. Most of the time, the invasion of enemy pathogens is defeated by the body’s non-specific responses, but if the numbers of invaders are too great, or if the pathogens get past the first two lines of defense, the next line of defense will take over the fight. The phagocyte (macrophage) sends a message or activates a helper cell (often called a **helper T cell**) to notify the next line of defense to take over.

Third Line. The third line of defense has many more soldiers to help with the fight. They are all specifically designed to battle only one type of invader. The third line of defense can be divided into two types: a **cell-mediated response** or an **antibody-mediated response**. Together, these are referred to as the body’s immune response. When a foreign invader is detected, both responses are initiated. The cell-mediated response is faster, but the antibody-mediated response lasts longer.

There are several types of cells that take part in the body’s immune response, but the general name for all of them is **lymphocytes** (**lim-fah-sites**) because they are either stored or mature in the lymphatic system. (See note about lymphocytes on the following page.) The basic lymphocytes are two types of “B cells” (one type forms antibodies, and the other type recognizes invaders the body has dealt with before), two types of “T cells” (helper T cells and killer T cells) and, of course, the phagocytes.

What causes a lymphocyte to know that it is time to go to battle? The fight is on when they detect antigens, complex molecules often found on the surface of invading pathogens or formed on the surface of macrophages that have gathered many pathogens.

- The **cell-mediated response** (sometimes called the T cell response) begins when a helper T cell has been activated by recognizing a specific antigen that has formed on the surface of a macrophage that has eaten pathogens. The helper T cell touches a killer T cell and stimulates it to divide, sending out a large army of killer T cells in search of the invaders. When it finds them, it kills them by producing a protein that ruptures their cell membranes.
- The same type of helper T cell that starts the cell-mediated response also starts the **antibody-mediated response** (sometimes called the B cell response or the humoral response) at the same time. The antibody-mediated response provides a way for the body to respond more quickly (usually in 2-4 days) the next time it comes in contact with an

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antigen it has seen before on an enemy pathogen. In this process, a helper T cell activates a B cell, causing it to grow and divide. Some of the B cells produce antibodies. Antibodies are “Y” shaped proteins that are produced by the B cells in response to a specific antigen. They attach to the antigen like a key might fit only into a specific lock. The antibodies don’t actually destroy the antigen; instead, they mark them for destruction and cause them to clump together so that they can then be destroyed by macrophages. It can take two weeks or so for antibodies to form and fight off the invader, so the first time we are exposed to a pathogen, we sometimes do get sick. Fortunately, though, when helper T cells activate B cells, some B cells produce antibodies, but others become memory B cells that will stay in the body for years or even a lifetime. When a pathogen that the body has seen before reinvades, the memory B cells begin dividing quickly and, usually within 2-4 days, can form many antibodies to repel the invaders. They can often fight off infection without the person ever becoming sick.

IMMUNITY

- Once a person has memory B cells prepared and ready to fight a disease, they have an **active immunity** to that pathogen. This is sometimes called **acquired immunity**. For example, when someone has chicken pox, they usually don’t get it a second time. **VACCINES** are a way of inducing active immunity to a disease by “priming the pump.” An altered or weakened pathogen is introduced into the body, the B cell response is initiated, and the memory cells are stored away to fight the real disease if the body ever becomes infected again. In **passive immunity**, antibodies that have been produced in another animal are given as a vaccine. Protecting the body from the millions of microbes just waiting to invade is a full time job for the body’s defense system. Luckily, the immune system is always ready for the battle!

DEFENSES OF THE IMMUNE SYSTEM

TYPE OF DEFENSE	LINE OF DEFENSE	PARTICIPANTS
Non-specific	First -----	Skin, sweat, mucous linings, cilia, stomach acid, etc. -----
	Second	Inflammatory response (including phagocytes/macrophages)
Specific	Third (both specific and non-specific responses begin at the same time)	Cell-mediated: includes helper T cells and killer T cells ----- Antibody-mediated: includes helper T cells, antibody-producing B cells, memory B cells, and macrophages; vaccines cause this same process to begin either actively or passively

NOTE TO THE TEACHER: Some of the immune system vocabulary can be difficult for students. The term *antibody* is tricky because it is not *anti* (against) the body at all. In fact,

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antibodies are very beneficial to our bodies. It may be helpful to remind students that antibodies are made by the body so that they can connect the word to its meaning in that way. The word *antigen* can be remembered by connecting the ending of the word—*gen*—to the word *germ* since they sound alike, but caution students that antigens are not *anti* germs at all, but are instead the molecules the body recognizes as being foreign. The word *phagocyte* means *cell-eater*, and that is what it does. *Macro* means large, and a macrophage is just a large phagocyte that can collect lots of antigen-containing molecules.

Leuco means white; *leucocyte* is the general term for all of the white blood cells, including phagocytes/macrophages, T cells, and B cells. There are other cells that are considered white blood cells, also. *Lymphocyte* is a more specific name for about 25% of all of the white blood cells and refers only to the T cell and B cell types.

Learning Objectives

The student will:

1. recreate the process by which the immune system detects and destroys invading pathogens using a play dough model.
2. model how the body reacts to the West Nile Virus pathogen.

Materials

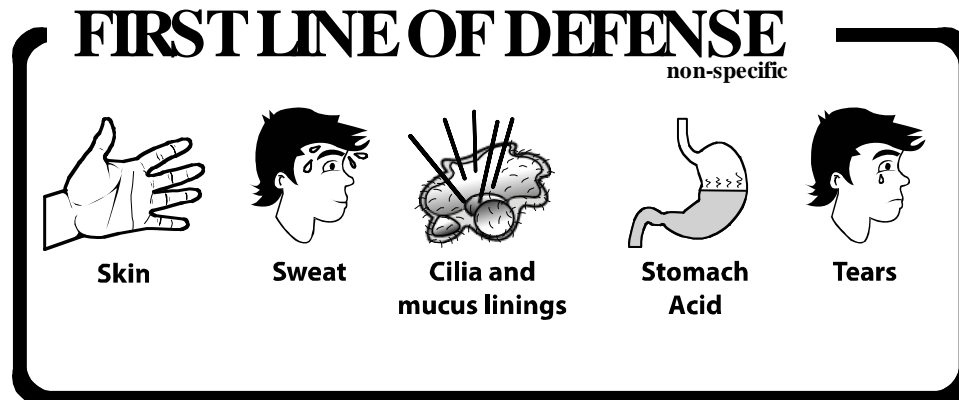
1. Containers of Play dough, **two colors** (one set of two colors for every pair of students) (Note: This is very reasonably priced at discount stores. An ideal sized container is a two-color, two-pack size totaling 6 ounces.)
2. Waxed paper or legal size copy paper (one piece for every pair of students)
3. Posters of the three “lines of defense chart” based on the information found in the Procedure section. (Alternatively, you could write this information on a white board.)

Procedure

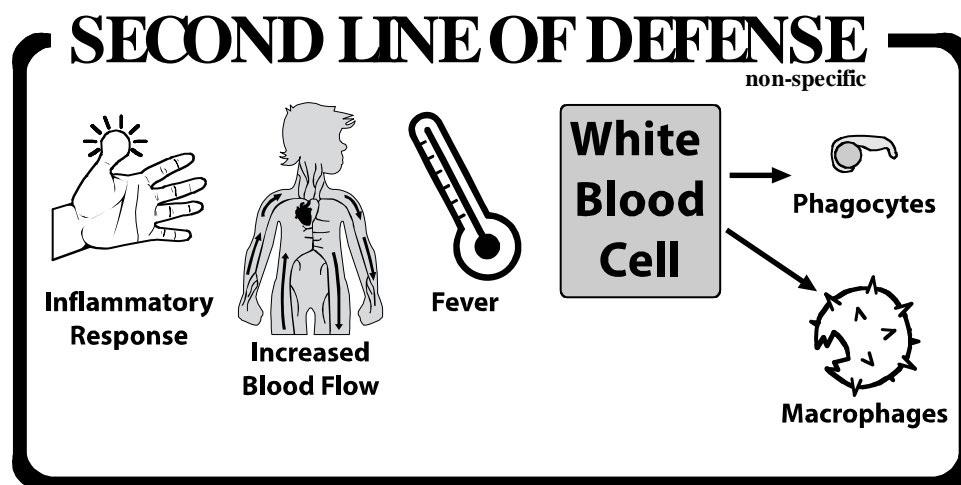
1. A warm-up question such as the following will allow the students to connect with existing knowledge plus engage their interest for the upcoming activity. Warm-up: In what ways can we fight off infectious disease? Answers should include some of the following: wash hands; cover mouth; don’t share food or drink; practice proper food preparation (washing, heating, and cooling foods); avoid contact with wild animals, insect protection, purify water, and our own immune system. They often won’t think of this last one and it provides a great segue to the activity.
2. The teacher will model the activity first. As each of the steps is described, put up the poster paper showing the key words. See the sample information shown below.
3. Begin by describing the immune response as a “battle” that the body undergoes daily. There is not a single general but instead there are several levels of attack used by the body.
4. Then, choose one color of the play dough to represent the “pathogens” and the other color will represent the “immune system.”
 - Begin by forming several viruses and bacteria in a variety of shapes. Make sure that one of them represents West Nile. (Here is the official description of the West Nile Virus for teacher background. Do not describe this depth to the students. *West Nile virus (WNV) is a single-stranded RNA virus of the family Flaviviridae, genus Flavivirus. Flaviviruses share a common size (40-60 nm) and symmetry (enveloped, icosahedral nucleocapsid.)*)
 - Explain that these pathogens are many, many times larger than an actual virus but they will be our model. Pinch small protrusions on the surface of one of the viruses to teach about antigens. Explain that an antigen is a protein the body recognizes as foreign and the immune system reacts to this substance.
 - As you describe the **FIRST LINE OF DEFENSE**, point out how **skin, sweat, cilia, mucus linings, stomach acid, and tears** stop most invaders. Form a “nose” and model how something like a cold virus could be stopped by the mucus lining and

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hairs of the nose. This response is **non-specific**; the body responds but does not really recognize the invaders as specific pathogens.



- If pathogens make it past the First Lines of Defense, the battle continues with the **SECOND LINE OF DEFENSE**. In this case you might model a bacterium that has penetrated the skin on a splinter. Describe how the **Inflammatory Response** causes an **increase in blood flow** to the area and sometimes even produces a **fever**. The blood delivers special white blood cells to the area.
- A **phagocyte** (means cell-eater) is a white blood cell that can engulf a pathogen. A large version of this cell is called a **macrophage**. Using the play dough, model a macrophage cell engulfing a bacterium. Pinch off small pieces of the bacterium antigens and deposit them gently on the outside of the macrophage. This seems to be the way the body sends the message on to begin the next line of defense.

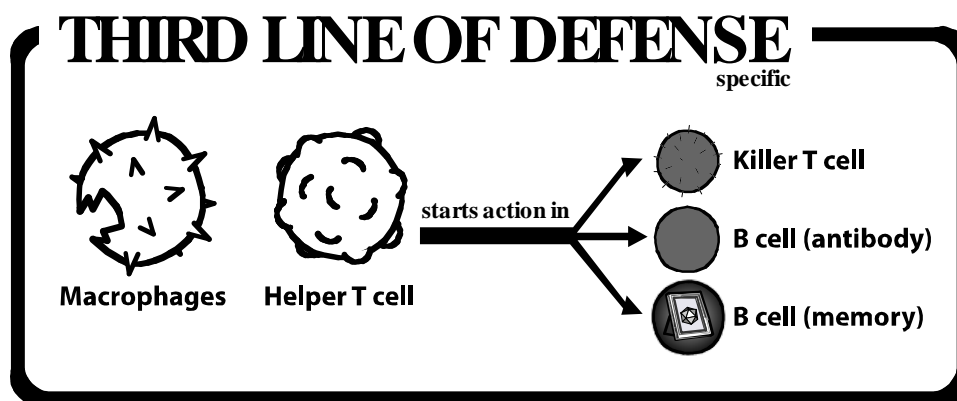


- The **THIRD LINE OF DEFENSE** is very specific. The body reacts to an individual invader in a very personalized way. Use the **West Nile Virus** as the invader for this example. Again, use this opportunity to reinforce the antigen concept as being the foreign proteins to which the immune system responds. You can discuss how the pathogen enters the body from the saliva of a mosquito vector.

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The mosquito has previously fed from a bird that had the virus. When the pathogen enters the blood stream, the Second Line of Defense, macrophage white blood cells, attack the invaders. If they cannot defeat the pathogen, the macrophage with antigens on its surface alerts a special white blood cell called a helper T cell.

- Form a **helper T cell** from play dough. This Helper T cell begins two other processes at the same time. It notifies a **Killer T cell** that goes out and destroys some of the pathogens. Model this with play dough. At the same time, the Helper T cell notifies **two kinds of B cells**. One type of B cell produces antibodies. Using the play dough, pinch small pieces off and form them in the shape of a “Y.” Show how this shape fits like a puzzle over the specific antigen that is on the surface of the pathogen, in this case, the West Nile Virus.
- Make several “Y”s hook on to the surface. Do this with another virus particle also. Then show how the antibodies cause the virus cells to clump together so a macrophage can engulf them. The antibodies don’t kill the virus themselves. The antibody response is very specific but effective. The downside of this is that it can take a couple of weeks for the antibodies to form. In the meantime, the person may develop symptoms of the illness and be suffering.
- Next, show another play dough **B cell**. This one is a memory cell. It is important because the next time the West Nile Virus invades it will kick into action and form antibodies in a much shorter time, maybe 2-4 days, so the person will not get as sick.



8. It is most effective to have the teacher model this concept first as described above. Then, allow student pairs to follow the step-by-step procedure themselves as the teacher models the activity again. Putting waxed paper or just paper on their desks will help with clean up. Remind them to not blend the play dough so it can be put back into separate containers at the end. **One student will be the “pathogen” play dough and the other student will represent the immune system play dough. Encourage them to have dialogue at each step using the correct terms.**

9. This is an excellent time to use the models to introduce the concepts of vaccines and active and passive immunity. It is also interesting for students to learn how the AIDS virus attacks the T-cells of the immune system or to discover how allergies or cancers interact with the system.

Extension Activities

- *Visual Arts*: Create models of different cells of the immune system.
- *History*: Research different vaccines and how they work.
- *Language Arts*: Create a story from the perspective of the immune system battling a disease.
- *Science*: Research how the immune system sometimes turns on itself in auto-immune diseases and allergies.
- *Science/Art*: Draw a cartoon showing how a vaccine provides immunity.

Standards

National Science Education Standards, Grades 5-8

- Science Content Standard A: All students should develop abilities necessary to do science.
- Science Content Standard C: All students should develop understanding of the structure and function of living systems.
- Science Content Standard C: All students should develop understanding of regulation and behavior.
- Science Content Standard F: All students should develop understanding of personal health.

Books and Articles

- Life, Death and the Immune System: Scientific American A Special Issue. 1994. New York. W.H. Freeman and Company.
- Balkwill, Frances R. 1993. Cell Wars. Minneapolis: Carolrhoda Book

Web Sites

- The National Cancer Institute: Understanding the Immune System
<http://newscenter.cancer.gov/sciencebehind/immune/immune00.htm>
- The National Institute of Allergy and Infectious Diseases
<http://www.niaid.nih.gov/final/immun/immun.htm>
- Wellesley College Department of Chemistry: Immune System Movies
<http://www.wellesley.edu/Chemistry/Chem101/antibiotics/immune.html>