Teaching Materials on Infectious Diseases

MEDICAL MYSTERIES

Mission 5: Zero-Hour Zoonoses

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MISSION BRIEFING: Contents

OVERVIEW

We hope that you and your students extend the MEDMYST adventures with the activities designed to cover related learning objectives. The activities described are intended for use both **before** and **after** students have "played" missions of MEDMYST. The files may be printed for classroom use ONLY. They consist of mini-labs that can be done with relatively little equipment or expense.

Feel free to adapt these activities to your own classroom needs. Another resource that we suggest is the National Institutes of Health (NIH) web site at http://www.nih.gov/. It contains some excellent resources and teaching materials.

If you have specific questions, please contact us.

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MISSION BRIEFING

MISSION DEBRIEFINGS

MISSION BRIEFING: Mission Synopsis

This synopsis is provided as an overview for TEACHERS. We advise teachers NOT to hand this out to the students prior to playing the adventure since much of the suspense will be eliminated.

The game begins at the headquarters for the Neuropolis Center for Disease Control (NCDC). Zack Laurer, head of the Counter Terrorism Unit (CTU) for Neuropolis, is attempting to contact the Reconstructors through the video screen, but communication is impaired by static interference. The player is requested to find a NET-Link and use it to communicate. When the player finds the NET-Link, an e-mail from Zack arrives with a coded message. The player decodes the message ("Twenty Hours Zoonoses Terror") and learns that a terrorist organization is threatening a zoonotic attack sometime in the next twenty hours. Zack asks the player to learn as much as they can about zoonotic diseases, and then explore Neuropolis for any potential zoonotic outbreaks.

A search of NCDC Headquarters yields several different tools and clues. The player collects a BDR card that looks like it can be used for access somewhere and a remote control. When the player uses the remote control on the nearby TV screen, he/she sees two interesting broadcasts—one about a "Unification Rally" being held at Neuropolis University later today and a second about the record number of people expected to attend the tri-ball playoffs. The player also finds a database of zoonotic diseases and completes a short activity covering the ways of transmitting zoonotic diseases, the types of pathogens that cause them, and important reasons for the recent rise in zoonotic diseases. After completing this activity, the player learns about the Bio-Defense Research Facility (BDR), a place where scientists study dangerous diseases that could be used by terrorists.

The player travels to the BDR, but to gain access the building he/she must use the BDR keycard and complete an activity covering the six "Category A" pathogens. Inside the BDR the player talks with a scientist about some of the diseases she studies, learns about anthrax and the way it affects humans, finds a clue that the bioterrorist weapon may be aerosolized, and collects the Tyvek suit and biological sample kit to aid in the investigation. Lastly, the player uses a 3D map of the city to locate an ongoing zoonotic outbreak occurring at Neuropolis University.

At Neuropolis University, the player can visit with a local pet adoption organization. After assisting the students in learning how to properly and healthily care for their pets, the player can interview the president of the organization and get permission to collect blood samples from the students and the pets. The player can also visit the local "Planet Pizza" where all the students ate before becoming sick. The owner of the pizza place is at first reticent to talk, but opens up when the player finds a newspaper clipping about a previous terrorist attack on his business. When confronted with the evidence, the owner allows the player to take a sample of the food on his salad bar. The player also assists a young girl in the pizza parlor by fixing her animated storybook and learns about the importance of washing fruits and vegetables before they are consumed. Lastly, the player visits the stadium at the university and learns it is the site of the upcoming "Unification Rally"—a rally in support of unifying Neuropolis with surrounding cities to form a "city state." It seems an organization called FLU (Fighting Lethal unity) is opposed to this idea—the student finds one of their flyers inside the control room of the stadium.

MISSION BRIEFING: Mission Synopsis

After completing the various activities available at the University, the player receives a new e-mail from Zack with the latest mole message. The decoded message reads "Animal Warnings." Zack interprets this message as referring to Animal Sentinels—animals that become sick with a zoonotic disease before humans do. He tells the player they've had a recent report of some sick cows at a local farm and requests he/she go investigate. At the farm the player encounters a local vet assisting with the investigation. The vet gives the player permission to take a blood sample from one of the sick cows.

At any point in the gameplay, the player can return to the BDR and test the samples at the BioSafety Level 4 laboratory (BSL4 lab). Entry to the BSL4 lab is ONLY granted if the player uses a sample on the autoclave next to the door. The first time the player tries to enter the BSL4, he/she must go through a short training exercise (during re-entry repeating this training is optional). The samples yield the following results:

University Students – Positive for Salmonella
Animals for Adoption – no contagion detected
Salad Bar Sample – Positive for Salmonella
Cow Blood – Positive for Anthrax

The player returns to the farm to inform the vet that her suspicions are correct—the sick cows are infected with anthrax. The vet begins to initiate emergency procedures, but before she leaves she asks the player to investigate some "strange sounds" she has been hearing in the barn. The player then finds a hidden door against the far wall. The player must complete a matching game covering various disease reservoirs before the door will open.

The door leads to the secret FLU lab hidden below the farmer's barn. Inside the lab, the player discovers a short video on the use of plague as a bioterrorist weapon in the 1930's and 40's, when infected fleas were spread through the use of clay bombs. Inside the secret lab are several clay bombs, one of which has broken open and is leaking a white powder. The player can sample this powder for analysis in the BSL4 lab. The player also discovers a "Terrorist Remote Control," a to-do list roughly outlining how the terrorist plan to use a naturally-occurring anthrax outbreak in cattle to infect people, and a copy of the FLU flyer initially found at the stadium in the university. Lastly, there are pictures of a blimp that is suspiciously identical to a blimp the player previously saw flying over the stadium in the university. Analysis of the white powder at the BSL4 lab reveals it is pure aerosolized anthrax.

At this point Alpha e-mails the player and explains that the twenty hours are up—he needs to know what organization is responsible for the terrorist threat, where they are going to attack, what disease they are planning to attack with, how they are going to spread it. When the player correctly answers these questions (FLU, the political rally, anthrax, and clay bombs, respectively) he/she is sent to the university stadium to neutralize the threat. At the stadium, the player uses the terrorist remote control on the FLU laptop computer. The player must "hack" the computer (answer a series of multiple choice questions covering the scientific content in the adventure) before the blimp can be safely landed. After the blimp lands, Zack and his CTU team show up to arrest the terrorists—but the blimp was unmanned! The terrorists escape to threaten Neuropolis another day, but Zack and the Reconstructors vow they will always be there to protect the city for all threats of infection disease.

MISSION BRIEFING: Correlation with Standards

National Science Education Content Standard Correlation
Grades 5-8

Instructional Objectives "Zero-Hour Zoonoses"	Science Content Standard
• Define Zoonoses	**Standard F:** Students should develop understanding of personal health.
• Differentiate various types of zoonotic transmission.	**Standard F:** Students should develop understanding of personal health.
• Describe different methods of zoonotic infection.	**Standard F:** Students should develop understanding of personal health.
• Discuss historical cases of zoonotic epidemics that occurred naturally or as a result of biological warfare.	**Standard F:** Students should develop understanding of personal health. **Standard G**: Students should develop understanding of history of science.
• Provide specific reasons for the increasing rate of emerging diseases.	**Standard F:** Students should develop understanding of personal health.
• Describe how researchers and scientists collaborate to monitor and prevent diseases.	**Standard F:** Students should develop understanding of personal health. **Standard G:** Students should develop understanding of science as a human endeavor. **Standard G:** Students should develop understanding of nature of science.
• Explain proper protection needed for collecting and analyzing pathogen samples.	**Standard A:** Students should develop abilities necessary to do scientific inquiry.
• Provide an explanation of the sources, symptoms, and treatment of Anthrax.	**Standard F:** Students should develop understanding of personal health. **Standard C:** Students should develop understanding of structure and function in living systems.

Correlation with Standards

• Provide an explanation of the sources, symptoms, and treatment of Salmonellosis.	**Standard F:** Students should develop understanding of personal health. **Standard C:** Students should develop understanding of structure and function in living systems.
• Encourage inquiry of multiple sources to collect information on zoonoses.	**Standard A:** Students should develop abilities necessary to do scientific inquiry. **Standard F:** Students should develop understanding of personal health.
• Require synthesis of information using logic and reasoning to solve a medical mystery.	**Standard A:** Students should develop abilities necessary to do scientific inquiry.
• Provide a summary of the mystery's story line.	

National Health Standard Correlation
Grades 6-8

Instructional Objectives "Zero-Hour Zoonoses"	Health Content Standard
• Define zoonoses.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Differentiate various types of zoonotic transmission.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Describe different methods of zoonotic infection.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Discuss historical cases of zoonotic epidemics that occurred naturally or as a result of biological warfare.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Provide specific reasons for the increasing rate of emerging diseases.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Describe how researchers and scientists collaborate to monitor and prevent diseases.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Explain proper protection needed for collecting and analyzing pathogen samples.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.

• Provide an explanation of the sources, symptoms, and treatment of Anthrax.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Provide an explanation of the sources, symptoms, and treatment of Salmonellosis.	**Standard 1:** Students will comprehend concepts related to health promotion and disease prevention to enhance health.
• Encourage inquiry of multiple sources to collect information on zoonoses.	**Standard 3:** Students will demonstrate the ability to access valid information and products and services to enhance health.
• Require synthesis of information using logic and reasoning to solve a medical mystery.	
• Provide a summary of the mystery's story line.	

MISSION BRIEFING: Vocabulary Terms

Vocabulary terms that are fundamental to understanding the concepts included in Mission Five are listed below. Some of the words will be encountered while playing Mission Five. They are hot-linked in the mission so you can click on them and get the definition as you play.

Aerosol Transmission – The ability for a disease to infect persons through the air via small droplets (as from a cough or sneeze).

Animal Sentinels – Animals that warn of health or environmental hazards. Zoonotic diseases may make animals sick before being transferred to humans. For example, outbreaks of West Nile are usually preceded by dead birds and sick horses.

Bacteria – A single-celled organism that has a cell wall but lacks a nucleus; bacteria can cause disease.

Bioterrorism – Intentionally using pathogenic organisms or agricultural pests to infect humans or critical food sources for political motives.

Cutaneous – Referring to or having to do with the skin.

Disease Reservoir – Place where a pathogen can be permanently maintained and transmitted to humans.

Epidemic – A disease that appears as new cases in a given human population, during a given period, at a rate that substantially exceeds what is "expected."

Fungi – An organism that has a cell wall and a cell membrane. They include molds (filamentous multicellular type) and yeast (unicellular spherical type). Fungi can spread through direct contact, indirect contact, water, air, and animals.

Gastrointestinal – Referring to or having to do with the digestive tract.

Helminth – Multicellular worms that can be parasites in the intestine, blood, or body tissue. Helminths can spread through direct or indirect contact, food, water, and air.

MISSION BRIEFING: Vocabulary Terms

Infectious Disease – Any disease caused by invasion by a pathogen that subsequently grows and multiplies in the body.

Lesions – Abnormal tissues on the body, usually on the skin or in the mouth. Examples include acne, rashes, scratches, etc.

NET-Link – A new tool issued to all Reconstructor agents. The NET-Link allows for instantaneous communications between agents. It also collects the clues agents may uncover during their investigations and all relevant locations.

Pandemic – An outbreak of an infectious disease across an entire country (or more); an epidemic over a wide geographic area and affecting a large proportion of the population.

Pathogen – An infectious or biological agent that causes disease or illness to its host. Examples include bacteria, viruses, prions, protozoa, fungi, and helminthes (multicellular worms).

Prion – (pronounced PREE-on) An infectious agent made only of proteins. Prions cause Bovine Spongiform Encephalopathy (Mad Cow) in cows and variant Creutzfeldt-Jakob disease (vCJD) in humans. The disease is spread through abnormal proteins that cause other normal proteins to change to the prion's abnormal form (and scientists are still unsure exactly how they do this!). All known prion diseases are currently untreatable and fatal.

Protozoa – Simple, single-cell organisms such as the amoeba and paramecium. Some have flagella or cilia and are capable of rapid movement. Protozoas can spread through food, water, and animals.

Pulmonary – Referring to or having to do with the skin.

Ruminant – Any animal that chews its cud (partially digested food that can be saved in the first of several stomachs and chewed repeatedly). Ruminants include cows, goats, sheep, camels, giraffes, buffalo, deer, and antelope, among others.

Symptoms – Information conveying the sensation of illness or change in health function.

MISSION BRIEFING: Vocabulary Terms

Vaccine – A substance made out of dead or weakened viruses or bacteria used to prevent a specific disease by producing an immune response in the body.

Vector – An organism, such as a mosquito or tick, that does not cause disease itself but carries pathogens from one host to another.

Virus – A tiny infectious agent that is only able to grow or reproduce inside a cell. Composed of an outer protective shell and an inner part consisting of genetic material. A virus has no other structures and does not have any metabolism. It cannot reproduce by itself, but instead invades a host cell and uses the cell to produce copies of itself (which leave the cell to infect other cells).

Zoonosis – (pronounced ZOO-no-sis) An infectious disease that can be transmitted from other animals, both wild and domestic, to humans or back and forth from humans to animals. Zoonoses comes from the Greek words "zoon" (animal) and "nosos" (disease). These diseases have been passed from animals to humans since prehistoric times, and new zoonotic diseases are always evolving. (Zoonosis is singular; zoonoses is plural.)

Teacher Version

Teacher Directions: Ask students to fill in the clues in the answer column as they proceed through the mission.

Question	Answer
NCDC Headquarters	
1. _____ are diseases that can be passed from animals to humans.	Zoonoses
2. Match each disease to the pathogen that causes it. 1. rabies 2. ringworm 3. mad cow 4. anthrax	1. virus 2. fungus 3. prion 4. bacteria
3. List **two** of the causes for the increasing number of zoonotic diseases.	Any two of the following: Larger Human Population, Rapid Air Travel, Changing Environment, Bioterrorism and War, Microbe Evolution
BioDefense Research Facility	
4. List the **four** "Category A" pathogens that are zoonotic diseases.	Anthrax Plague Tularemia Viral Hemorrhagic Fever
5. Match each type of anthrax with the organ(s) in affects. a. Cutaneous Anthrax b. Gastrointestinal Anthrax c. Pulmonary Anthrax	C Lungs A Skin B Digestive System
Neuropolis University	
6. After handling any animal, including your pets, you should always _____.	wash your hands
7. True or False: You can catch a zoonotic disease from unwashed vegetables.	True

Biosafety Level 4 Lab	
8. Why do researchers tape their gloves and socks to their BSL4 coveralls?	To prevent contamination
Farm	
9. What did the Japanese use to spread plague infected fleas over China before World War II?	Clay (or ceramic) bombs
10. From where did the terrorist get the anthrax bacteria?	From the sick cows on the farm

MISSION BRIEFING: Mission Log

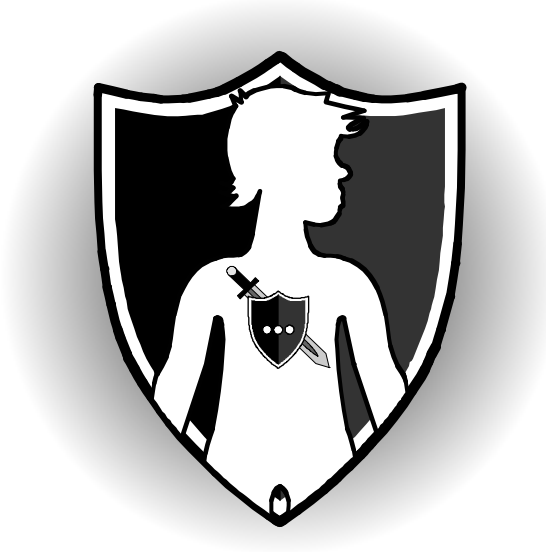
Name _____ **Class** _____ **Date** _____

Directions: Record your observations by finding the clue that correctly matches each description. Write down the clues as you proceed through the mission.

Question	Answer
NCDC Headquarters	
1. _____ are diseases that can be passed from animals to humans.	
2. Match each disease to the pathogen that causes it. 1. rabies 2. ringworm 3. mad cow 4. anthrax	1. 2. 3. 4.
3. List **two** of the causes for the increasing number of zoonotic diseases.	1. 2.
BioDefense Research Facility	
4. List the **four** "Category A" pathogens that are zoonotic diseases.	1. 2. 3. 4.
5. Match each type of anthrax with the organ(s) in affects. a. Cutaneous Anthrax b. Gastrointestinal Anthrax c. Pulmonary Anthrax	____Lungs ____Skin ____Digestive System
Neuropolis University	
6. After handling any animal, including your pets, you should always _____.	
7. True or False: You can catch a zoonotic disease from unwashed vegetables.	

Biosafety Level 4 Lab	
8. Why do researchers tape their gloves and socks to their BSL4 coveralls?	
Farm	
9. What did the Japanese use to spread plague infected fleas over China before World War II?	
10. From where did the terrorist get the anthrax bacteria?	

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 **leucocyte**s, (**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

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 ---------- Second	Skin, sweat, mucous linings, cilia, stomach acid, etc. ---------- Inflammatory response (including phagocytes/macrophages)
Specific	Third (both specific an 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,

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

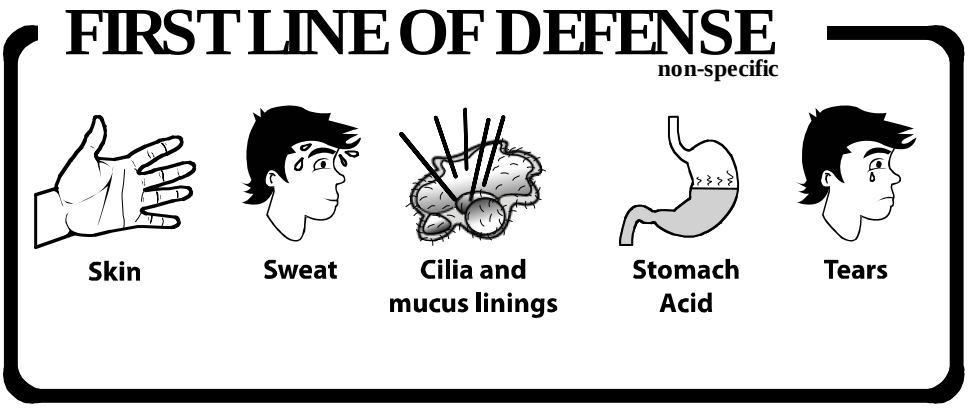
1. A warm-up question such as the following will allow the students to connect with existing knowledge plus engage their interest for the upcoming activity. Warm-up: In what ways can we fight off infectious disease? Answers should include some of the following: wash hands; cover mouth; don't share food 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.)*

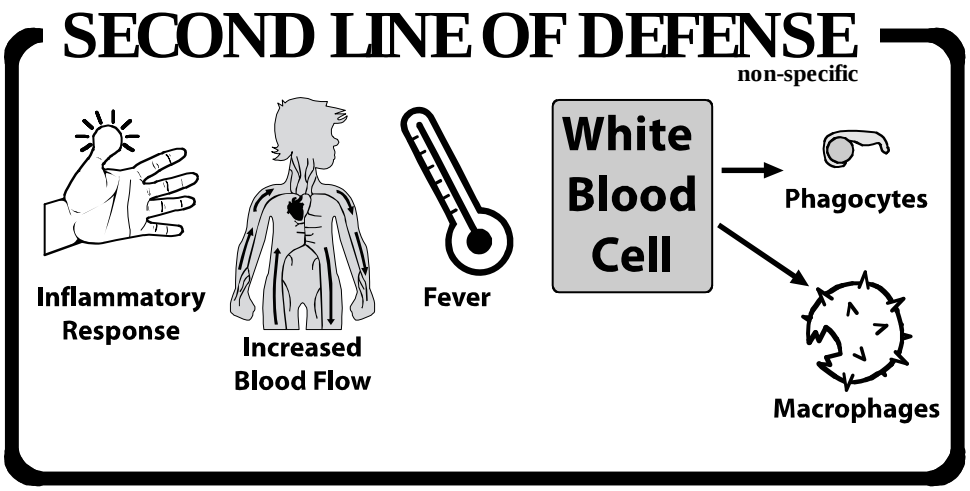
    - Explain that these pathogens are many, many times larger than an actual virus but they will be our model. Pinch small protrusions on the surface of one of the viruses to teach about antigens. Explain that an antigen is a protein the body recognizes as foreign and the immune system reacts to this substance.

    - 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

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



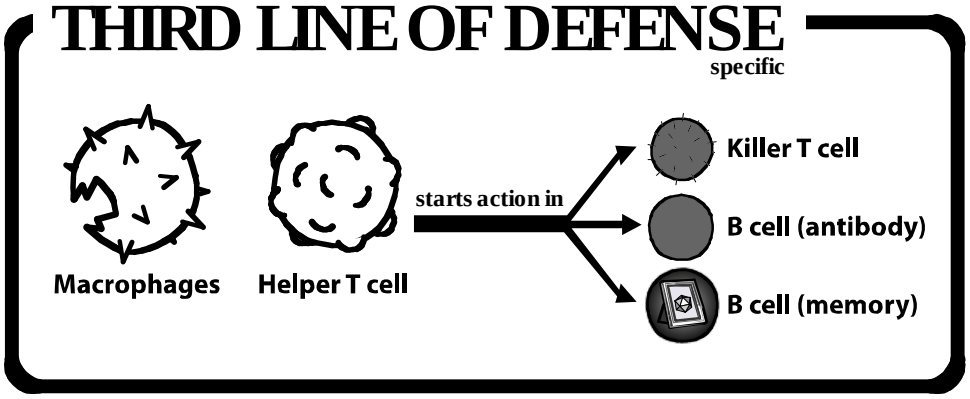
- If pathogens make it past the First Lines of Defense, the battle continues with the **SECOND LINE OF DEFENSE**. In this case you might model a bacterium that has penetrated the skin on a splinter. Describe how the **Inflammatory Response** causes an **increase in blood flow** to the area and sometimes 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.

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 teach 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