Solve a One Health Mystery!

Middle School Lesson Plan from the One Health Commission

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Age Range: Grades 6-8

Overview and Purpose: In this lesson students will simulate a real life disease outbreak involving people and animals to learn about the importance of taking a One Health approach to health problems in our interconnected world.

Learning Objectives: At the conclusion of this two-part lesson, students will be able to:

1. Understand what a disease outbreak is and the range of experts that are needed to respond.
2. Discuss what is meant by One Health and describe how an emerging infectious disease can be an example of One Health.
3. Understand where inadequate communication between human, animal, and environmental specialists can complicate a response to a disease outbreak.
4. Discuss what is meant by a vector and a reservoir as these terms relate to transmission of an infectious disease.
5. Explain how data and numbers can be used to describe an event.

Introduction:

Diseases are emerging (these are NEW diseases) and spreading through our communities all the time. Students might be familiar with disease outbreaks discussed in the media (e.g. flu or influenza virus, bird or swine flu, West Nile virus, Ebola virus) or maybe their favorite show involves a fictional disease outbreak (zombies anyone?), but what they might not be familiar with is how we identify outbreaks as they start, find the source of the outbreak, discover how these diseases move around through animals and the environment outside of humans, and figure out how to control the spread.

Understanding this process is becoming ever more important in our changing world because there has been an increase in infectious diseases and some have been big surprises. The increase is thought to be due to many factors that scientists and health professionals may not have fully understood in the past (for example rapid demographic, social, environmental and technological changes). Can students name some of these changing factors? (Responses might include things like climate change, greater movement due to technological advances in transportation, habitat destruction/deforestation, changing species diversity, urbanization, changes in farming practices.)

Environmental changes and rapid human development (e.g. climate change, landscape alteration and destruction, pollution) alter the way in which humans, animals, and the environment interact. For example, as the climate becomes warmer, some species (like mosquitos) that did not previously live in colder areas are able to move into newly warming areas and bring the diseases they carry with them to cause new outbreaks. To best understand this complicated picture, experts need to learn better ways to communicate and work together to rapidly respond and devise prevention strategies in order to minimize disease in humans and animals.

This two-part lesson teaches students about some of the ways their health is connected with animals and the environment and how to solve a disease outbreak. Students will be acting through a real world disease outbreak event that happened approximately 20 years ago in the New York area, where a virus, called the West Nile Virus, appeared for the very first time in North America. This virus has now spread across the entire country and the disease affects people and animals every year. Weather has a direct and an indirect influence of the mosquito vector's ability to spread the disease and therefore climate change is contributing to the epidemiology of this disease.

Video: https://www.youtube.com/watch?v=h5Gwvxp_VvQ&feature=youtu.be

Supplies:

- Stickers (two different colors ; e.g. 3 red and 6 green/10 students)
- Multiple name tags for each role: Mosquito, Bird, Human, Horse, Disease detective (wildlife biologist, veterinarian, human physician)
- Printed worksheets
- Clip boards

Classroom Format: Part 1 (60 minutes)

Agenda

1. Set-up (5 minutes)
2. Transmission phase (10 minutes)
3. Investigation phase (15 minutes)
4. Reporting phase (15 minutes)
5. Discussion (15 minutes)

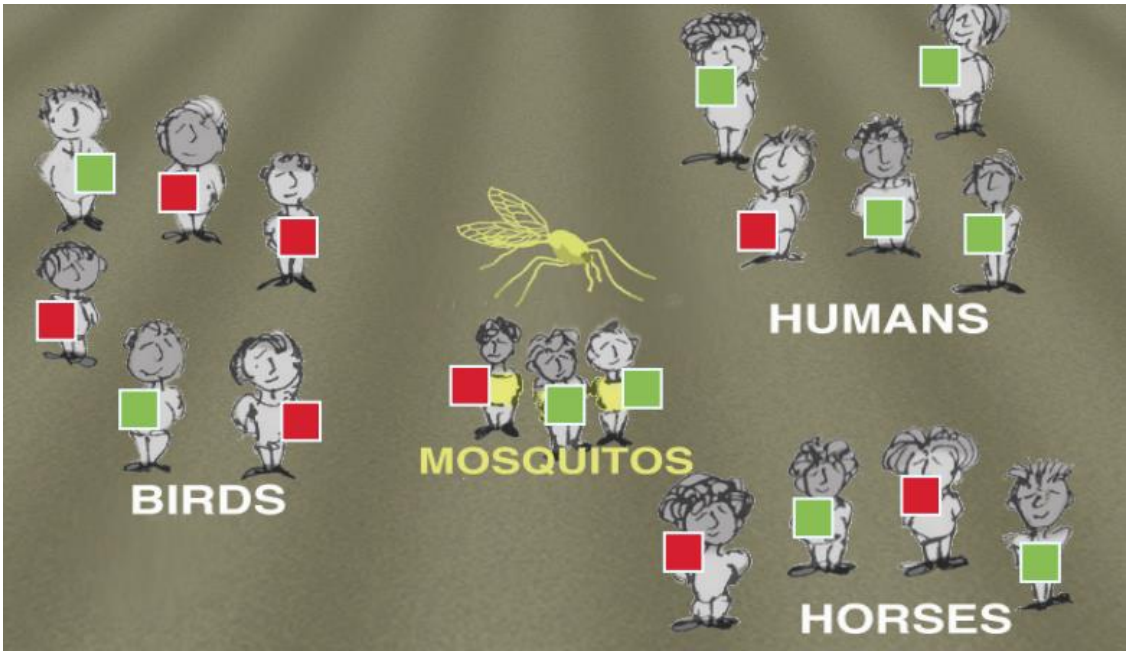
Set-up (5 minutes)

1. Divide the classroom into roles: Mosquito (3), Bird, Human, Horse, Disease detective (wildlife biologist, veterinarian, human physician). Give each student a name tag with their role on it.

2. Assign three students to be mosquitos. One of the mosquitos will be given red stickers and the other two will be given green stickers. Mosquitos with the red stickers will considered infected with the virus. Mosquitos with green stickers will be considered infection free. Mosquitos will be circulating in the group of humans, birds, and horses and periodically placing stickers on the other students (simulating a mosquito bite). Different mosquitoes can bite one person but the same mosquito should not bite the same person twice. Mosquitos will later be given a disease detective role (as a human) for the investigation phase of the lesson.
3. Assign the same three mosquito students plus three additional students, to be one of three types of disease detectives. Disease detectives will not participate in the transmission phase but will play a crucial role when the disease is being investigated (investigation phase). There should be at least 2 students in each disease detective role. Larger classes can accommodate more detectives.
    a. Wildlife Biologist: This person will study the birds and report on their symptoms during the investigation phase. *(Please note: In the West Nile Outbreak it was actually a Zoo veterinarian who made this observation, but for the simplicity of this exercise we are using a wildlife biologist since they often are involved in detecting outbreaks in wildlife).*
    b. Veterinarian: This person will study the horses and report on their symptoms during the investigation phase.
    c. Human physician: This person will study the humans and report on their symptoms during the investigation phase.
4. Assign the remaining students into three equal groups: birds, humans, and horses.

Transmission Phase: (10 minutes)

1. Bring students to an area where they can move freely.
2. Inform students of safety rules as appropriate.
3. Explain to the class that there are three mosquitos that will be circulating among the students and putting stickers on them to simulate a mosquito bite. Different mosquitos may “bite” the same person but the same mosquito may not “bite” one person multiple times. Students should not remove or exchange stickers.
4. When the mosquitos have passed out all of their stickers they are to return to the teacher and assume their new roles in the Investigation Phase (disease specialist). When all of the stickers are passed out it will be the end of the Transmission Phase.
5. Disease detectives (non-mosquitos) will stand to the side and observe. They will participate in the investigation phase.



Investigation Phase (15 minutes):

1. Have the students split up into their different species groups according to role: birds, humans, and horses. Provide the students in each group with the worksheet of symptoms to act out for their species (see Appendix 1). Students in these species groups should not share this table of information with the disease detectives that come to observe their group.
2. Have the mosquito students and other disease detectives form into 3 groups: wildlife biologists, veterinarians, human physicians. Give each disease detective group a clipboard with the investigation worksheet. Their job will be to go around and record the symptoms that are observed in the species they study.
3. Tell the students in the species group to act out the symptoms given to their species based on what color stickers they have. If a student has multiple stickers, they should always act out only the most severe symptoms (e.g. a student with a red and a green sticker would always act out the red sticker only).
4. Have students make sure their stickers are placed in a uniform spot that is easily visible to the disease detective.
5. Once students feel comfortable with what they need to do, have the students start acting out their symptoms and send the disease specialists to start observing their species and filling out the worksheet.
6. The human physicians may ask the human subjects questions, for example what symptoms they are acting out or how they are feeling, but horses and birds cannot talk to their investigators disease detectives. Give students about 10 minutes to make these observations.

7. The disease detectives fill out the Investigation worksheet which will be used for data analysis and reporting in the next phase.

Reporting Phase (15 minutes):

1. Students remain in their separate groups joined by the corresponding disease detective (e.g. Humans with human physicians).
2. Students use the information on the Disease Detective Investigation worksheet to complete an Outbreak Investigation Report of their own (or teacher defined) design. The report should include a summary of observations and use of numerical data to describe the event (e.g. graphs, percentages, ratios).
3. Each group assigns reporter status to one or two students.
4. Students will complete the suggested Reporting Worksheet as a team and plan a presentation.

Presentation and Discussion (15 minutes, End of Part 1)

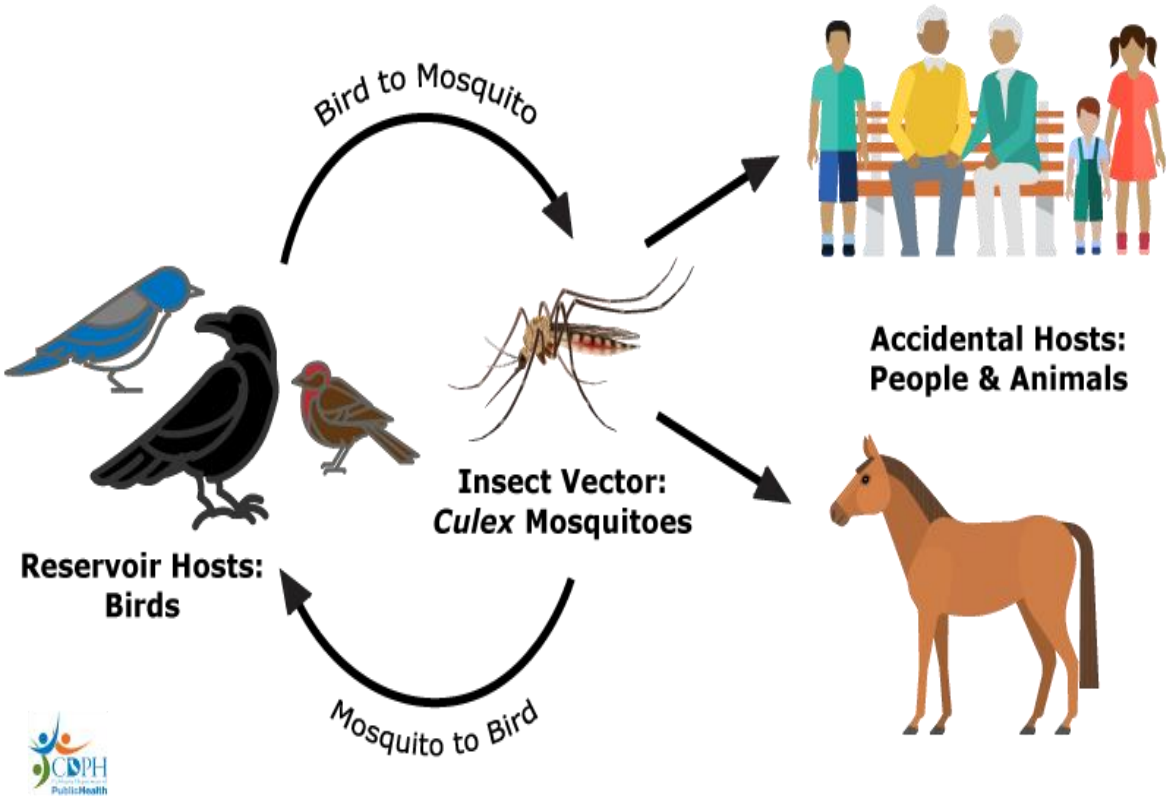
1. Presentations: a student from each group discusses his/her group's findings and presents their data: Percentage of species bitten by mosquitos, Percentage of species showing symptoms, etc.

2. Discussion: Students are given time to write down or ask questions about the presentations and comment on their findings. Students identify new words and enter them into a word bank (Appendix 3) to discuss. Teachers can provide definitions, or students can be assigned to research definitions of these words (homework).

Classroom Format: Part 2 (60 minutes)

General Discussion (20 minutes)

1. Discuss with the class that the previous day's activity was supposed to model a real life outbreak of the West Nile Virus.
    a. What is an outbreak?
    b. Each group has identified that there is an outbreak in their species, but what is it?
    c. What is the West Nile Virus? How is it transmitted?



2. Discuss words identified in Part 1 (word bank) : what is a "virus" (students can share their experiences with viruses like the flu, or chickenpox) ; discuss the term "vector" and how it applies in this context. Discuss what the term "reservoir" means and note that we don't yet know the reservoir for the virus in this exercise.

Additional investigation (20 minutes): Each group conducts additional investigation and leads a discussion about what they are finding out.

1. The **bird group**: Students read a newspaper article that reports on the number of dead birds residents of New York are seeing. They view a map of the geographic distribution of dead birds.

   News Article: Drought Plus Dining Habits Are Doing In Crows.
   https://www.nytimes.com/1999/09/05/nyregion/neighborhood-report-bayside-update-drought-plus-dining-habits-are-doing-in-crows.html

Advanced Article: Crow Deaths as a Sentinel Surveillance System for West Nile Virus in the Northeastern United States, 1999. https://wwwnc.cdc.gov/eid/article/7/4/01-7402_article

The group discusses the following questions:

- Are you concerned about birds dying? If you are, who would you notify?
- What do you think happened even after authorities were notified?
- What actions would you like to take to protect birds, if any?

The group then prepares to report to the class about what they learned and the type and number of birds that died by geographic distribution that were observed and their answers to the questions.

2. The **human group**: Students read a newspaper article reports on the increase in people hospitalized for a mystery illness in Queens and the Bronx.

   News Article: African virus may be culprit in mosquito-borne illness. https://www.nytimes.com/1999/09/26/nyregion/exotic-virus-is-identified-in-3-deaths.html

   Advanced Article: The Outbreak of West Nile Virus Infection in the New York City Area in 1999. https://www.nejm.org/doi/full/10.1056/nejm200106143442401The group discusses the following questions:

   - Are you concerned about people getting sick and dying? If you are, who would you notify?
   - What do you think happened even after authorities were notified?
   - What actions would you like to take to protect people, if any?

   The group then prepares to report to the class about what they learned and the number of people that died or were hospitalized using different criteria (age, location, symptoms, etc.) and their answers to the questions.

3. The **horse group**: Students read a newspaper or veterinary medical article on a mystery illness affecting horses.

   News Article: As Fears Rise About Virus, The Answers Are Elusive. https://www.nytimes.com/1999/09/29/nyregion/as-fears-rise-about-virus-the-answers-are-elusive.html

   Advanced article: West Nile Virus Outbreak Among Horses in New York State, 1999 and 2000. https://wwwnc.cdc.gov/eid/article/7/4/01-7427_article

The group discusses the following questions:

- Are you concerned about horses getting sick and dying? If you are, who would you notify?
- What do you think happened even after authorities were notified?
- What actions would you like to take to protect horses, if any?

The group then prepares to report to the class about what they learned, the number of horses affected and their symptoms, and the answers to the questions.

Group Discussion/Video and Wrap-Up (20 minutes):

1. Each group reports to the class about what they learned and shares their answers to the questions. The class compares the different perspectives they have discovered from the three groups and discuss possible impacts of each on other species as well as potential unintended consequences.

2. View short video news clip on West Nile Virus. https://whyy.pbslearningmedia.org/resource/envh10.sci.life.eco.westnilenyc/west-nile-virus-outbreak-in-nyc/#.W0f2ZdhKgWo. Read brief summary of WNV outbreak from the One Health Commission (https://www.onehealthcommission.org/index.cfm/38649/15886/west_nile_virus):

   West Nile virus causes an emerging infectious disease that was first discovered in Uganda in 1937. In recent years it has spread beyond its traditional boundaries, causing illness in birds, horses, and humans in Europe and the United States. Since its discovery in New York in 1999, West Nile virus has been detected in humans, animals, and mosquitoes throughout the United States.

   In 1999 in New York City, several elderly people became deathly ill with signs of encephalitis, and crows began dying in large numbers in the same area. Analyses of human blood specimens by the Centers for Disease Control and Prevention (CDC) initially suggested St. Louis encephalitis (SLE), a disease that had previously occurred in the area and is transmitted from infected birds to humans by mosquitoes. But something didn't seem right since birds do not normally show any signs of illness from SLE. Dr. Tracey McNamara, head pathologist at the Bronx Zoo, began to investigate why a growing number of crows were becoming ill and dying. An epidemiologist at the city health department raised concern that the large numbers of dead birds might be connected to the human cases of encephalitis. McNamara soon was dealing with the deaths of a cormorant, several flamingos, and a bald eagle.

Analysis of samples from the dead zoo birds by the US Department of Agriculture National Veterinary Services Lab in Ames, Iowa, revealed a virus too small to be SLE virus. It was soon clear that the human and bird deaths were being caused by the same virus and that this was a newly emerging disease. Nearly 3 months after the initial outbreak, government scientists announced that the disease was caused by West Nile virus, which had never before been found in the Western hemisphere.

The 1999 epidemic in the New York City area resulted in 62 cases of encephalitis and 7 deaths. Zoo birds, American crows and at least 20 other North American wild bird species and horses were also affected. It is not clear how West Nile virus entered the United States. It could have come from a mosquito carried on a plane, or it may have been from an infected wild or imported bird. But since its introduction, West Nile virus has continued to spread and is now a significant threat to the health of humans, birds, and horses. Since 1999, there have been 1.5 million West Nile virus infections in the United States.

3. Wrap-up discussion addresses final questions and lessons learned from this exercise.
    a. How does a virus like this "emerge" on a new continent: where did it come from, and how did it get here?
    b. Were their problems with communication between the different types of Disease detectives and how could better sharing of information have changed the outcome?
    c. Discuss the term "One Health" as an integrated concept of health and well-being that combines knowledge and input from many different stakeholders to attain optimal health for people, domestic and wild animals, plant life, and the environment (see www.onehealthcommission.org/en/why_one_health/what_is_one_health/).

Next Gen Science Standards that are relevant to this case:

ETSA

- ETS1-A: Defining and delimiting problems
- ETS1-B: Developing possible solutions
- ETS1-C: Optimizing the design solution

Life Sciences

- MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Additional References and Resources for Teachers:

1. FULL REPORT GAO/HEHS-00-180 West Nile Virus Outbreak. https://www.gao.gov/assets/230/229648.pdf
2. CDC West Nile Virus information. https://www.cdc.gov/westnile/index.html
3. CDC on Zoonotic Diseases. https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html
4. WHO West Nile Virus Fact Sheet http://www.who.int/news-room/fact-sheets/detail/west-nile-virus
5. WHO on Climate Change and Infectious Diseases. http://www.who.int/globalchange/environment/en/chapter6.pdf
6. PBS program on West Nile Virus (including multiple videos) http://www.pbs.org/wgbh/rxforsurvival/series/diseases/west_nile_virus.html
7. One Health Educational Resources from the One Health Commission. https://www.onehealthcommission.org/en/resources__services/one_health_educational_resources/

Appendix 1. Worksheets for Investigation Phase

Each of the Students in their groups should be provided with a worksheet for their species. Disease detectives should be provided with the Investigation Worksheet

Birds

Birds are the host species for West Nile Virus meaning that the virus can complete its life cycle in birds. Many birds do not show any symptoms when infected with West Nile Virus but some species of birds, like crows, develop serious disease and may die in large numbers. An infected bird may appear drowsy, be unable to fly or walk properly or may have problems standing upright. In severe cases birds may show signs of inflammation of the brain late in the disease.

If you were bitten by a mosquito (red or green stickers), act out one or all of the symptoms that match the sticker that you have. If you have more than one sticker, act out the most severe symptom only.

Please remember that birds and humans cannot talk to one another. If the wildlife biologists asks you what symptom you are acting out, you cannot answer. There are no Dr. Doolittles in the classroom today!

Sticker	**Symptoms in Birds**
No Sticker	Normal bird-like behaviors or walk around normally.
Green sticker	Normal bird-like behaviors or walk around normally.
Red sticker	Difficulty Flying or walking properly (stumble around) Dead (act dead/lay on the ground and don't move) Drowsy (pretend to keep falling asleep)

Horses

Horses are accidental or dead-end hosts of West Nile Virus meaning that they get sick from the virus but the virus cannot replicate (reproduce) in this host and then be passed to other mosquitos. Horses with West Nile Virus have fever, incoordination, stumbling, hind limb weakness, tiredness, anorexia, inability to get up, muscle tremors, teeth grinding, head pressing, aimless wandering, excessive sweating, behavior changes, and convulsions or even coma and death.

If you were bitten by a mosquito (red or green stickers), act out one or all of the symptoms that match the sticker that you have. If you have more than one sticker, act out the most severe symptom only.

Please remember that horses and humans cannot talk to one another. If the veterinarian asks you what symptom you are acting out, you cannot answer. There are no Dr. Doolittles in the classroom today!

Sticker	Symptoms in Horses
No Sticker	Normal horse-like behaviors or walk around normally.
Green sticker	Normal horse-like behaviors or walk around normally.
Red sticker	Stumbling (stumble around) Lays down (lay down on the floor) Grinding Teeth (pretend to grind your teeth)

Humans

Most cases of West Nile Virus are mild and go unreported because they don't have symptoms or the symptoms are so mild. Some mild symptoms include fever, **headache**, **body aches**, joint pain, and weakness. Some people develop inflammation of the brain or tissue surrounding the spinal cord and have much more severe symptoms. **Severe** symptoms and signs may include **stiff neck**, **sleepiness**, **disorientation**, convulsions, and **paralysis**.

If you were bitten by a mosquito (red or green sticker sticker), act out the some of the symptoms listed below following symptoms. If you have more than one sticker, act out the red sticker symptoms only.

Humans can talk to each other but sometimes human patients have a hard time describing how they are feeling. If the human physician (doctor) asks you what symptom you are acting out, you can describe how you are feeling. For example, if you are acting out a headache, you might tell the doctor that your head hurts.

Sticker Color	Symptoms in Humans
No Sticker	Normal human-like behavior
Green Sticker	Normal human-like behavior
Red Sticker	Fever (if asked describe having chills) Headache (hold you head like it hurts) Stiff neck (keep your neck straight and stiff, patients may rub their neck) Sleepiness (pretend to fall asleep; may make snoring noises to indicate that you are sleeping)

Disease Detective Investigation Worksheet

Disease detectives are highly trained responsible and professional people. They follow specific scientific evidence-based investigation techniques to determine the causes of an unusual event and make recommendations for responding and minimizing harm. They also often help to develop policies that will prevent a future similar outbreak or event.

Data collection, including observations, is very important and must be accurate.

Instructions: observe the species group that you are best trained to study and write your observations below. Only human physicians may talk to their subjects.

Disease Detective Group (circle)	Wildlife Biologists	Veterinarians	Human Physicians
Species observed:			
Number of Individuals in the Species Group: _____			
Number of Individuals without any Stickers: **____**	**Symptoms of Individuals without any stickers (record):**		
Number of Individuals with Green Stickers: ____	**Symptoms of Individuals with Green stickers (record):**		
Number of Individuals with Red Stickers: ____	**Symptoms of Individuals with Green stickers (record):**		

Appendix 2: Worksheet for Reporting Phase

Outbreak Investigation Report

Species Observed (circle): birds horses humans

1. Did all of the students bitten by mosquitos show symptoms?

   If not, which color sticker caused your species to show symptoms and what symptoms did they show?

2. What percentage of your species (horses, birds, humans) were bitten by mosquitos?

   _____

3. Data Activity : Students will graph out their findings:
   a. What type of graph should be used and why? discuss what the term “histogram” means and how it’s used; discuss what the term “bar graph” means and how it’s used.
   b. Construct a graph showing the number of unaffected individuals (not bitten), the number of bitten but no infected, and the number of bitten infected, symptomatic individuals.
4. Summarize your findings describing the symptoms you observed in text form and showing your graph to present to the class.

Appendix 3: Sample Word Bank table

Word	Definition
Virus	
Vector	
Reservoir (disease)	
Accidental or Dead-end Host	
Encephalitis	

Appendix 4: Variations for the Day 1 Outbreak

The following are variations that could be used to teach different lessons using the outbreak activity.

1. It's not as Easy as it Looks Scenario: Make things more complicated. Sometimes outbreaks involve symptoms that are easily confused and not specific for a particular disease (e.g. St Louis Encephalitis in this case, see video). Can you think of other diseases which might cause drowsiness or fever, for example? Add in an additional color stick and assign symptoms to that sticker. Students need to figure out which individuals have the disease of interest.

2. Hidden Carriers: Sometimes when there is a disease outbreak and reservoir or host are asymptomatic carriers of the disease (like most birds for West Nile Virus) or the symptoms are so mild that they don't get identified as being part of the outbreak. Make the activity more complicated by adding a different color sticker for asymptomatic or mild manifestations of the disease. Have students hide their stickers from the disease detectives and just have the disease detectives observe numbers of students showing symptoms and what symptoms.
    a. How do these asymptomatic carriers affect the reporting of the number of individuals affected? How would these asymptomatic carriers impact the ability of the disease detectives to figure out the source of the problem?
    b. West Nile virus is not contagious from human to human. What would happen if the disease was contagious within a species (e.g. human to human transmission)?

3. Specialists or responders can also be infected: During an outbreak, the people treating the sick or studying the disease can become infected too- sometimes at even higher rates than those not involved with the disease outbreak! Did some of the Disease Detectives get sick in this exercise? How might this affect their work?

4. Repeat the activity but increase the number of mosquitos or number of infected mosquitos to stimulate what happens when changes in the environment increase the likelihood of infection. Ask students to compare the number of individuals infected/showing the different types of symptoms. Discuss different factors that might cause the number of mosquitos or the number infected mosquitos to increase.

5. Reservoir Hosts Scenario: Perform several "days" of infection by completing multiple rounds. Start with 4 mosquitos that have green stickers and 1 mosquito that has red stickers OR start with mosquitos that all have green stickers and 2 birds that are already infected. If a mosquito with a green sticker bites a bird with a red sticker, that mosquito will become infected (you can have infected mosquitos change out their green stickers immediately or

wait until the next round). Infected birds will have a different color sticker to stick on mosquitos when a mosquito bites them. Perform 3 rounds.

   a. Have the students graph the number of individuals with symptoms on each day so they can see the number of cases and how the disease spreads overtime.
   b. What happens to the amount of disease when mosquitos can become infected? If birds became sick and died so that mosquitos couldn't be infected by them, what do you think would happen to the amount of disease? Why are asymptomatic carriers a problem?
   c. What happens when there are more infected mosquitos in the environment? Use this exercise to explain how the disease is perpetuated.

6. Virulence: Change the number of stickers the mosquitos are passing out to change the virulence of the disease. (More stickers=more virulent).
   a. Why do some viruses cause disease outbreaks while others do not?
   b. Have the students learn about what factors makes a disease more virulent. Discuss the trade offs to a disease being very deadly verses very contagious.

7. VACCINATION Scenario: There is now a West Nile Virus vaccination available for horses. Many times when there is an outbreak, scientists quickly try to develop a vaccine. Teach students about how vaccination prevents disease outbreaks. "Vaccinate" some of the students against the disease and then run the outbreak scenario again (this can be done with the basic outbreak or one of the variations).
   a. How does this change the number of animals infected?
   b. Why are vaccines important in preventing disease outbreaks?
   c. Do vaccines really cause health problems?
   d. How do vaccines work? Why do vaccines only work sometimes?