OVERVIEW

This game is a companion to the Click & Learn From Birds to People: The West Nile Virus Story, which introduces students to West Nile virus and other vector-borne diseases.

In this game, students play either a host or a vector (mosquito) to simulate how West Nile virus spreads. Each student playing a host is given a playing card that explains his or her role. The student is then responsible for acting out the results of West Nile infection as described on the playing card.

KEY CONCEPTS

- A number of emerging viral diseases in the United States, such as West Nile disease and dengue fever, require a nonhuman vector, such as arthropods, in order to spread between people.
- Some vectors are bloodsucking insects, which ingest disease-producing microorganisms from an infected host (human or animal) during a blood meal and then inject those microorganisms into a new host in a subsequent blood meal.
- The life cycles of insect vectors that transmit diseases consist of egg, larval, pupal, and adult stages. In particular, many of these insects undergo complete metamorphosis.
- Viral infection has different effects in different species of animals and in different individuals.

STUDENT LEARNING TARGETS

- Differentiate the roles of vectors and hosts in West Nile virus infection.
- Explain how a virus spreads through a community.
- Understand that some hosts play a role in spreading a virus and others don't.

CURRICULUM CONNECTIONS

Standards	Curriculum Connection
NGSS (2013)	HS-LS2-1, HS-LS2-8
AP Bio (2015)	3.C.3, SP3, SP6
IB Bio (2016)	6.3
AP Env Sci (2013)	III.B.3
Common Core (2010)	ELA.RST.6-12.7, WHST.6-12.1, MP1, MP2
Vision and Change (2009)	CC2, CC5

KEY TERMS

insect, mosquito, vector, viral disease, West Nile virus

TIME REQUIREMENTS

- One 50-minute class period

SUGGESTED AUDIENCE

- Middle school life sciences
- High school general, AP/IB biology

PRIOR KNOWLEDGE

Students should

- understand some of the factors that contribute to the spread of disease
- understand the basic functions of viruses
- be familiar with the life cycles of insects

MATERIALS

- Game cards
- Blue and red dry erase markers

PROCEDURE

Setting up the activity

- Assign 20% of the students to play the role of mosquitoes (half uninfected and half infected). Give the uninfected mosquitoes blue markers and the infected mosquitoes red markers.

- Divide the rest of the participants as follows: 30% robins, 20% humans, 10% blue jays, 10% crows, and 10% horses. Each student receives a game card that indicates which host he or she is playing.

Note: The percentage of mosquitoes may be changed to investigate the effects of an increase in the total number of mosquitoes. The ratio of infected to uninfected can also be varied.

The game consists of **three (3) rounds** of mosquito "biting." Each round will last a predetermined period of time set by the instructor; one minute or less is recommended, depending on the classroom arrangement.

Round 1

- Mosquitoes randomly "bite" as many hosts as possible; however, each host can only be bitten once per round. (You may want all the hosts to be sitting or to stand in line to minimize confusion; mosquitoes would move from host to host.)

- To bite a host, a mosquito marks the host's game card in the box numbered 1. Infected mosquitoes mark the box in red and uninfected mosquitoes in blue. For example, if an uninfected mosquito bites a crow, the crow receives a blue mark on its card in the box numbered 1.

- After a mosquito marks a host's card (that is, bites the host), it can move on to another host.

- The outcome for the hosts will differ depending on the type of mosquito that bit them and the type of host. (See the "Different Outcomes for Different Hosts" section below.) Some infected hosts will die in subsequent rounds, and others will not.

- At the end of Round 1, count the number of infected and uninfected mosquitoes and hosts.

Round 2

Players follow the same steps as in Round 1 with the following additional rules:

- Mosquitoes randomly "bite" as many hosts as possible, marking the hosts' cards in the box numbered 2. Again, each host can only be bitten once per round.

- If an uninfected mosquito bites an avian host and the card has a red mark from Round 1 (i.e., the bird is infected), the mosquito becomes infected and must trade in the blue marker for a red one.

- Once a mosquito becomes infected, it immediately starts marking other playing cards in red.

- If an uninfected mosquito bites a horse or human that has a red mark from Round 1 (i.e., an infected host), the mosquito does not become infected.

- An infected mosquito will always be infected, regardless of which host it bites.

- If an infected host dies at the end of Round 2, the player sits down and can no longer be bitten.

- At the end of Round 2, count the number of infected and uninfected mosquitoes and hosts.

Round 3

Players follow the same steps as in Round 2 with the following additional rules:

- Mosquitoes randomly "bite" as many hosts as possible, marking the hosts' cards in the box numbered 3.

- Mosquitoes cannot bite a dead host.

- If an uninfected mosquito bites an avian host that received a red mark in either Round 1 or Round 2, the mosquito becomes infected and must trade in the blue marker for a red one.

- At the end of Round 3, count the number of uninfected and infected mosquitoes and hosts.

Different Outcomes for Different Hosts

1. If an uninfected mosquito bites a host, nothing happens to that host.

2. Avian hosts:

   - If a *robin* is bitten by an infected mosquito, it becomes infected but does not get sick or die. It continues in the game for all three rounds. *If an uninfected mosquito bites a robin that is infected, that mosquito becomes infected.*

   - If a *crow* is bitten by an infected mosquito, it becomes infected and gets sick. It goes on to the next round and then dies at the end of that round. When a crow dies, it is out of the game and cannot get bitten again. *If an uninfected mosquito bites a crow that is infected, that mosquito becomes infected.*

   - If a *blue jay* is bitten by an infected mosquito, one of two outcomes is possible. One-half of infected blue jays will go on to the next round and then die (same as crows). One-half of infected blue jays will continue in the game for all three rounds (same as robins). *If an uninfected mosquito bites a blue jay that is infected, that mosquito becomes infected.*

3. Nonavian hosts:

   - If a *horse* is bitten by an infected mosquito, it becomes infected and gets sick. An infected horse will live until the final round and then die. *If an uninfected mosquito bites a horse that is infected, that mosquito will NOT be infected.*

   - If a *human* is bitten by an infected mosquito, he or she may become infected and get sick. A human does not transmit the virus and remains in the game. *If an uninfected mosquito bites a human that is infected, that mosquito will NOT be infected.*

DISCUSSION POINTS

The game is designed to illustrate the complexity of viral infections that involve multiple hosts, categorized here as vectors, primary hosts, and secondary hosts. To keep the rules of the game easy to understand and carry out, the interactions between vectors and hosts were simplified. You may want to discuss the following points with your students:

- How did the numbers of infected and uninfected mosquitoes and hosts change throughout the game? What do these results indicate about how infection spreads?

- In this game, a mosquito can bite many times, but a host is only bitten once per round. In nature, a host could be bitten by many mosquitoes in a given time period. How would biting frequency affect the chances of infection? And how would the proportion of the mosquito population that is infected affect the chances of infection?

- The ratio of mosquitoes to hosts is often quite large (many hundreds of mosquitoes per host), but the fraction of mosquitoes that are infected is usually small (5% is considered large). Why are the total population size as well as the proportion of infected mosquitoes both important to know and understand?

- In this game, a mosquito always becomes infected if it bites an infected bird. In nature, the probability that a mosquito will become infected depends on the species of the bird it's biting. The probability that an infected bird would infect a mosquito on each of the five days postinfection is 40% for blue jays, 31% for American crows, and 17% for American robins. What might be some of the possible reasons for this?

West Nile Virus: Vectors and Hosts Game

- Both crows and blue jays that succumb to severe infection die around four to seven days after infection with West Nile virus, but the fraction of birds that die differs: nearly all infected crows get sick and die, whereas about 50% to 75% of blue jays die and the rest have mild symptoms. What might be a cause for this?

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