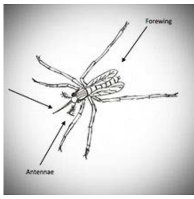

Battling Vector-Borne Diseases: Factors That Affect the Mosquito Life Cycle

hhmi BioInteractive

Activity
Educator Materials

OVERVIEW

This activity is a student-designed investigative experiment which complements the Click & Learn From Birds to People: The West Nile Virus Story.

Arthropod vectors, such as mosquitoes, ticks, and flies, can transmit various disease-causing bacteria, viruses, and protozoa between vertebrate hosts. Some familiar vector-borne infectious diseases include malaria, dengue fever, West Nile disease, and trypanosomiasis. Vector-borne diseases represent a serious health problem worldwide, particularly in Africa, South America, and parts of Asia (see figure below). According to the World Health Organization, malaria alone kills more than 1.2 million people annually, mostly African children under the age of 5. Some vector-borne diseases are also increasing in prevalence in North America. West Nile virus was first detected in New York in 1999 and has since spread throughout the United States.

Studying the life cycles of disease vectors may suggest strategies for limiting, or even stopping, the spread of the diseases they transmit. In this activity, students test variables that might affect the life cycle of the mosquito. Students will rear mosquitoes in chambers that allow them to make observations without risking the release of the insects into the classroom. Although it takes about two weeks for the mosquito life cycle, and this activity, to be completed, observations require only a few minutes each day.

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.

STUDENT LEARNING TARGETS

- Understand how the life cycle of any organism can be influenced by a variety of factors.
- Develop and utilize protocols for a scientific investigation: formulate a simple, testable hypothesis; design an experiment with proper controls; make detailed observations; and develop conclusions using evidence from the experimental data.
- Demonstrate how scientific data can be used to design meaningful and executable public policy to prevent disease.

CURRICULUM CONNECTIONS

Standards	Curriculum Connection
NGSS (2013)	HS-LS2-1, HS-LS2-8, HS-ETS1-1
AP Bio (2015)	3.C.3, SP3, SP4, SP5, SP6, SP7
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, MP3
Vision and Change (2009)	CC2, CC5, DP1, DP6

KEY TERMS

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

TIME REQUIREMENTS

- One to two 50-minute class periods are needed to introduce the investigation and for students to plan the experimental design. Alternatively, some of the planning can be assigned for homework.
- Rearing the mosquitoes requires 11 to 14 days, depending on conditions. (For example, cooler classroom temperatures will slow the hatching process.) Although daily observations should be made during this time period, observations should only take 5 to 10 minutes each day.

SUGGESTED AUDIENCE

- High school honors, AP/IB biology
- Undergraduate biology course

PRIOR KNOWLEDGE

Students should

- understand some factors that contribute to the spread of disease
- understand the basic functions of viruses
- be familiar with the life cycles of insects
- be proficient with planning and implementing a scientific investigation

MATERIALS

- **Mosquito rearing chambers:** These can be made from inexpensive plastic food storage containers, as shown in the "Mosquito Life Cycle Activity" documents. Rearing chambers are also available for purchase from BioQuip (www.bioquip.com).
- **Mosquito eggs:** These can be collected from standing water or obtained from some state health departments. (See Steinly, B.A. The Collection of Mosquito Eggs for Classroom & Field Investigation. 2004. *The American Biology Teacher*, 66:363–369.)
- **Mosquito food:** Food is available from Carolina Biological Supply Company (www.carolina.com). You can also use Kaytee Koi's Choice fish food with 35% protein, which is available at most pet stores.
- Sugar cubes
- **Water:** Dechlorinated water or tap water may be used.
- Hand lenses or dissecting scopes (optional)

PROCEDURE

1. **Introduce students to the activity:** You may use the Click & Learn "From Birds to People: The West Nile Virus Story" (http://www.hhmi.org/biointeractive/birds-people-west-nile-virus-story) to introduce students to vector-borne diseases and the importance of understanding the factors that affect their spread.
2. **Introduce students to the mosquito life cycle:** The "Mosquito Reference Document" contains information and illustrations about the mosquito life cycle. Students may review this information as homework, listen to you present it, or review it quietly in groups.
3. **Introduce working groups and begin brainstorming:** Divide the class into small working groups of three to five students and tell each group to select one person to record the group's ideas. Allow 5 to 7 minutes for brainstorming, after which groups should share their ideas.
4. **List and evaluate questions of interest:** Students need to consider variables in the environment that might

have an effect on the mosquito life cycle. Some easily tested variables include the pH of the water, temperature, light, humidity, chemicals in the water, water quality, and amount of organic matter in the water. Avoid prompting students to consider these variables, because they may have more creative and surprising ideas.

Once working groups have formulated questions, evaluate these questions either by visiting each group individually or by having each group share its questions with the class. Students may also share their questions via an electronic medium, such as Google Docs. Help guide each group toward choosing **one question** that is interesting and can be adapted into a testable hypothesis.

5. **Consider the basic protocol for experimentation:** The "Mosquito Life Cycle Activity" provides guidelines for observing the mosquito life cycle. Instruct students to review this handout so that they understand the basic protocol for rearing mosquitoes, which they should then adapt to their own experiments.
6. **Review student hypotheses:** There are many ways to define a hypothesis, but most include the idea that it is a possible explanation, based on prior observations, of a phenomenon of interest. The best hypotheses are simple and testable. For instance, "Temperature influences the rate of mosquito development" is simple and can be tested by observing mosquitoes developing at two different temperatures.
7. **Identify variables:** Students must select a single variable that will be the experimental variable. They then identify other variables that they must carefully control.
8. **Design the experiment:** Students should design the procedures they will use to test their hypothesis and make a list of the materials they will need. Students should also identify specific needs, such as a dark space, a warm space, or unusual water conditions, and know how they will accommodate these requirements. The experimental design can be written up as homework. You can have each group turn in a printed copy of the experimental design and materials, or have students share these documents through a collaborative electronic medium, such as Google Docs, or by e-mail. Review your students' experimental designs and materials before they start their experiments, allowing enough time for feedback and refinements.

   The Guidelines document for this activity, available for download, provides some information for teaching students about experimental design, including setting up controls. One possible cost-saving technique is to set up <u>one</u> control experiment—for example, one egg raft at room temperature and ambient light—for all groups to use as a reference. (Depending on the experiments, one control may not work for everyone.)
9. **Conduct the experiment:** Experimental setup will take only a few minutes of class time if students are organized. Students may set up their own mosquito chambers in class or as an at-home assignment before the conducting experiment.
   - Instruct students to follow the procedures they have outlined.
   - Students should carefully record daily observations.
   - On occasion, encourage students to observe the eggs, larvae, and pupae using hand lenses or dissecting scopes, which will allow them to notice subtle changes.
   - Students may also choose to document their experiments by taking photographs or videos with their smartphones.
10. **Presentation/Evaluation:** There are several ways to evaluate the results of student experiments. Here are a few suggestions:
    - *Students may write a formal lab report*. This is the traditional means through which students organize their results and consider the importance of the outcome. Guidelines for writing a formal lab report and a

sample grading rubric are provided in the Guidelines document.

- *Students may prepare a scientific poster*. Poster sessions at scientific meetings are an important way for scientists to present their work to peers.
- *Students may write a proposal about methods to control mosquitoes in their community*. Students may apply their data (and data from other lab groups) to write a proposal for cost-effective and simple methods for controlling mosquitoes in their own community.
- *Students may create a public service announcement about how mosquito populations can be controlled in their own community*. This can be accomplished by using smartphone technologies that are readily available to many students.
- *Pool data*. Different lab groups may have chosen to study the same variable in very similar ways. When possible, encourage groups to pool data and discuss the results when they do so.

AUTHOR

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