

# Battling Vector-Borne Diseases: Factors That Affect the Mosquito Life Cycle—Teacher Materials



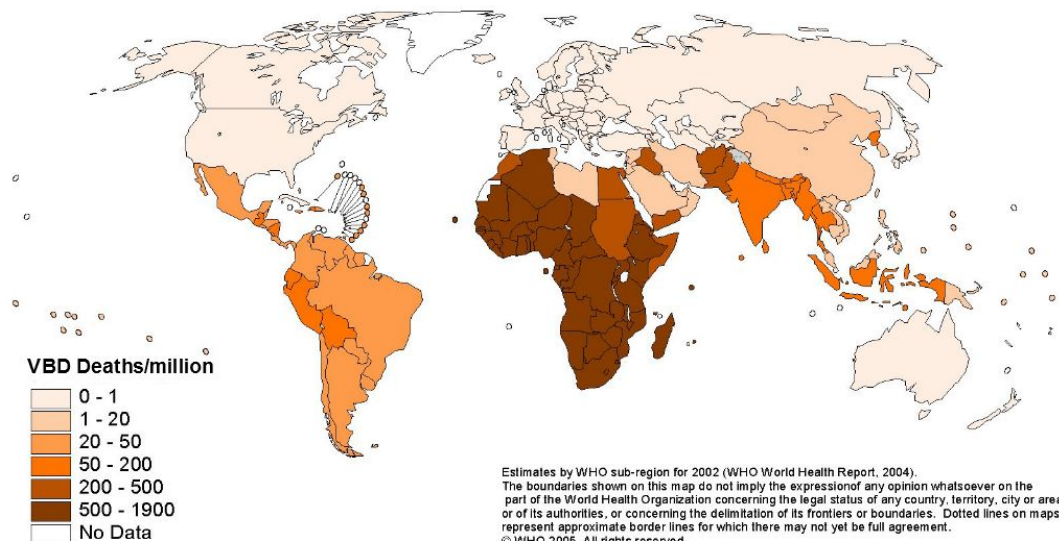
## About This Activity

This activity complements the HHMI 2010 Holiday Lectures on Science, “Viral Outbreak: The Science of Emerging Disease.” It will take a few days to plan and set up the experiment. You will then need to make **daily** observations for about two weeks.

## Overview

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 five. 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.

## Deaths from vector-borne disease



(Image published with permission from <http://www.who.int/heli/risks/vectors/en/>)

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.

## Appropriate Levels

This activity is appropriate for a general, honors, or AP high school biology course and an undergraduate biology course. It can also be adapted for the middle school or primary school life science classroom.

## Learning Objectives

Students will:

- Understand that a number of emerging viral diseases in the United States, such as West Nile disease and dengue fever, are transmitted by vectors.
- Gain an appreciation that vector-borne diseases require a nonhuman vector, such as arthropods, in order to spread between people.
- Learn about the life cycles of insect vectors that transmit diseases—in particular, many of these insects undergo complete metamorphosis, with life cycles that consist of egg, larval, pupal, and adult stages.
- Learn that the life cycle of any organism can be influenced by a variety of factors.
- Become familiar with the scientific method of formulating a simple, testable hypothesis; designing an experiment with proper controls; making detailed, careful observations; and drawing meaningful conclusions from experimental data.
- Gain an appreciation that scientific data can be used to design meaningful and executable public policy to prevent disease.

## Materials

- **Mosquito rearing chambers.** These can be made from inexpensive plastic food storage containers, as shown in the “Mosquito Life Cycle Activity” handout (<http://media.hhmi.org/biointeractive/activities/mosquito/mosquito-activity-web-v1.pdf>). Rearing chambers are also available for purchase from BioQuip ([www.bioquip.com](http://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](http://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.** These are optional.

## Time Requirement

Introducing the lab and planning the experimental design will require a minimum of one 50-minute class period and some 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, such observations will only take 5 to 10 minutes each day.

## Suggested Teacher Background

You can gain all needed background for this activity by reviewing the Click and Learns “From Birds to People: The West Nile Virus Story” (<http://www.hhmi.org/biointeractive/birds-people-west-nile-virus-story>) and “Stopping Mosquito-Borne Disease” (<http://www.hhmi.org/biointeractive/stopping-mosquito-borne-disease>).

Additional background information is provided in the following segments of the 2010 Holiday Lectures on Science (<http://www.hhmi.org/biointeractive/viral-outbreak-science-emerging-disease>):

- “Dengue Fever: Breaking Epidemic Cycles” by Eva Harris
- “Fighting Viruses in the Lab and Beyond” by Eva Harris
- “Biology of the Mosquito Vector” (Chapters 1–13) by Laura Kramer

## Conducting the Activity

1. **Introduce the activity to your students.** You may use the Click and 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 Manual” ([http://media.hhmi.org/biointeractive/activities/mosquito/mosquito\\_reference\\_manual.pdf](http://media.hhmi.org/biointeractive/activities/mosquito/mosquito_reference_manual.pdf)) 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 their working 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. **Consider 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.
5. **Evaluate group questions.** 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.

6. **Consider the basic protocol for experimentation.** The handout “Mosquito Life Cycle Activity” (<http://media.hhmi.org/biointeractive/activities/mosquito/mosquito-activity-web-v1.pdf>) 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.
7. **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.
8. **Identify variables.** Students must select a single variable that will be the experimental variable. They then identify other variables that they must carefully control.
9. **Designing 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.
10. **Designing the control experiment.** Appendix 1 provides some information for teaching students about experimental design, including setting up controls. One possible cost-saving technique is to set up one 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.)
11. **Setting up the experiment.** Experimental setup will only take 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 experiment.
12. **Conducting the 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.
13. **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 are provided in Appendix 2. To expedite grading, a sample grading rubric is provided in Appendix 3.

- *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.

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**About the Holiday Lectures on Science and BioInteractive.org**

As part of its mission to strengthen science education, HHMI presents the Holiday Lectures on Science, an annual series that brings the latest developments in a rapidly moving field of research into the classroom. The lectures are given by HHMI investigators and other leading scientists. The series began in 1993.

To complement the Holiday Lectures and enhance their usefulness in the classroom, HHMI produces a variety of free science education materials. Lecture summaries, biographies of the lecturers, and other resources are available at [www.holidaylectures.org](http://www.holidaylectures.org). DVDs and CD-ROMs can be ordered through HHMI's Catalog at <http://catalog.hhmi.org>.

The BioInteractive website ([www.BioInteractive.org](http://www.BioInteractive.org)) features virtual labs, animations, and other engaging instructional materials. They can be used to supplement the lecture topics or to learn important concepts in the biomedical sciences.

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**About the Howard Hughes Medical Institute**

The Howard Hughes Medical Institute is a nonprofit medical research organization that employs hundreds of leading biomedical scientists working at the forefront of their fields. In addition, through its grants program and other activities, HHMI is helping enhance science education at all levels and maintain the vigor of biomedical science worldwide. Headquartered in Chevy Chase, Maryland, HHMI is one of the world's largest philanthropies, with laboratories across the United States and grants programs throughout the world.

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## Appendix 1: Experimental Design Considerations

**Question.** After preliminary observations or brainstorming, scientists generate questions about the topic under study.

**Hypothesis.** A hypothesis is a possible answer to a question or an explanation for some currently unexplained phenomenon. Good hypotheses are testable and falsifiable. Because we can never test every possible factor that might influence the outcome of an experiment, hypotheses are never proved right, but they can be supported or rejected by experimental data. An example of a hypothesis is “Increasing the amount of sunlight will cause a garden pea plant to grow taller.”

**Variables.** Variables are factors that might be expected to change during the course of an experiment. The investigator deliberately changes (manipulates) the **independent variable** (e.g., sunlight in the hypothesis above) to learn how these changes affect the **dependent variable** (e.g., the height of a plant). The investigator tries to hold other variables (the **controlled variables**) constant so that any changes in the dependent variable(s) can be attributed to changes in the independent variable. Controlled variables might include water and temperature in the example above.

**Controls.** A simple experimental design involves two groups, one called the **experimental (or treatment) group** and the other the **control (or comparison) group**. In a way, they are like two experiments run simultaneously. Each group is treated exactly the same way with one exception: the independent variable is manipulated in the experimental group. The control treatment may involve setting the independent variable at a normal or standard value. The results from the control and experimental groups are then compared.

**Random samples.** Because an investigator usually cannot work with an entire population of organisms, he or she must instead rely on a **sample** (subset) of the population. Individuals should then be **randomly assigned to control and treatment groups**. Random assignment will make it more likely that those two groups are comparable in all variables that are the result of individual differences. If the two groups are different from the outset and they respond differently to treatment during the experiment, then you cannot be sure that the independent variable that you manipulated is the cause of the difference.

## Appendix 2: Lab Report Writing Guidelines

The lab report must be typed, double-spaced, and in a 12-point font. It should also have standard margins. A complete lab report includes an appropriate title and four labeled sections:

1. **Introduction.** The introduction should provide background information and explain the motivation for the design and pursuit of your experiment. Describe what led you to ask the question that became your hypothesis. If your prelaboratory activity included an initial brainstorming session, provide notes from that session (rewritten in a logical way). Your hypothesis must be stated in your introduction, typically as the last sentence.
2. **Materials and Methods.** This section should be written in the first person, past tense. List, in paragraph form, the items needed for your experiment and describe your methodology. Report exactly what you did in enough detail to allow a naive reader to repeat your experiment.
3. **Results.** Provide the data you gathered in your experiment and any calculations you performed. Include the equations you used, if any, when analyzing your data. Properly labeled tables and graphs are often the most informative, concise way to present data. Do not discuss the results in any way in this section. Simply present the data.
4. **Conclusion.** Is your hypothesis supported? Rejected? How do you know? A hypothesis is never proved right. It can only be supported or rejected by the data gathered in the experiment. A rejected hypothesis is of scientific interest because it may lead to new ideas and hypotheses. Do not just state whether your hypothesis is supported. Instead, tell the reader what evidence leads you to conclude whether the hypothesis is supported.
5. **Discussion.** This section allows the scientist to consider the implications of his or her research. Can these results be applied to solve a problem in science or society? How do the results fit into the body of scientific knowledge? How could you improve this experiment? Do not be afraid to discuss errors in scientific procedures that may have affected the results. Are there specific sources of errors that could be addressed with a more careful experimental design? Were there limitations to your experimental design that could be addressed in a future experiment (assuming you had unlimited resources)? An excellent discussion always ends with a new question that could be tested by further experimentation.

## Appendix 3: Lab Report Grading Rubric

Criterion	Points Possible	Points Earned
<b>Title and Section Format (4 points)</b>		
Typed with correct format.	2	
Has an appropriate title.	1	
Sections are labeled properly.	1	
<b>Introduction (12 points)</b>		
Provides background information about the general topic.	4	
Explains what observations led to the research project.	4	
Explains why the study was done.	2	
States a hypothesis.	2	
<b>Methods and Materials (6 points)</b>		
Provides enough information so that someone could repeat the study.	4	
Written in first person and past tense.	1	
Written in paragraph form.	1	
<b>Results (6 points)</b>		
Findings summarized visually with pictures, maps, illustrations, tables, and/or graphs.	4	
Tables/graphs labeled correctly.	2	
<b>Conclusion (6 points)</b>		
States whether hypothesis is supported or rejected by the data.	2	
Explains <i>why</i> the hypothesis is supported or rejected.	4	
<b>Discussion (12 points)</b>		
Discusses the implications of the work. How does it fit into the greater body of knowledge on the subject? How can the data be applied to a problem that needs a solution?	4	
Discusses limitations of experimental design and suggestions for improvements or revisions.	4	
Discusses new questions the observations/results have raised and possible ways they might be answered.	4	
<b>Writing Skills (4 points)</b>		
Two or fewer sentence structure or spelling errors.	4	
<b>Total</b>	<b>50</b>	