

# **The New Plague? Dengue, Mosquitoes, and Climate Change**

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**Grade Level:** High School

**Subject Areas:** Life science, environmental science, health

**Duration:** Variable depending on depth of study

## **Next Generation Science Standards:**

- HS-LS2-7 – Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-LS4-5 – Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species...
- HS-ETS1-3 – Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- Practices of science
  1. Asking questions and defining problems
  2. Planning and carrying out investigations
  3. Analyzing and interpreting data
  4. Constructing explanations and designing solutions
  5. Obtaining, evaluating, and communicating information
- Crosscutting concepts
  1. Stability and change

## **Common Core State Standards – ELA/Literacy**

- RI.1- 9-10 - Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- RI.1-11-12 - Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.
- SL.9-12.1 - Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–12 topics, texts, and issues.
- SL.9-12.4 - Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
- SL.9-12.5 - Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
- W.9-12.7 - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem.

## **Maryland State Curriculum – Health Education (High School)**

- 7.A.1 - Describe risk factors and behaviors that influence contraction and transmission of communicable diseases.

- 7.E.1 - Examine the roles of the individual and society in preventing disease.

**Environmental Literacy:**

- 1.A.1 – Identify an environmental issue
- 1.A.4 – Design and conduct the research
- 1.A.5 – Use data and references to interpret findings to form conclusions.
- 1.B.1 – Use recommendation(s) to develop and implement an action plan
- 1.B.3 – Analyze the effectiveness of the action plan in terms of achieving the desired outcomes

**Objectives:**

- Students will understand the interrelationships between dengue fever, *Aedes* mosquitoes, and climate change.
- Students will be able to identify *Aedes* mosquitoes.
- Students will design and build homemade mosquito traps to monitor for the presence of *Aedes* mosquitoes.
- Students will develop a community education/action plan to reduce mosquito populations and prevent mosquito bites.

**Background:**

Given that Lyme disease is common in the mid-Atlantic, many students may already be familiar with the concept of a “vector-borne” disease – a disease that is spread by the bite of an infected arthropod species such as a tick or mosquito, rather than directly from person to person like the flu. World-wide, approximately 17% of infectious disease is vector-borne, resulting in over 1 million deaths from diseases such as malaria and yellow fever (<http://www.who.int/mediacentre/factsheets/fs387/en/>). In the mid-Atlantic, the two most common vector-borne diseases are Lyme disease and West Nile virus.

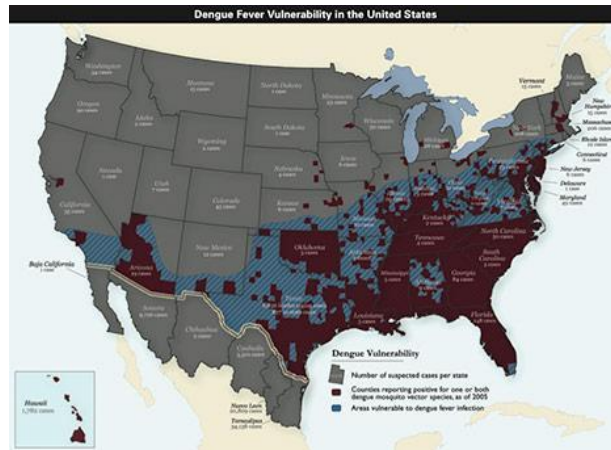
Thanks to an invasive mosquito species and increasing temperatures due to climate change, there may soon be a new player in town. Dengue fever (also known as “break-bone fever”) was considered a tropical or sub-tropical disease, found in Mexico and Central and South America but not found in the United States. As recently as 2013, however, there were 821 cases of dengue in the continental United States; 772 of these cases were acquired elsewhere, but 49 were acquired within the U.S. ([http://diseasemaps.usgs.gov/del\\_historical.html](http://diseasemaps.usgs.gov/del_historical.html)).

Dengue is spread by two mosquito species. The primary vector is *Aedes aegypti*, the yellow fever mosquito, which is usually a tropical mosquito. The problem is the second vector – a recently arrived (1985) invasive species called the Asian tiger mosquito (*Aedes albopictus*). Unlike the yellow fever mosquito, Asian tiger mosquitoes have been able to adapt to temperate climates. The eggs can survive very cold winters; once the water warms to 60°F, the eggs hatch and the adults thrive as long as the temperature is 68° F or above and there are at least 20 inches of rain (<http://www.issg.org/database/species/ecology.asp?si=109>). Currently, Asian tiger mosquitoes are found in more than thirty states, including Maryland, Pennsylvania, and Delaware, and have demonstrated the ability to survive as far north as Minnesota, Michigan, and New England.

So what impact does climate change play in the possible spread of dengue?

- Warmer weather extends the disease-transmission season because the breeding cycles of mosquitoes shorten. This means that they can reproduce multiple times instead of once or twice – resulting in even more mosquitoes to spread the disease.
- Heat speeds up the incubation of the dengue virus inside the mosquito, so it becomes infective much faster, giving it a longer time to sicken someone during its 3-4 week life span.
- Female mosquitoes bite more frequently when it is hot.

According to NRDC (Natural Resources Defense Council) senior scientist Kim Knowlton, “A changing climate may allow dengue-spreading mosquitoes to flourish in nearly half of the United States.” (From: *Fevered: Why a Hotter Planet Will Hurt Our Health* by Linda Marsa)



Source: <http://www.21stcentech.com/biomedicine-update-genetically-modified-organisms-making-difference-diseases/>

### Materials:

- For mosquito trap
  - 2 liter soda bottle
  - Scissors or knife for cutting bottle
  - Basket style coffee filters
  - Masking tape
  - Sugar, yeast, water
- Dissecting scopes or magnifying glasses (WalMart carries a 40X magnifying glass with LED light for jewel/ watch repair for \$2.99)
- Forceps

### Activity:

#### Engage

- Begin discussion of “vector borne disease”
  - Ask students what they know about Lyme disease. Do they know anyone who has had it? How did they get it? Have them go to

<http://borellia.weebly.com/> or [http://www.nature.com/nrmicro/journal/v10/n2/fig\\_tab/nrmicro2714\\_F1.html](http://www.nature.com/nrmicro/journal/v10/n2/fig_tab/nrmicro2714_F1.html) for more information.

- Key questions:
  - What causes the disease? *Borrelia burgdorferi* (bacteria)
  - How is it spread? *Spread by the bite of an infected tick*
  - Is it spread between humans by the bite of a tick? *No; the tick becomes infected by biting an infected rodent*
  - Is Lyme disease currently a problem in the mid-Atlantic? *Yes!*
- Now have them compare Lyme disease with an emerging vector borne disease – dengue fever
  - Have they ever heard about it? Do they know of anyone who has had it?
  - What are the similarities and differences between Lyme and dengue? (<http://www.nature.com/scitable/topicpage/dengue-transmission-22399758>)
    - *Both are vector borne diseases*
    - *Dengue caused by a virus, not a bacterium*
    - *Dengue is spread by mosquitoes, not ticks*
    - *Dengue can be spread from human to human by way of the mosquito vector; Lyme is spread from infected rodents to humans by way of ticks*
  - Is dengue currently a problem in the mid-Atlantic? *No*
- Could dengue become a problem in the mid-Atlantic?
  - Have them go to the following websites for research. This could be a homework assignment.
    - <http://www.climatecentral.org/blogs/the-climate-connection-to-dengue-fever>
    - <http://www.nrdc.org/health/climate/disease.asp>
    - [http://diseasemaps.usgs.gov/2013/dep\\_us\\_human.html](http://diseasemaps.usgs.gov/2013/dep_us_human.html)
    - Mosquito vectors
      - <http://www.issg.org/database/species/ecology.asp?si=109>  
(Read section on Geographical range)
      - [http://www.cdc.gov/dengue/resources/30Jan2012/comparison\\_dengue\\_vectors.pdf](http://www.cdc.gov/dengue/resources/30Jan2012/comparison_dengue_vectors.pdf)
      - <http://www.cdc.gov/dengue/resources/30Jan2012/aegyptifaactsheet.pdf>
      - <http://www.cdc.gov/dengue/resources/30Jan2012/albopictusfactsheet.pdf>
      - [http://mda.maryland.gov/plants-pests/Pages/asian\\_tiger\\_mosquito\\_md.aspx](http://mda.maryland.gov/plants-pests/Pages/asian_tiger_mosquito_md.aspx)
  - Based on their research, have them write a paragraph answering the question, “In the future, could dengue become a problem in the mid-Atlantic?” Why or why not?
    - What is the most likely way that dengue will be introduced?
    - What are the vectors? Which one is more likely?

- What is the possible impact of climate change?
- Have students share the results of their research to reach a consensus. *They should come to the conclusion that dengue could become a problem because the Asian tiger mosquito vector is already found in the mid-Atlantic. In addition, climate change (warmer temperatures) could allow the yellow fever mosquito to spread farther north. This is especially important in neighborhoods where residents visit or travel to countries where dengue is prevalent.*

### Explore

- Ask students how they could find out if *Aedes* mosquitoes are found in their neighborhood. Could they build a mosquito trap to catch and identify *Aedes* mosquitoes?
  - Have them research “homemade mosquito traps”. The most common one is one made from a 2 liter bottle baited with sugar water and yeast.
    - One possible site is <http://www.wikihow.com/Make-a-Plastic-Bottle-Mosquito-Trap>
    - They will have to modify the trap to prevent the mosquitoes from falling into the sugar water. A coffee filter taped above the bait works well.
  - Once they have agreed on a design, they will need to write a formal protocol. At that time, they will have to decide on the number of traps, where they should be placed, how to keep rain out, whether they should be covered with black fabric, how often they should be checked, etc.
- Once the traps are in place, they will have to remove any mosquitoes and identify Asian tiger mosquitoes.
  - In order to kill the mosquitoes, the opening of the trap will need to be plugged and the trap placed **upright** in a cooler filled with ice or in a freezer overnight.
  - They will need to develop a data sheet with location of trap, numbers of mosquitoes, etc.
  - They will need either a dissecting scope or good quality magnifying glass (see Materials) to see details.
  - The website <https://www.cdc.gov/dengue/resources/30jan2012/comparison dengue vectors.pdf> has a good description of both mosquitoes. There are also numerous images on the internet. **Both *Aedes aegypti* and *Aedes albopictus* are black with white bands on the legs.**

### Explain

- At the end of the test period, have the students summarize their results. They might want to develop a formal presentation in the form of a poster or PowerPoint presentation. They should be sure to include the possible impact of climate change on mosquito populations and the potential spread of dengue.
- If the students are finding *Aedes* mosquitoes, ask them what they think they should do with the information.
  - Should they share the information with the community, given that tiger

- mosquitoes carry West Nile virus as well as the possibility of dengue?
  - Have them develop and implement a community education/action plan that will reduce mosquito populations and/or protect people from being bitten. For ideas, go to <http://mda.maryland.gov/plants-pests/Pages/Zika.aspx> and check out the section “Website Resources”
- They might want to do a community survey to find out if residents travel to areas where dengue is prevalent (Mexico, Central or South America, Southeast Asia, etc.). How can they protect themselves from acquiring dengue when travelling and bringing it back to their community?
- This activity could be repeated from year to year to see if the mosquitoes are appearing earlier in the spring due to climate change or if the students are seeing increasing numbers.

#### Extend

- Students might want to debate some proposed solutions for controlling dengue carrying mosquitoes:
  - One solution that has been suggested to control dengue carrying mosquitoes in the Florida Keys involves releasing GMO mosquitoes; <http://www.npr.org/blogs/health/2015/01/28/382168407/florida-health-officials-hope-to-test-gmo-mosquitoes-this-spring>
    - There are numerous websites both pro and con on the issue.
  - Another possibility is to infect mosquitoes with a bacteria which makes it impossible for the mosquitoes to transmit dengue - <http://www.npr.org/2012/06/07/154322744/a-scientists-20-year-quest-to-defeat-dengue-fever>
  - A third idea is one that is being used to trap malaria carrying mosquitoes <https://www.sciencedaily.com/releases/2016/08/160810084811.htm>. Could this idea be used to eliminate dengue carrying mosquitoes?

## Background:

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Dengue is spread by two mosquito species. The primary vector is *Aedes aegypti*, the yellow fever mosquito, which is a tropical mosquito. The problem is the second vector – an invasive species called the Asian tiger mosquito (*Aedes albopictus*) that was first found in Texas in 1985. Unlike the yellow fever mosquito, Asian tiger mosquitoes have been able to adapt to temperate climates. The eggs can survive very cold winters; once the water warms to 60°F, the overwintering eggs hatch and the adults thrive once the temperature reaches 68° F as long as there are at least 20 inches of rain. Currently, Asian tiger mosquitoes are found in more than thirty states, including Maryland, Pennsylvania, and Delaware, and have shown the ability to survive as far north as Minnesota, Michigan, and New England.

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- Heat speeds up the incubation of the dengue virus inside the mosquito, so it becomes infective much faster, giving it a longer time to sicken someone during its 3-4 week life span.
- Female mosquitoes bite more frequently when it is hot.

## Vector Borne Disease

What do you already know about vector borne disease? Think about Lyme disease. Do you know anyone who has had it? How did they get it? If you need some answers, go to

<http://borellia.weebly.com/> or

[http://www.nature.com/nrmicro/journal/v10/n2/fig\\_tab/nrmicro2714\\_F1.html](http://www.nature.com/nrmicro/journal/v10/n2/fig_tab/nrmicro2714_F1.html) for more information.

- What causes the disease?
- How is it spread?
- Is it spread between humans by the bite of a tick?
- Is Lyme disease currently a problem in the mid-Atlantic?

Now think about another vector borne disease – dengue fever. Have you ever heard of it? Do you know anyone who has had it?

- What are the similarities and differences between Lyme and dengue?  
(<http://www.nature.com/scitable/topicpage/dengue-transmission-22399758>)
- Is dengue currently a problem in the mid-Atlantic?

What do you think? Could dengue become a problem in the mid-Atlantic?

- Go to the following websites for research.
  - <http://www.climatecentral.org/blogs/the-climate-connection-to-dengue-fever>
  - <http://www.nrdc.org/health/climate/disease.asp>
  - [http://diseasemaps.usgs.gov/2013/dep\\_us\\_human.html](http://diseasemaps.usgs.gov/2013/dep_us_human.html)
  - Mosquito vectors
    - <http://www.issg.org/database/species/ecology.asp?si=109> (Read section

- on Geographical range)
- <http://www.cdc.gov/dengue/resources/30Jan2012/comparison dengue vectors.pdf>
- <http://www.cdc.gov/dengue/resources/30Jan2012/aegyptifactsheet.pdf>
- <http://www.cdc.gov/dengue/resources/30Jan2012/albopictusfactsheet.pdf>
- [http://mda.maryland.gov/plants-pests/Pages/asian\\_tiger\\_mosquito\\_md.aspx](http://mda.maryland.gov/plants-pests/Pages/asian_tiger_mosquito_md.aspx)
- Based on your research, write a paragraph answering the question, “In the future, could dengue become a problem in the mid-Atlantic?” Why or why not?
  - What is the most likely way that dengue will be introduced?
  - What are the vectors? Which one is the more likely?
  - What is the possible impact of climate change?



You've probably come to the conclusion, based on your research, that dengue could become a problem in this area in the future and that one reason is the increase in the number of *Aedes* mosquitoes due to warming temperatures. How can you find out if *Aedes* mosquitoes are found in your neighborhood or around your school? Can you design and build a mosquito trap to catch and identify tiger mosquitoes?

- Go on the Internet and research "homemade mosquito traps". The most common one is made from a 2 liter bottle baited with sugar water and yeast, but you may find or develop a design you like better.
  - One possible site is <http://www.wikihow.com/Make-a-Plastic-Bottle-Mosquito-Trap>
  - If you decide to use the 2 liter bottle design, you will have to modify the trap to prevent the mosquitoes from falling into the sugar water. (It is hard to remove and identify a sticky, soggy mosquito.)
- Once you have agreed on a design, you will need to write a formal protocol. At that time, you will have to decide on the number of traps, where they should be placed, whether they should be covered with black fabric, how often they should be checked, etc.
- Once the traps are in place, you will have to remove any mosquitoes and identify *Aedes* mosquitoes.
  - In order to kill the mosquitoes, the trap should be placed **upright** in a cooler filled with ice or in a freezer overnight. Be sure to keep the trap upright.
  - You will also need to develop a data sheet with location of trap, numbers of tiger mosquitoes, etc.
  - You will need either a dissecting scope or good quality magnifying glass to see details.
  - The website <https://www.cdc.gov/dengue/resources/30jan2012/comparison dengue vectors.pdf> has a good description of both mosquitoes. There are also numerous images on the internet.
    - **Both *Aedes* mosquitoes that carry dengue (yellow fever and Asian tiger) are black with white bands on the legs. Brown or tan mosquitoes don't matter!**

At the end of the test period, you will need to develop a formal presentation in the form of a poster or PowerPoint presentation, summarizing your results. Be sure to include information on the possible impact of climate change on mosquito populations and the potential spread of dengue.

### **Community Action Project**

Now comes the important part. If you are finding *Aedes* mosquitoes, what should you do with the information? Should you share the information with the community, given that *Aedes* mosquitoes carry West Nile virus and Zika virus as well as the possibility of dengue?

- Brainstorm ideas for developing and implementing a community education or action plan that will reduce mosquito populations and/or protect people from being bitten.
- Do you want to include information on climate change and what the community can do to reduce their carbon footprint?
- You might want to do a community survey to find out if residents travel to areas where dengue is prevalent (Mexico, Central or South America, Southeast Asia, etc.). How can you educate them about protecting themselves from acquiring dengue when travelling and bringing it back to their community?

