Lesson Seven: Climate Change and Disease

Subjects
Science, Social Studies, Geography, Technology, Environmental Education, Language Arts

Estimated Time
One 45-minute class period

Grade Level
9-12

Objectives
Students research the relationship between hosts, parasites, and vectors for common vector-borne diseases (VBDs) and evaluate how climate change could affect the spread of disease.

- Students explain how VBDs are transmitted.
- Students describe how climate affects the life cycle of vectors.
- Students explore how social factors affect the occurrence and spread of disease.

Materials
- Computers with Internet access
- Map of malaria distribution (see suggested resources)
- Global Warming: Early Warning Signs map available at http://www.climatehotmap.org/ by the Union of Concerned Scientists

Lesson designed by the Union of Concerned Scientists.
Prerequisite Knowledge – Teacher

- Climate models project a global mean warming by 2100 in the range of 1-3.5°C. Increasing temperatures will be accompanied by changes in rainfall and humidity, including a likely increase in the frequency of heavy precipitation events. Some areas will become drier because higher temperatures also increase evaporation.

- A VBD is one in which the disease-causing microorganism is transmitted from an infected individual to another individual by an arthropod (e.g., mosquito, tick, etc.) or some other agent. Other animals, wild and domesticated, sometimes serve as intermediary hosts. Key VBDs of concern include malaria, Lyme disease, dengue fever, yellow fever, Hantavirus pulmonary syndrome, and several forms of encephalitis.

- Climate constrains the range of many VBDs. Vector-borne diseases are currently found mainly in tropical and subtropical countries and are relatively rare in temperate zones. Mosquitoes, for example, are limited to seasons and regions where temperatures stay above a certain minimum. Winter freezing kills many eggs, larvae, and adults. Climate also influences the availability of suitable habitat and food supply for vectors.

- Weather affects the timing and intensity of disease outbreaks. Within their temperature range of tolerance, mosquitoes will reproduce more quickly and bite more in warmer conditions. Warmer temperatures also allow the parasites within mosquitoes to mature more quickly, increasing the chances that the mosquito will transfer the infection. Floods can trigger outbreaks by creating breeding grounds for insects. Droughts can reduce the number of predators that would normally limit vector populations.

- Several modeling studies have predicted that increasing temperatures will lead to the spread of malaria and other diseases into previously unaffected areas. Climate change may also affect the severity of the disease at a given location. Due to the complexity of the relationships, the models do not account for all of the ways in which climate can affect the vector, human host, and parasite, and the interactions among them.

- Socioeconomic factors also affect the distribution of VBDs. A good public health infrastructure, including prompt treatment of cases to reduce the risk of spread of disease and mosquito-control measures, helps limit disease transmission in developed countries. For example, malaria once extended into the northern U.S. and Canada, but, by 1930, was confined to southern regions of the U.S. and, by 1970, had been eradicated. Additionally, international travel increases the likelihood of an outbreak in nonendemic areas (although weather also plays a role by making conditions suitable for the spread of the disease). And an increase in drug and pesticide resistance as a consequence of overuse makes control of VBDs more difficult. Land-use by humans can change the availability of habitat for vectors.

Prerequisite Knowledge – Student

- Students should understand the concept of an ecosystem, including the relationship between abiotic and biotic factors and how a food chain works.

- Students should know the physical/atmospheric measurements that are used to characterize a region’s climate.
Lesson 7: Climate Change and Disease

**Procedure**

**Engage**

Have students look over maps of the present-day distribution of malaria to characterize the countries where malaria occurs. Specifically, they should consider the climate of the country, such as average annual temperatures, average nighttime (low) temperatures, and precipitation, and whether it is a developing or developed nation. [A world atlas with maps of global temperature and precipitation distribution is probably the easiest way to search for this information. General information on climate for individual countries can be found in the CIA’s World Factbook at https://www.cia.gov/library/publications/the-world-factbook/index.html. Climate statistics for world cities can be found at http://www.weatherbase.com.]

Instruct students to write short essays comparing countries with malaria to those without malaria, suggesting possible reasons for the differences between the two groups.

**Explore**

1. Write the names of different VBDs, along with the name of the vector, onto 3 x 5 index cards (see list of diseases on chart). Divide students into pairs and have each pair pull an index card out of a box. One student in the pair should research how the disease spreads from one human to another, and the other student should research the life cycle of the vector. Ask the students to create a poster or diorama that illustrates the relationships between the host, parasite, and vector, and how the disease can be transmitted from one human to another. The students should present their findings orally to the class.

2. Bring the class together as a group and ask them to use what they have learned from the oral presentations to brainstorm about how climate might influence the spread of the diseases discussed. Guide the discussion by having students consider three perspectives:
   a. How does climate impact the vector directly?
   b. How does climate impact the vector’s (or intermediary host’s) habitat?
   c. How does climate impact the parasite?

Students should consider the role of climatic factors such as temperature, precipitation, presence of surface water, humidity, wind, soil moisture, and frequency of storms or droughts. Record ideas on an overhead at the front of the room, and provide a summary sheet for the students to use as reference.

3. Divide students into new groups of four to explore in more detail the impact of climate on vectors. Assign each group a specific vector: tick, rodent, mosquito, snail, bird. Ask the students to fill out a chart highlighting how projected climate changes due to an enhanced greenhouse effect might impact their vector. This can be done as an in-class group activity, with students drawing on the ideas and examples from the previous exercises. Alternatively, students could research the vector in more depth individually as a take-home assignment, then complete the chart as a group during the next class period. An example chart format is shown on the following page. Students can either
read the Global Warming: Early Warning Signs map to learn about overall projected climate changes, or they can research climate changes for their region of the country by reading the U.S. National Assessment reports (http://www.usgcrp.gov/usgcrp/nacc/default.htm). Students may not be able to fill in all of the spaces in their charts for their vectors, but they should try to fill in as many as possible.

4. Have each student write a reflective essay in which they comment on the group’s predictions of the potential effects of climate change on disease transmission. Questions to consider include: How easy/difficult was it to evaluate the impacts on the vector and vector habitat? How easy/difficult was it to evaluate the impacts on disease transmission? What, if anything, made the evaluation difficult? How accurate does the group think their predictions are? What additional information would the group like to have to complete the chart? If possible, the teacher should follow up this activity with a discussion on the use of models to predict the impact of climate change on disease. A color map showing model projections of changes in malaria distribution with a warming climate can be found in the Epstein (August 2000) Scientific American article.

http://www.sciam.com/article.cfm?collID=1&articleID=0008C7B2-E060-1C73-9B81809EC588EF21

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**Vector-Borne Diseases**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Vector</th>
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</thead>
<tbody>
<tr>
<td>Malaria</td>
<td><em>Anopheles</em> mosquito</td>
</tr>
<tr>
<td>Yellow fever</td>
<td>mosquito</td>
</tr>
<tr>
<td>Dengue fever</td>
<td><em>Aedes</em> mosquito</td>
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<tr>
<td>Schistosomiasis</td>
<td>water snails</td>
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<tr>
<td>West Nile virus</td>
<td><em>Culex</em> mosquito</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>Sand flies</td>
</tr>
<tr>
<td>Lyme disease</td>
<td>Tick</td>
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<tr>
<td>Plague</td>
<td>Flea/Rodent</td>
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<tr>
<td>Japanese encephalitis</td>
<td><em>Culex</em> mosquito</td>
</tr>
<tr>
<td>African trypanosomiasis</td>
<td>Tsetse flies</td>
</tr>
<tr>
<td>Hantavirus pulmonary syndrome</td>
<td>Rodents</td>
</tr>
<tr>
<td>St. Louis encephalitis</td>
<td><em>Culex</em> mosquito</td>
</tr>
<tr>
<td>Dracunculiasis</td>
<td><em>Cyclops</em> (minute crustacean)</td>
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<tr>
<td>Onchocerciasis</td>
<td>blackflies</td>
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**Extend**

Students can examine a specific example of how weather affects disease by reading about the West Nile virus outbreak in New York City (see http://query.nytimes.com/gst/fullpage.html?sec=health&res=9B05E3DB103BF935A3575BC0A9649C8B63) or Hantavirus pulmonary syndrome in the U.S. Southwest. The sequence of extreme weather events that likely contributed to the outbreaks is described in the passage “Opportunists Like Sequential Extremes” from the Epstein (2000) article. Have the students read this passage and draw a timeline or flow diagram illustrating the sequence of events leading to the outbreak. An example for the West Nile virus outbreak is shown in the article. Then ask students to look at their diagrams and mark places where changes in human behavior (both individual and community level) could have helped curb the spread of the disease. As a final assignment, students redraw their first diagram incorporating the changes in human behavior and illustrate how those changes influenced the outcome.
<table>
<thead>
<tr>
<th>Climate Change</th>
<th>Direct Impact on Vector</th>
<th>Impact on Vector Habitat</th>
<th>Impact on Parasite</th>
<th>Potential Impact on Disease Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>More heat waves</td>
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<td>Change in flooding</td>
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<tr>
<td>Change in drought frequency</td>
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<tr>
<td>Heavier snowfalls</td>
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<tr>
<td>Sea level rise</td>
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<td></td>
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<tr>
<td>Extreme weather</td>
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</tbody>
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Suggested Resources

**Malaria Maps:**

This resource includes a section on malaria and a map showing countries in which malaria is endemic. A separate listing at the front of the book shows disease risk for specific countries. A world map showing countries in which malaria is endemic can also be found at the Malaria Database, “Introduction” section. http://www.wehi.edu.au/MaIDB-www/intro.html

**General Information on VBDs:**
This site provides fact sheets, images, and world maps showing the distribution of several types of VBDs. A good resource for student research.

Malaria Foundation International
http://www.malaria.org/
Provides basic information about malaria, including answers to frequently asked questions, a comprehensive glossary of terms, and links to other sites with information about malaria.

West Nile Virus Information
http://www.audubon.org/bird/wnv/
A site with strong background information and numerous links to more information about the West Nile virus outbreak in the U.S.

**Vector Life Cycles:**
The Life Cycle of the Mosquito
http://www.mosquitoes.org/LifeCycle.html

Mosquito Bytes
http://whyfiles.org/016skeeter/index.html

**Climate Change and Human Health:**


The Physicians for Social Responsibility
http://www.psr.org/site/PageServer?pagename=Links_global_warming
Links to facts sheets and other resources on climate change and human health.

U.S. National Assessment Health Sector
Executive summary of the report from the health sector of the U.S. National Assessment. Includes a section on VBDs, as well as adaptation and prevention strategies.

This enhanced electronic version provides an extensive list of additional Web sites and literature on the topic.

World Health Organization – Climate and Health
http://www.who.int/globalchange/climate/en/
National Standards Alignment:

National Science Education Standards
Unifying Concepts and Processes (K-12): Consistency, change, and measure

Science as Inquiry, Content Standard A (9-12): Abilities necessary to do scientific inquiry; Understandings about scientific inquiry

Life Science, Content Standard C (9-12): Interdependence of organisms; Matter, energy, and organization in living systems; Behavior of organisms

Earth and Space Science, Content Standard D (9-12): Energy in the Earth system

Science in Personal and Social Perspectives, Content Standard F (9-12): Personal and community health; Environmental quality; Science and technology in local, national, and global changes

Curriculum Standards for Social Studies
Strand 3: People, Places, and Environments
Strand 8: Science, Technology, and Society
Strand 9: Global Connections

National Geography Standards
Standard 1: World in Spatial Terms. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Standard 4: Places and Regions. The physical and human characteristics of places.


Standard 18: Uses of Geography. How to apply geography to interpret the present and plan for the future.

Technology Foundation Standards
Standard 1: Basic Operations and Concepts. Students are proficient in the use of technology.

Standard 5: Technology Research Tools. Students use technology to locate, evaluate, and collect information from a variety of sources.

Environmental Education Guidelines for Learning (K-12)
Strand 1: Questioning and Analysis Skills
Strand 2: Knowledge of Environmental Processes and Systems
Strand 2.1: The Earth as a Physical System
Strand 2.2: The Living Environment
Strand 2.3: Environment and Society
Strand 3: Skills for Understanding and Addressing Environmental Issues
Strand 3.1: Skills for Analyzing and Investigating Environmental Issues
Strand 3.2: Decision-making and Citizenship Skills

Standards for the English Language Arts
Standard 4: Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 8: Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Standard 12: Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).