TEACHER BACKGROUND INFORMATION

CLIMATE CHANGE AND INFECTIOUS DISEASES

- **Climate models** project a global average warming by 2100 in the range of from 2 to 4 °C (2-8 °F).

- Increasing temperatures will be accompanied by changes in rainfall and humidity; the rate of occurrence of heavy precipitation events will increase; some areas will become drier due to evaporation increases resulting from higher temperatures .

  A **vector-borne disease** (VBD) is one in which the microorganism which causes the disease is transmitted from an infected individual to another individual by a mosquito,tick or some other agent. Other animals, wild and domesticated, sometimes serve as go-between hosts. The vector-borne diseases of most concern include malaria, Lyme disease, dengue fever, yellow fever, hantavirus pulmonary syndrome, and several forms of encephalitis.

- Climate constrains the **range** of many vector-borne diseases. VBDs are presently found mainly in tropical and subtropical countries and are relatively rare in temperate zones. For example, mosquitoes are limited to seasons and regions where temperatures stay above a minimum low temperature. Winter freezing temperatures kill 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 that carry the disease within mosquitoes to reach adulthood 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 control vector populations.

- Modeling studies have predicted that rising temperatures will cause the spread of **malaria** and other diseases into areas where these diseases have been relatively rare. Climate change may also affect the gravity of the disease at a given location. Because there are so many variables to consider in relationships between species, the models do not take into 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 vector-borne diseases. A good public health system which includes prompt treatment of cases to reduce the risk of spread of the disease and **mosquito-control measures**, helps to limit the spread of the disease in developed countries. For example, malaria once extended into the northern U.S. and Canada. However, by 1930 it was limited to southern regions of the U.S., and by 1970 had been wiped out. International travel increases the probability of an outbreak in areas where the disease is generally not seen. Weather also plays a role by making conditions suitable for the spread of the disease. An increase in **drug and pesticide resistance** from overuse makes control of vector-borne diseases more difficult. Land-use by humans can affect the amount of habitat available for vectors.

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

INSTRUCTIONAL ACTIVITY #1

UNDER THE WEATHER

OVERVIEW: Students will investigate and present written and oral information on various vector-born diseases that may be affected by changes in the average global temperature of the Earth.

OBJECTIVES:

Students will:

- compute and analyze data regarding the possible growth of infectious diseases as a result of global warming.
- create information sheets on various vector-borne diseases for public use.

MATERIALS: Paper/pencil/pen, colored pencils, calculator and blank world map and/or access to Microsoft Printshop/ Publisher;

PROCEDURE:

PART A: About 80% of the illnesses in developing countries are caused by waterborne For example, more than 5 million people each year die from malaria which is transmitted by mosquitos that breed in standing water. Another 20 million suffer from Guinea worm infections and over 200 million people are affected by Schistomiasis. If scientific predictions are correct and we are experiencing global warming , these numbers will increase immensely. In addition, with rising global average temperatures, the ranges of these mainly tropical diseases will expand and move into previously temperate regions affecting millions more people.

TASK: You have been hired as an educational consultant for the **World Health Organization (WHO)** , a branch of the United Nations. Your job is to produce a small pamphlet about one of the diseases listed below. This pamphlet will be used by UN volunteers to educate people in developing nations about the threat of these diseases and what they can do to protect themselves. Be sure to include the following information:

- Organism that causes the disease
- Method of infection
- Symptoms
- Treatment
- Preventative measures

1. You may choose to report on any one of the diseases listed below:

- ✓ Malaria
- ✓ Schistosomiasis
- ✓ Guinea worm
- ✓ River blindness
- ✓ Sleeping sickness
- ✓ Filariasis

2. Pamphlets should be made from a single sheet of 8.5 x 11 (standard letter size) paper or light cardboard and folded in three sections horizontally.

- ✓ The name of the disease and a map showing the geographic location of the disease should appear on the front cover.
- ✓ An references used to research information should be noted on the last page.

PART B: Scientists know that the transmission of many infectious diseases is controlled to some degree by climatic factors: temperature, humidity, surface water, wind, soil moisture and changes in the distribution of vegetation. Diseases like malaria for example, are especially influenced by changes in these factors since they require an intermediate organism like a mosquito to actually transmit the disease. It is predicted that climate change altered weather patterns would affect range (latitude and longitude), intensity and seasonality of many infectious diseases. In general, increased warmth and moisture would increase the transmission of these diseases.

TASK:

1. With your teacher and classmates read and discuss the **Introduction** and the **Data Table: Incidence and Locations of Infectious Disease (1994-2050)**.

2. You will be creating a map indicating the present ranges of the 10 diseases listed in the data table.

- ✓ Create a code for each disease (either a color or symbol).
- ✓ Include a key on the map explaining the code.

3. Compute the numbers for columns 7 and 8 on the data table using your calculator.

- ✓ Use the following formulas:

Column 7: New cases each year x % increase = New cases yearly in 2050

Column 8: Population at risk x % increase = Population at risk in 2050

4. Transcribe the new data onto the **Data Table.**

5. Respond to the related questions in the **Analysis** section.

DATA TABLE:INCIDENCE AND LOCATIONS OF INFECTIOUS DISEASES (1994-2050)

DISEASE	VECTOR	POPULATION AT RISK 1994 (MILLIONS)	NEW CASES YEARLY	Present distribution	Probability (%) of increase	New cases yearly	Population at risk by 2050
Malaria	Mosquito	2400	300-500 m	Tropics subtropics	40%		
Schistomiasis	Fluke	600	200 m	Tropics Subtropics	25%		
Filaiasis	Mosquito	1094	117 m	Tropics Subtropics	12.5%		
Sleeping sickness	Tsetse fly	55	300000	Tropical Africa	12.5%		
Guinea worm	Crustacean	100	100000	S. Asia Arabian Pen. C/W Africa	No Data available		
Leichmaniasis	Sand fly	350	500000	Asia S. Europe Africa Americas	12.5%		
River blindness	Black fly	123	17.5 m	Africa Latin America	25%		
Chagas disease	Triatomine bug	100	18 m	Central/ South America	12.5%		
Dengue fever	Mosquito	1800	10-30 m	All tropical regions	25%		
Yellow fever	Mosquito	450	<5,000	Tropical S. America and Africa	25%		

INSTRUCTIONAL ACTIVITY #2
THE TICKS HAVE IT!

I.OVERVIEW

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

II.OBJECTIVES

Students will:

1. Explain how vector-borne diseases are transmitted;
2. Describe how climate affects the life cycle of vectors;
3. Explore how social factors affect the incidence and spread of disease.

MATERIALS

- Access to the Internet, or school and public library for research.
- Maps of disease distribution (See attached list of available resources.)

PROCEDURE:

PART I: CONNECTION

1. Have students look over maps of the present-day distribution of malaria in order to characterize the countries where malaria occurs.
   - They should especially 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.

2. Ask students to write a short essay comparing countries with malaria to those without malaria, and suggesting possible reasons for the differences between the groups.

PART II: INVESTIGATION

1. Write the names of different vector-borne diseases, along with the name of the vector, onto 3 x 5 index cards (see list of diseases below).

2. Group students into pairs and have each pair pull a disease index card out of a box.
   - One student in the pair should do some research to find out how the disease spreads from one human to another.
   - The other student in the pair should research the life cycle of the vector.

3. Have students 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.

4. The students should present their findings orally to the class.

5. 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 the question from three perspectives:
     a. How does climate impact the vector directly?
     b. How does climate impact the vector's (or go-between host's) habitat?
     c. How does climate impact the parasite?

****[Students should consider the role of climatic factors such as temperature, rainfall/snow, presence of surface water,humidity,wind,soil moisture,and frequency of storms or droughts.]**

6. Record ideas on an overhead at the front of the room, and provide a summary sheet for the students to use as reference.

7. 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.

****[Note: This can be done as an in-class group activity, with students drawing on the ideas and examples from the previous exercises. Students can also research the vector in more depth individually as a take-home assignment, and then complete the chart as a group during the next class period. An example chart format is shown on the following page.]**

****[Note: If interested,students can research climate changes for their region of the country by reading the U.S.National Assessment Reports at:**
http://www.usgcrp.gov/usgcrp/nacc/default.htm

[Note:Students may not be able to fill in all of the spaces in their chart for their vector,but they should try to fill in as many as possible.]

9. Student will now write a reflective essay in which they comment on the group's predictions of the potential effects of climate change on the spread of the disease. 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?

[Note: 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 August 2000 *Scientific American* article at: http://www.sciam.com/article.cfm?colID=1&articleID=0008C7B2-E060-1C73-9B81809EC588EF21

EXTENSIONS:

- Students can examine a specific example of how weather affects disease by reading about the West Nile virus outbreak in New York City or hantavirus pulmonary syndrome in the U.S. Southwest.

- The sequence of extreme weather events that likely contributed to the outbreaks in described in the passage "Opportunists Like Sequential Extremes" from the **Scientific American** article.
    1. 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 "Scientific American" article.

    2. 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.

PERFORMANCE ASSESSMENT: Students can redraw their first diagram incorporating the changes in human behavior and illustrating how those changes influenced the outcome.

ACTIVITY 1:STUDENT WORKSHEET: INFLUENCES OF CLIMATE CHANGE ON DISEASE VECTORS

Climate Change	Direct Impact on Vector	Impact on Vector Habitat	Impact on Parasite	Potential Impact on Disease Transmission
More heat waves				
Change in flooding				
Change in drought frequency				
Heavier snowfalls				
Sea level rise				
Extreme weather				

SUGGESTED RESOURCES

Malaria Maps:

- The Center for Disease Control's "Yellow Book," entitled *Health Information for International Travel, 1999–2000*, can be downloaded for free at http://www.cdc.gov/travel/reference.htm. 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 at:
  http://www.wehi.edu.au/MalDB-www/intro.html

GENERAL INFORMATION ON VECTOR-BORNE DISEASES:

Division of Vector-Borne Infectious Diseases, Centers for Disease Control and Prevention at:http://www.cdc.gov/ncidod/dvbid/index.htm
This site provides fact sheets, images, and world maps showing the distribution of several types of vector-borne diseases. 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.globalchange.org/impactal/westnile.htm
A site with numerous links to information about the West Nile Virus outbreak in the U.S.

Vector Life Cycles:

- "What's All the Buzz about Mosquitoes?"
  http://www.nysipm.cornell.edu/publications/mosquitobro/index.html

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

- Climate Change and Human Health: Epstein, P.R., 2000. Is global warming harmful to health? *Scientific American* (August 2000):
  http://www.sciam.com/2000/0800issue/0800epstein.html

Climate Change Research Information Office:

http://www.gcrio.org/CONSEQUENCES/vol3no2/climhealth.html

World Health Organization – Climate and Health:

http://www.who.int/peh/climate/climate_and_health.htm