Overview
This activity guides students in an exploration of the online exhibit *Infectious Disease: Evolving Challenges to Human Health*. Students will explore the question:

*What strategies and challenges exist to effectively control infectious disease around the world?*

The class will discuss the types of decisions that the evidence gathered today could support, as well as the uncertainty associated with the evidence. For example:

- What evidence is used to determine the status of infectious diseases?
- What are the biological mechanisms that contribute to the spread of infectious disease?
- How do sociopolitical (geographic, economic, cultural) forces contribute to the spread of infectious disease?
- What are the main challenges involved with controlling infectious disease in both developing and industrialized countries?

Directions
1. Direct all students to explore the sections *Rapid Evolution, Where are They?, Global Distribution of Disease*, and *Public Health*. Students may work individually or in groups and may visit the sections in any order. They should use the appropriate worksheet to guide their exploration.

2. Students should then be assigned to one of three “expert groups” and explore the rest of the exhibit using this particular focus.
   - **Public Health**: What strategies and challenges exist to effectively control infectious disease around the world?
   - **Therapeutic Drugs**: What strategies and challenges exist to effectively control infectious disease around the world?
   - **Vaccines**: What strategies and challenges exist to effectively control infectious disease around the world?

3. Once students have explored the exhibit they should remain in their expert groups to answer the questions on the discussion worksheet.
4. Lead a whole class discussion, allowing each group to report out the information they have gathered and to discuss answers.

5. The **Disease Spread Activity** can be used as an extension activity.

---

Explore the sections *Rapid Evolution, Where Are They?, Public Health*, and *Global Distribution of Disease*. The following questions will guide you through the sections.

**Rapid Evolution**

1. Watch the Rapid Evolution video and pay close attention to the graph as time passes. Which strain of bacteria is resistant to more than one drug? Why do you think this?

2. If a bacterium divides every half hour, how many bacteria are there...
   - At two hours (4 generations)?
   - At four hours (8 generations)?
   - At eight hours (16 generations)?
   - What if they continued reproducing for 24 hours (48 generations)?

3. What two factors combined lead to microbial evolution?

   \[ \text{Normal Environment} + \text{Antibiotics} = \text{Evolution} \]

4. Antibiotics can kill bacteria, yet bacteria may continue to spread. Why do you think this might be?
Where Are They?

Explore the interactive to discover how bacteria, viruses, fungi and parasites differ and complete the following chart:

<table>
<thead>
<tr>
<th>Source</th>
<th>Fungus</th>
<th>Parasite</th>
<th>Bacteria</th>
<th>Virus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated Disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease Location on Body</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pathogenic?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commensal?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmless?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Global Distribution of Disease

1. Describe where cholera is most prevalent. What do you think the relationship is between cholera prevalence and access to sanitation? What do you think the relationship is between cholera prevalence and access to clean drinking water?

2. Choose another disease and describe where it is most widespread.

Disease

Where is it most widespread?
Public Health

1. Not all countries enjoy the same level of public health as the U.S.

How many people worldwide lack clean water? ________________________

How many people worldwide lack basic sanitation? ________________________

2. Study “The Impact of Public Health” graphs and note that both life expectancy (blue) and mortality rates (yellow) have improved in the United States from 1900 to 2000. Life expectancy at birth has increased (people live longer) and mortality rates have decreased (less people are dying from infectious diseases).

Gather data on the mortality rate and the change in mortality rate:

<table>
<thead>
<tr>
<th>Year</th>
<th>Mortality Rate</th>
<th>Year Range</th>
<th>Change in Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>_______ deaths per 100,000 people</td>
<td>1900 – 1940</td>
<td>_______ deaths per 100,000 people</td>
</tr>
<tr>
<td>1940</td>
<td>_______ deaths per 100,000 people</td>
<td>1940 – 1980</td>
<td>_______ deaths per 100,000 people</td>
</tr>
<tr>
<td>1980</td>
<td>_______ deaths per 100,000 people</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Based on the data you gathered in the previous question, did mortality rates drop most before or after antibiotics and vaccines were first used (around 1940)? (circle one)

Before antibiotics and vaccines (1900-1940)

After antibiotics and vaccines (1940-1980)

4. List two public health measures that resulted in improved life expectancy in the U.S. before 1940. (Many answers are possible.)

5. What disease caused a large “spike” in the graphs prior to 1920?
Public Health Expert Group

Your team will gather in-depth information on how well public health measures can effectively prevent the spread of disease. The information you gather on these topics will be vital for the group discussion, which will focus on:

What strategies and challenges exist to effectively control infectious disease around the world?

Explore the following sections and give examples where public health measures have been used successfully and where challenges still exist.

Vector Control and Malaria
Explore how effective public health measures, such as bed nets and indoor spraying, can be in controlling the spread of malaria by themselves and in combination with other measures.

Successes:

Challenges:

Antiretrovirals and the HIV Pandemic
Watch both HIV/AIDS videos and describe how effective public health measures have been in controlling the spread of the HIV virus.
Your team will gather in-depth information on how well therapeutic drugs can effectively prevent the spread of disease. The information you gather on these topics will be vital for the group discussion, which will focus on:

*What strategies and challenges exist to effectively control infectious disease around the world?*

Explore the following sections and give examples where therapeutic have been used successfully and where challenges still exist:

**Antibiotics and Emerging Drug Resistance**
Using the exhibit and interactive sliding screen, explore how effective antibiotics can be in preventing the spread of bacterial diseases.

Successes:
Challenges:

**Antiretrovirals and the HIV Pandemic**
Watch both HIV/AIDS videos and describe how effective antiretroviral drugs can be in controlling the spread of the HIV virus.

Successes:

**Vector Control and Malaria**
Explore how effective therapeutic drugs can be in controlling the spread of malaria by themselves and in combination with other measures.

Successes:
Challenges:

**Vaccines Expert Group**

Your team will gather in-depth information on how well vaccines can effectively prevent the spread of disease. The information you gather on these topics will be vital for the group discussion, which will focus on:

*What strategies and challenges exist to effectively control infectious disease around the world?*

Explore the following sections and give examples where vaccines have been used successfully and where challenges still exist:

**Vaccines and Human Immunity**

Using the exhibit and interactive table display, explore how effective vaccines can be in preventing the spread of disease.

Successes:
Challenges:

Antiretrovirals and the HIV Pandemic
Watch both HIV/AIDS videos and describe how effective vaccines can be in controlling the spread of the HIV virus.

Successes:

Challenges:

Expert Summary

Answer the questions for your expert group and brainstorm responses to the “all groups answer” questions before sharing your findings with your classmates.
Public Health Expert Group

1. What are some of the specific public health measures used to prevent the spread of disease?

2. Give three examples where public health measures can be effective tools in preventing the spread of disease.

3. Describe three challenges for using public health measures in preventing the spread of disease.

Vaccine Expert Group

1. What are some of the specific vaccine programs used to prevent the spread of disease?
2. Give three examples where vaccines have been effective tools in preventing the spread of disease.

3. Describe three challenges for using vaccines in preventing the spread of disease.

**Therapeutic Drugs Expert Group**

1. What are some of the specific therapeutic drugs used to prevent the spread of disease?

2. Give three examples where therapeutic drugs can be effective tools in preventing the spread of disease.
3. Describe three challenges for using therapeutic drug in preventing the spread of disease.

**All Groups Answer**

1. Why is an understanding of evolution so important to addressing infectious disease?

2. What ideas can you come up with that might help address the major scientific, medical, and public health challenges to treating infectious diseases throughout the world?
BONUS: Give one example where global warming has already had an impact on human health.

Simulating the Spread of an Infectious Disease

Introduction
From bubonic plague to AIDS to the Guinea worm parasite, scientists and public health officials have struggled to understand and contain the spread of infectious diseases. Using simple reagents, students can simulate the spread of a simple imaginary disease in order to explore some factors that affect the rate of infection, the challenges of epidemiology, and measures which can help prevent the spread of disease.

Materials
- Test tube and dropper for each participant
- Test tube lids
- Distilled water
- 0.1 molar NaOH
- pH 7.0 buffer solution
- Phenolphthalein solution, dissolved in alcohol and diluted in water (pH indicator)

Procedure
1. Prepare the test tubes prior to the activity. Fill one tube halfway with 0.1 molar NaOH and one with the phenolphthalein solution; fill the rest of the tubes halfway with distilled water. If you have a large group (35 or more) you may want to begin with two test tubes containing NaOH.

2. Explain to students that they are going to model the transmission of a disease by exchanging some of their test tube’s contents with that of other participants. Mention that one of the test tubes is "infected" with an imaginary infectious disease.

2. Distribute prepared test tubes and droppers to the class. Make a mental note of who receives the test tube containing NaOH. Keep the test tube with the phenolphthalein.
3. Have participants walk around the room with their test tubes. When you say "Stop!", each participant should use a dropper to trade a drop of fluid with the person nearest them. Repeat until at least three trades have occurred.

4. Now it’s time to test for the imaginary infection. Put a drop of phenolphthalein in each test tube. If the fluid turns pink, the cup is "infected" with NaOH. The final number of "infected" test tubes will vary depending on (1) the number of trades and (2) how many trades occur between two already infected tubes.

**CAUTION:** Sodium hydroxide (NaOH) and phenolphthalein can irritate the eyes and skin. Alert students to avoid spilling and warn them to NEVER drink what is in the test tube.

**Tracing the Source of Infection**

Now that a portion of the group has been "infected," put students in the role of epidemiologists. Their challenge is to collect data that will help them trace the path of the epidemic and locate the original carriers.

As a group, use the data to try to deduce which individual was the original carrier of the disease. Why might it be important to locate the source of infection? What difficulties arise in trying to collect and interpret data? Note that the simulated disease has a 100% rate of infection that appears immediately under testing. Some infections, such as AIDS and chicken pox, can remain dormant in the body for a long time. Others, such as Ebola, kill the host rapidly. How might each of these factors affect the spread of disease and the ability to identify carriers?

A possible method to find "patient zero" is to have each participant write his or her name on the board and underneath it the names of participants with whom he or she exchanged fluids in the order in which the exchanges occurred. Then, as a group, highlight the names of the currently "infected" people.

The sample chart shows one example of how to trace the infection (bolded names are infected). Participants who "test positive" and find that everyone with whom they traded also tested positive may be original carriers of the disease (Cal, Dee, Gib, and Hal in this example). It is likely that there will be several candidates for "patient zero." Cross-checking the history of each contact can narrow the field, but probably not to less than two candidates. (For example, here, Cal and Dee can be eliminated as "patient zero" because their first contacts, Bob and Ed, did not infect their own second contacts, Fran and Ilsa; either Gib or Hal, however, could be "patient zero." If participants are unable to reach a clear conclusion, the exercise will raise useful questions about the challenges facing real epidemiologists as they try to trace the sources of an infection.

**Sample Chart Tracing Infection**

<table>
<thead>
<tr>
<th></th>
<th>Ann</th>
<th>Bob</th>
<th>Cal</th>
<th>Dee</th>
<th>Ed</th>
<th>Fran</th>
<th>Gib</th>
<th>Hal</th>
<th>etc...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exchange 1</strong></td>
<td>Fran</td>
<td>Cal</td>
<td>Bob</td>
<td>Ed</td>
<td>Dee</td>
<td>Ann</td>
<td>Hal</td>
<td>Gib</td>
<td>etc...</td>
</tr>
</tbody>
</table>
**Discussion**

Lead a class discussion about measures for preventing the spread of disease.

First, discuss how rapid and constant evolution challenges our main defenses against infectious diseases, which include

- *public health measures* that minimize exposure to disease-causing organisms;
- *immunity*, whether gained by infection or vaccination; and
- *therapeutic drugs* used to treat infections.

Discuss these defenses, then brainstorm and demonstrate how these defenses could be enacted in the context of the activity.

1. **Public Health**: Minimizing or eliminating exposure to disease agents through public health measures can greatly diminish the impact of a disease outbreak. Some examples that represent public health measures:
   - Put a cap on your test tube
   - Isolate yourself so that you are not near anyone else

   The cap represents measures such as bed nets or condoms, which prevent exposure to disease causing agents. Isolating yourself is the same as a quarantine, which is often used to isolate disease carrying individuals during an outbreak.

2. **Immunity**: Vaccines provide immunity for an individual against a disease, even after exposure. Using the test tube with the buffer solution, add a couple of drops of the phenolphthalein indicator, followed by a couple of drops of the NaOH solution. While there might be a quick flash of pink when the drops of NaOH hit the test tube solution, the color should quickly return to clear. The buffer is acting to neutralize the NaOH.

3. **Therapeutic drugs**: Drugs can be an effective means for treating a disease after exposure. Take a test tube that has tested positive by turning pink and add a few drops of the buffer. In this case, the buffer will neutralize the solution and turn the color back to clear, thus eliminating the infection.

**Infectious Disease Terms Glossary**
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commensalism</td>
<td>An unequal relationship in which one species derives benefit without harming the other.</td>
</tr>
<tr>
<td>Endemic Disease</td>
<td>A native disease that exists continuously in a geographic region.</td>
</tr>
<tr>
<td>Epidemic</td>
<td>A sudden and simultaneous outbreak or increase in the number of cases of a disease in a community.</td>
</tr>
<tr>
<td>Eradicate/Eradication</td>
<td>To eliminate completely (a disease).</td>
</tr>
<tr>
<td>Host</td>
<td>Organisms in which smaller organisms or viruses live, feed, and reproduce.</td>
</tr>
<tr>
<td>IOM (Institute of Medicine)</td>
<td>A branch of the National Academies with the mission to serve as adviser to the nation to improve health. The Institute provides unbiased, evidence-based, and authoritative information and advice concerning health and science policy to policy-makers, professionals, leaders in every sector of society, and the public at large.</td>
</tr>
<tr>
<td>Mortality Rate</td>
<td>Total number of deaths in a population attributable to a particular disease.</td>
</tr>
<tr>
<td>Nasopharyngeal</td>
<td>Related to the nasopharynx, which is the upper part of the pharynx (throat) behind the nose.</td>
</tr>
<tr>
<td>Non-endemic</td>
<td>A disease that is not native to and contained within a certain geographic region.</td>
</tr>
<tr>
<td>Pandemic</td>
<td>A disease afflicting an increased proportion of the population over a wide geographic area (often worldwide).</td>
</tr>
<tr>
<td>Pathogenic</td>
<td>The ability of microbes to cause disease.</td>
</tr>
<tr>
<td>Public Health Measure</td>
<td>Any number of steps taken in a community to contain, prohibit, and eliminate the spread of an infectious disease. These range from the use of vaccinations on a large scale, to chlorination of water, to the use of bed nets among many other methods.</td>
</tr>
<tr>
<td>Therapeutic Drug</td>
<td>Any drug taken to help cure a disease or symptoms associated with it.</td>
</tr>
<tr>
<td>Vaccines</td>
<td>Vaccines present a pathogenic organism’s signature molecules to the immune system. A vaccine stimulates the natural immune response, creating antibodies and a chemical memory of the infection without the danger of an actual infection. The chemical memory helps protect us if we are ever exposed to the pathogen in the future.</td>
</tr>
<tr>
<td>Vector</td>
<td>An animal that transmits infectious agents from one host to another, usually a biting or piercing arthropod like the tick, mosquito, or fly. Infectious agents can be conveyed mechanically by simple contact or biologically whereby the parasite develops in the vector.</td>
</tr>
</tbody>
</table>
This activity addresses the following Next Generation Science Standards and Common Core State Standards for high schools.

<table>
<thead>
<tr>
<th>Next Generation Science Standards Standards</th>
<th>Common Core State Standards</th>
</tr>
</thead>
</table>
| • **HS-LS2 Ecosystems: Interactions, Energy, and Dynamics**: HS-LS2-1, HS-LS2-6  
  • **HS-LS3 Heredity: Inheritance and Variation of Traits**: HS-LS3-2  
  • **HS-LS4 Biological Evolution: Unity and Diversity**: HS-LS4-2, HS-LS4-4, HS-LS4-5  
  • **HS-ETS1 Engineering Design**: HS-ETS1-1 | **ELA/Literacy**  
  • **Literacy in Science and Technical Subjects (Grades 9 and 10)**: RST.9-10.8  
  • **Literacy in Science and Technical Subjects (Grades 11 and 12)**: RST.11-12.1, RST.11-12.7, RST.11-12.8, RST.11-12.9  
  • **Speaking and Listening (Grades 11 and 12)**: SL.11-12.4  
  • **Writing (History/Social Studies, Science, and Technical Subjects)**: WHST.9-12.1, WHST.9-12.2, WHST.9-12.9 | **Science and Engineering Practices**  
  • Asking questions (for science) and defining problems (for engineering)  
  • Using mathematics and computational thinking  
  • Constructing explanations (for science) and designing solutions (for engineering)  
  • Engaging in argument from evidence | **Mathematics**  
  • **Standards for Mathematical Practice**: MP.2, MP.4  
  • **Number and Quantity – Quantities**: HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3  
  • **Statistics & Probability – Interpreting Categorical & Quantitative Data**: HSS.ID.A.1  
  • **Statistics & Probability – Making Inferences & Justifying Conclusions**: HSS.IC.A.1, HSS.IC.B.6 | **Crosscutting Concepts**  
  • Cause and effect: Mechanism and explanation  
  • Scale, proportion, and quantity  
  • Stability and change |