MARIAN KOSHLAND
SCIENCE MUSEUM
OF THE NATIONAL ACADEMY OF SCIENCES
at 6th & E Streets, NW, Washington, DC

Exhibit Guide for a Field Trip to the Koshland Science Museum

Infectious Disease: Evolving Challenges to Human Health Focus for Science Education Standards

INTRODUCTION

Welcome to the Koshland Science Museum. A visit to the museum is a unique experience. The Koshland Science Museum is not a collection of artifacts. Rather, it presents scientific data and explanations so that visitors can make decisions about vital public policy issues based on the information they acquire.

Your class visit to the Museum has been designed to model good learning and teaching practices. Using the Jigsaw method described below, your class will divide into smaller groups that simultaneously will visit different parts of the museum. Together, the members of the groups will become "experts" as they seek information to share with their classmates during small-group and whole-class discussions. Students will collaborate in thinking about evidence and formulating ideas much as scientists do in their daily work.

Your visit to the museum will last approximately two hours. During that time, your class will study in detail the *Infectious Disease: Evolving Challenges to Human Health* exhibition. Your class will also spend some time with the museum's *Wonders of Science* and *Global Warming Facts & Our Future* exhibitions. All class visits must be scheduled in advance due to limited space.

The Museum's Exhibitions

The museum has three exhibitions.

The *Wonders of Science* exhibition asks, "What's the Universe Made of?" It encourages visitors to think about some of the big unsolved questions in science, fostering creative thinking and a sense of wonder about the universe. All students will visit this exhibition briefly and ponder the questions it poses.

The *Global Warming Facts & Our Future* exhibition uses interactive displays to present evidence about natural climate variability and the effects of human activities on climate. The exhibition also provides tools with which visitors can explore the consequences of climate change and potential responses to the possibility of change. Your students will visit this exhibition briefly and consider some of the broad issues it raises.

The *Infectious Disease: Evolving Challenges to Human Health* exhibition introduces students to microbe, fungus and parasite biology, the evolution of microbes, the role of public health, and to some of the current global issues related to this topic. Issues explored include vaccines, emerging bacterial resistance, current status of HIV worldwide, and controlling malaria. This is the exhibition where your class will focus most of its attention.

EDUCATIONAL OBJECTIVES AND PROCEDURES

The Koshland Science Museum embodies the inquiry-based approach to education set forth in the *National Science Education Standards* (National Research Council, 1996) and DC-area science standards. By asking questions, gathering information, formulating explanations, and communicating those findings to others, students develop critical and logical thinking skills. Class visits to the museum also reflect current understanding about the processes of learning, as described in *How People Learn* (National Research Council, 2000). Active learning in collaborative teams combined with peer teaching gives students a powerful and meaningful experience with the information and ideas they encounter.

Your class's overall objective will be to address the following question:

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

To break down this question into manageable parts, the students will divide into groups and gather information from a specific part of the *Infectious Disease: Evolving Challenges to Human Health* exhibition. They then will communicate their findings and conclusions within their groups and to the entire class.

A Step-By-Step Agenda for a Class Visit

1. Orientation (10 minutes)

A field trip coordinator will join your class to describe the mission to be accomplished over the following two hours. With the assistance of the teacher and adult chaperones, the field trip coordinator will manage the flow of the class through the museum and guide the class discussion. Classes should arrive 10 minutes before their start time to enter the building and congregate in the area where the orientation will occur. (Note: The time allotments shown include the time required to move from one stage of the visit to the next.)

2. Hands-On Activity (15 minutes)

The field trip coordinator will lead the class through a hands-on group activity in which the students will simulate the spread of an infectious disease. The activity will provide an overview to basic principles of epidemiology and introduce students to basic control measures used to prevent the spread of disease. The measures will be the focus for the rest of the visit.

3. Touring the Exhibitions (50 minutes)

Your class will be split into three groups. Each group will be assigned a color and then will cycle through three rotations in the museum. During one rotation, they will become experts in one aspect of the *Infectious Disease: Evolving Challenges to Human Health* exhibition. During another rotation, they will tour the overview information areas in the *Infectious Disease: Evolving Challenges to Human Health* exhibition. During the third rotation, they will visit the *Wonders of Science* and *Global Warming Facts & Our Future* exhibitions. Thus, in two of the three rotations, students will be exposed to the general messages of the two main exhibitions and using the interactive displays. In the third rotation, students will be digging more deeply into the focus exhibition to build a base of knowledge that they will use during the group discussions later in their visit.

For your visit to the *Infectious Disease: Evolving Challenges to Human Health* exhibition, the rotations will be as follows (in this schedule the gray boxes are the rotations that each group will study in the greatest detail):

Groups	Rotation #1	Rotation #2	Rotation #3
Yellow (Public Health)	• *Infectious Diseases Overview* – Microbial Growth – Where are they? – Global Burden – Public Health	• *Infectious Diseases Expert* – Public Health	• *Wonders of Science* • *Global Warming Facts & Our Future*
Blue (Vaccines)	• *Infectious Diseases Expert* – Vaccines	• *Wonders of Science* • *Global Warming Facts & Our Future*	• *Infectious Diseases Overview* – Microbial Growth – Where are they? – Global Burden – Public Health
Red (Therapeutic Drugs)	• *Wonders of Science* • *Global Warming Facts & Our Future*	• *Infectious Diseases Overview* – Microbial Growth – Where are they? – Global Burden – Public Health	• *Infectious Diseases Expert* – Therapeutic Drugs

Each student will receive a clipboard, pencils, and a field trip packet. One worksheet in the packet will facilitate a detailed analysis of the Overview areas in the *Infectious Disease: Evolving Challenges to Human Health* exhibition. The second worksheet, which focuses on broader themes of the exhibit, will help the Expert Groups analyze in detail the area they are assigned. Because your class is focusing on the *Infectious Disease: Evolving Challenges to Human Health* exhibition, your students will not receive worksheets on either the *Wonders of Science* or the *Global Warming Facts & Our Future* exhibitions.

Students should use their worksheets to record any questions they have about any of the data or other information presented. Students can also ask questions of the field trip coordinator.

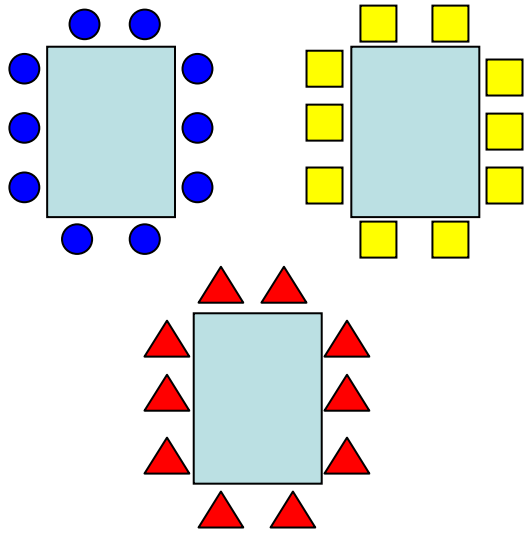
4. Expert-Group Discussions (15 minutes)

After the students have cycled through all three rotations, each Expert Group will move to a discussion area off the museum floor where they will meet separately to discuss the topic they were assigned to analyze in detail. Working together, each Expert Group will prepare their main points to present during the following Interdisciplinary-Group discussions. By working cooperatively, each of the students in the Expert Groups can become knowledgeable in that area. Students will be responsible for summarizing the material discussed by the Expert Groups in subsequent group discussions.

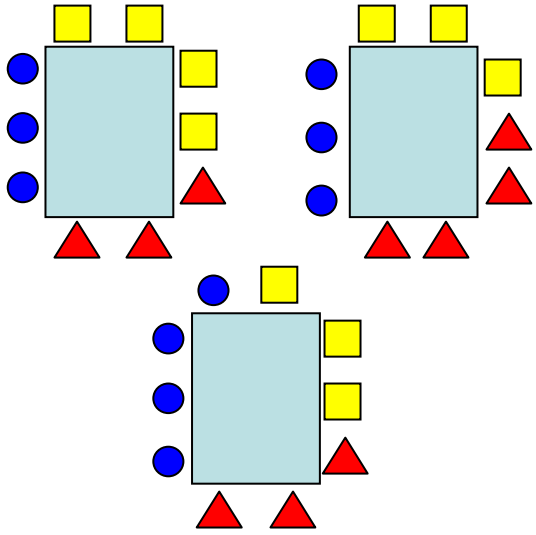
5. Interdisciplinary-Group Discussions (15 minutes)

Next, the students in the Expert Groups will be split up and redistributed to form two or more new "Interdisciplinary Groups." (The number of Interdisciplinary Groups will vary depending on the size of the class.) Each member of the Interdisciplinary Groups will share some of the main points learned earlier and discussed in the Expert Groups. The Interdisciplinary Groups will think about the major question they have been asked to address and will formulate recommendations or suggestions for action. The Interdisciplinary Groups will discuss key pieces of evidence that support their conclusions. The groups also may outline possible additional research questions that need to be answered.

Expert Group Example



Interdisciplinary Group Example



5. Plenary Discussion (15 minutes)

Your visit to the Museum will conclude with a discussion involving the entire class. The discussion will center on the major question being addressed by the class:

How can we apply our knowledge and understanding of the current challenges and strategies for controlling infectious diseases to the future?

Students will synthesize the discrete information they have learned into a "big picture." They will discuss the pros and cons of the applications of controlling infection and emerging diseases that are currently in

use. Students will be asked to think about how infectious diseases could affect the United States in coming years from biomedical, economic, and political perspectives. What will it mean for people to be more responsible for their health in an increasingly global community, particularly as new strains emerge? What specific areas can scientists and medical professionals hope to target in developing new treatment and prevention options? How will our understanding of the pathogens that cause diseases affect the control measures that are adopted? A particular focus of this discussion will be how the evidence gathered by the students supports their conclusions and what uncertainties remain.

The Jigsaw method requires that students become actively engaged with the information they are studying and that they develop an understanding sufficient to enable them to share their understanding with other classmates and make informed recommendations. Students with some experience in working collaboratively and taking responsibility for their own learning will have the most to gain from the visit. Pre- and post-visit materials will offer guidance to teachers to enhance the value of the museum visit to their students.

The Role of Field Trip Coordinators, Teachers, and Chaperones

During your class visit, the field trip coordinator will:

- Instruct your class on its mission.
- With your assistance, manage your class's flow through the museum.
- Lead the class discussion after the Expert-Group and Interdisciplinary-Group discussions.
- Encourage comments based on evidence.

Teachers and chaperones are asked to:

- Facilitate students' inquiry at the individual rotations
- Prepare their class for the visit.
- Maintain appropriate behavior of students.

MAKING THE MOST OF YOUR MUSEUM VISIT

To help ensure a successful visit:

- Prepare your students for their museum visit based on the information in this and other documents available on the museum's web site and that you receive when you register for your class's visit.
- Have your students leave backpacks, portable devices and other items on the bus or at school.
- Discuss appropriate behavior with your students ahead of time. Remember, the museum is housed in the Keck Center, the workplace of the National Research Council.
- Refer to the group visits section of the Koshland Science Museum website for information on motorcoach parking
- Have your class complete some of the pre-visit activities suggested on the website
- Assign students to Expert and Interdisciplinary Groups using the Group Assignment Form prior to the visit. Each group should have a student leader. Each group will tour the exhibits together and

become an expert in one of the three rotations of the exhibit you are studying. Responsibilities of the student group leader include:
    - Delegating tasks
    - Speak on behalf of the group
    - Monitor group progress (facilitate getting all the answers as a "team")
- Have enough chaperones for a ratio of no more than ten students to one chaperone.
- Read through the science content of the exhibition you are studying in detail. Think about how the visit will fit into your curriculum.
- At the end of your visit, contribute comments on the postcards provided, including one new thing that was learned and offering suggestions to improve the museum experience. After the museum staff use the postcards to evaluate the program offered, they will mail the postcards to your school.
- Develop a system to award credit to students for their participation in museum activities.

PROCEDURES FOR SIGNING UP FOR A FIELD TRIP

All field trips must be scheduled in advance. Unscheduled visits by school groups cannot be accommodated because of limited space.

To ensure that you get the date you want for your trip:

- Submit your request for a time and date at least four weeks ahead of the desired time.
- Request either a morning or afternoon time.
- Check the time and date in your confirmation of trip information.
- Two weeks ahead of time, send out the field trip permission forms to your class's parents and arrange for chaperones.
- One week ahead of your trip, reconfirm your trip's schedule with the museum. Ask any additional questions you may have about parking or our facility at this time.

THE CONTENT OF THE *INFECTIOUS DISEASE: EVOLVING CHALLENGES TO HUMAN HEALTH* EXHIBITION

1. Overview Rotation: Orientation to Infectious Diseases
The main messages of this rotation are:

- Bacteria, viruses and parasites evolve continuously – they grow and mutate more quickly than humans – and present new challenges to human health
- Microbes are found almost everywhere
- Global burden of disease is uneven around the world.
- Disease prevalence is correlated with environmental, socio-economic, nutritional and cultural factors (e.g. human population growth, poverty, increasing contact with animals, speed and volume of international transport) and can be used to trace emerging diseases
- Public health strategies like vaccinations, clean water, and sanitation significantly reduce the burden of infectious disease

This rotation provides an introduction to microbial evolution, where microbes live, how disease is transmitted, and the role of public health in global burden of disease. Students can use an interactive

exhibit to see the great variety of microbes and their interaction with people. Using examples such as HIV, TB, malaria and cholera, students will explore where in the world different diseases are most prevalent, particularly as they are overlaid with other factors such as poverty and population and learn how scientists trace emerging diseases. Finally, students will be introduced to the concept of public health—including clean water, sanitation and vaccination programs that have drastically improved life expectancies in developing countries.

2. Expert Rotation: Vaccines
The main messages of this rotation are:

- Vaccines have led to dramatic improvements in human health.
- Vaccines stimulate the immune system to protect against future infection without causing disease.
- Vaccines protect communities as well as individuals from infectious diseases.
- Vaccines eradicated smallpox and have nearly eradicated polio.
- New vaccines will always be needed for protection against emerging and evolving pathogens.

In this rotation, students will learn how vaccines work and what diseases have been successfully curbed by vaccination campaigns. Using interactive displays and videos, students will be able to evaluate the effectiveness of vaccines as a control measure for various diseases presented in the exhibit.

3. Expert Rotation: Therapeutic Drugs
The main messages of this rotation are:

- The development of therapeutic drugs has changed the relationship between humans and infectious diseases.
- The widespread and improper use of therapeutic drugs accelerates the rate at which drug-resistant pathogens emerge.
- Prudent use of therapeutic drugs can delay the emergence of drug-resistant pathogens, yet new drugs will also be needed as pathogens evolve.
- In most cases, patients must be vigilant about taking their medication properly in order to prevent the emergence of multi-drug resistant strains.
- Inequities in the distribution of medications compounded with cultural, geographical, technological barriers allow some diseases to thrive in certain parts of the world

Students will explore how drug-resistant pathogens evolve. Using interactive displays and videos, students will be able to evaluate the effectiveness of therapeutic drugs as a control measure for various diseases presented in the exhibit.

4. Expert Rotation: Public Health
The main messages of this rotation are:

- Public health measures that minimize exposure to disease-causing organisms can be an effective way of preventing the spread of many infectious diseases
- Many diseases, such as malaria, are carried by multiple hosts and persist because the pathogen successfully infects two host species.
- Diseases can be eliminated from much of the world through a combination of public health measures.
- Vaccines and therapeutic drugs can be important components of a public health strategy.

This rotation focuses on the use of public health measures to prevent exposure to disease causing pathogens. Using interactive displays and videos, students will be able to evaluate the effectiveness of public health measures as effective tools for preventing the spread of various diseases presented in the exhibit.

HOW IS THE MUSEUM EXPERIENCE CORRELATED WITH THE NATIONAL SCIENCE EDUCATION STANDARDS?

Fieldtrips to the Koshland Science Museum are modeled on recommendations made in the *National Science Education Standards* (National Research Council, 1996). Through the information presented and opportunities to interact with hands-on displays, the *Infectious Diseases* exhibition meets the following Inquiry and Science Content standards.

For Middle School Students

- Content Standard A – Science **as Inquiry**
  "All students should develop understandings about scientific inquiry."
  "Think critically and logically to make the relationships between evidence and explanations"
  - Students have an opportunity to think critically and logically about infectious diseases, how different organisms contribute to disease, and how scientists use scientific information to approach and solve current issues in world health. Students use graphs, charts, and interactive displays to formulate their own decisions about the data. In this way, students consider how science makes use of logical analysis and problem solving.

- Content Standard C - **Life Science**
  - "All students should develop understanding of structure and function in living systems and diversity and adaptations of organisms.**"**
  - Students discover the differences between bacteria, viruses and parasites. They also explore examples of different organisms that are responsible for distinct diseases and that control of disease relies on knowledge of the biology of the causative organism. Students discover how exponential growth and fast mutation rates provide microbes an evolutionary advantage in a changing environment. Other rotations focus on the emergence of bacterial resistance and how some diseases elude effective vaccination.

- Content Standard E – **Science and Technology**
  - "All students should develop understandings about science and technology."
  - Students enhance their understanding of how science and technology work together in generating new knowledge. In their expert groups, students use their understanding of microbes and disease to investigate how science has developed technologies and practices to combat disease. Students are introduced to the history of antibiotics and vaccines, as well as public health measures including sanitation and clean water. These modern developments have curbed infectious disease significantly in the developed world.
- Content Standard F - **Science in Personal and Social Perspectives**
  - **"**All students should develop an understanding of personal health, populations, resources and environments, risks and benefits, and science and technology in society."

- Students will also use interactive displays to explore how social and cultural barriers can impede public health and medical technologies from being implemented in less developed countries. For example, the lack of vaccines and cultural taboos in Africa are two formidable foes in combating the spread of HIV. Students will the risks and benefits of delivering antimalarial and antibacterial drugs, especially within the economic constraints of less-developed countries. Student will also learn how decisions that ultimately target far-away places can impact our personal health, especially in an age where increased globalization means increased migration of people around the planet.

- Content Standard G – **History and the Nature of Science**
  - "All students should develop understanding of science as a human endeavor and of the history of science"
    - Students learn about the history of the development of antibiotics and the first vaccines and explore the advent of public health policy. Technological advances and policy decisions have drastically improved health in the U.S. in the past 100 years. Using a timeline, students observe the numerous scientists who have contributed to the development of medicine. A graph illustrates how scientific advances and legislation have greatly curbed infectious diseases in this country.

For High School Students

- Content Standard A **– Science as Inquiry**
  - "All students should develop understandings about scientific inquiry."
  - "Think critically and logically to make the relationships between evidence and explanations"
    - Students have an opportunity to think critically and logically about infectious diseases, how different organisms contribute to disease, and how scientists use scientific information to approach and solve current issues in world health. Students use graphs, charts, and interactive displays to formulate their own decisions about the data. In this way, students consider how science makes use of logical analysis and problem solving. The current events presented in these exhibits highlight the many complex difficulties involved in providing health care worldwide and encourage students to think deeply and broadly about the challenges of solving world health problems.

- Content Standard C – **Life Science**
  - "All students should develop an understanding of the cell, biological evolution, and interdependence of organisms.**"**
    - Students will be introduced to the differences between bacteria, viruses, and parasites and the different types of diseases they cause. Students will also focus on the evolutionary potential of microbes, namely their ability to mutate and grow rapidly. Malaria is introduced as a disease with two hosts – mosquito and human – and thus, this parasite depends on two organisms for its life cycle. Other rotations focus on how infectious disease organisms depend on a human or other host for their survival and reproduction.

- Content Standard E – **Science and Technology**
  - "All students should develop understandings about science and technology."

- Students enhance their understanding of how science and technology work together to generate new knowledge. Students use their understanding of microbes and disease to investigate how science has developed technologies and practices to combat disease. Throughout the exhibit, students see examples of how understanding the underlying biology of disease has led scientists to develop technologies to prevent or sometimes cure infectious diseases. For example, students learn about how antibiotics and vaccines were developed, and their resulting effect on public health. Furthermore, sewer and water purification systems have improved public health immeasurably, and speak to the importance of innovative engineering. Scientifically savvy policymakers improved public health by developing legislation to prevent contagious infectious disease. These modern technologies have curbed infectious disease significantly in the developed world.

- Content Standard F - **Science in Personal and Social Perspectives**
  - "All students should develop an understanding of personal and community health and of population growth."
    - Using evidence and logical thinking, students develop an understanding of the magnitude of the effect of infectious disease and the tremendous technological and sociological barriers to combating disease worldwide. For example, the lack of vaccines and cultural taboos in Africa are two formidable foes in combating the spread of HIV. Students will weigh the risks and benefits of delivering antimalarial and antibacterial drugs in second and third world countries. Students see how medical technology and public health will affect their lives, both as individuals susceptible to infectious diseases as members of a global community. Students are asked about the need for and implications of greater public understanding public health worldwide.

- Content Standard G – **History and Nature of Science**
  "All students should develop understanding of science as a human endeavor and of the nature of scientific knowledge."
    - Students learn about the history of the development of antibiotics and the first vaccines and explore the advent of public health policy. Technological advances and policy decisions have drastically improved health in the U.S. in the past 100 years. Using a timeline, students observe the numerous scientists who have contributed to the development of medicine. A graph illustrates how scientific advances and legislation have greatly curbed infectious diseases in this country.