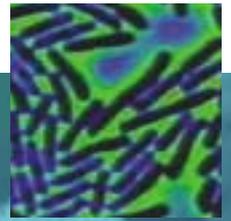


UNIT 6

WHY DOES EVOLUTION MATTER NOW?



Evolution TV Shows
“The Evolutionary
Arms Race” and “Extinction!”



AT A GLANCE

Learning Goals

Understand how natural selection creates **antibiotic-resistant** bacteria

Recognize the applications of evolutionary principles for medicine, agriculture, and conservation

Understand how science contributes to decisions in the context of society

QUICK CLICKS

Teacher's Guide Web Resources

Access the Web resources referenced in this guide—from handouts to video segments to Web features—by going to pbs.org/evolution and clicking on Teachers and Students, and then going to the *Evolution Teacher's Guide*, where the material is presented by unit.

Siberia once seemed so remote. Not anymore. A drug-resistant strain of tuberculosis (TB) from a Siberian prison has now been tracked to New York City. Using DNA fingerprints, microbiologists at the Public Health Research Institute in New York City have identified over 12,000 different strains of TB from all over the world and are using this information to track the evolution of TB and its spread worldwide. But the strain they recently found in New York is different. It's one of the multi-drug resistant strains from Russia that is very difficult to treat. Russian prisons have become breeding grounds for new multi-drug resistant strains of TB because of crowded conditions, the use of low-quality antibiotics, and inadequate follow-up treatment for prisoners. At least 30,000 Russian inmates now have multi-drug resistant TB.

A disease that had once been considered readily curable, TB has become a considerable foe. TB is on the rise worldwide and now rivals AIDS in the number of lives it claims—between two and three million a year. That's why microbiologists Barry Kreiswirth and Alex Goldfarb of the Public Health Research Institute are focusing on Russian prisons. Kreiswirth says, “What's dramatically affected the spread of TB is our ability to travel. All the strains that are in the Russian prisons among prisoners will eventually come to our doorstep.” To meet this challenge head on, Goldfarb has developed a pilot program in the Siberian prison system to change the way that TB is treated, with the hope of preventing the evolution and spread of multi-drug resistant TB.

TB is only the tip of the iceberg. Use and misuse of antibiotics, especially in the United States, has spurred the evolution of drug-resistant forms of pneumonia, gonorrhea, and other infectious diseases. Kreiswirth laments, “We've created this problem. Multi-drug resistance is a man-made problem....By developing as many antibiotics as we have over the last 50 years, we've essentially accelerated an evolutionary process. The outcome is that we're going to have more drug-resistant microbes to the point where some of the most dangerous bacteria will not be treatable. We're racing against the microbe everyday, and unfortunately we're losing.”

BACKGROUND



Almost daily, evolution-related stories are reported in the press. Some of these reports, like the story about antibiotic-resistant strains of TB, depict serious problems that need to be understood and solved. Clearly, the ubiquitous presence of antibiotics in our environment—antibiotics in animal feed, over-prescribing by doctors, and rampant use in hospitals—has created a crisis in the evolution of drug-resistant **pathogens**. In addition, our bacteria-phobic society has created a potpourri of new antibacterial products from soaps to toys—without considering the possible consequences for bacterial evolution. The presence of substances that select against certain microorganisms will most certainly have an effect on future populations.

At the same time, we regularly see how knowledge gleaned from evolution is providing very practical applications to real-world concerns: finding oil fields by analyzing fossils or understanding how **coevolution** of organisms and their natural parasites contribute to disease and recovery. But sciences such as geology and medicine are not the only arenas where an understanding of evolutionary processes is valuable. Selective breeding of food crops and domesticated animals has created many valuable new varieties and breeds: “burpless” cucumbers, larger tomatoes with fewer seeds, cows that produce ten times more milk than cows of a century ago, and hens that lay four times as many eggs. All have been bred by the process of artificial selection, which is evolution guided by humans.



Perhaps the reports we remember most are those that are controversial. They often deal with biotechnology or conservation and environmental management. For example, efforts to avert plant and wildlife extinction through controls on over-cutting of timber or over-fishing often place conservationists at odds with the lumber or fishing industries.

Genetically engineered foods are another controversial issue. In this case, genes of a desirable trait in one organism are introduced into another organism. There are already many **bioengineered food** crops in the marketplace, many designed to resist pests. Today we have biotech corn that has been engineered to produce a pesticide that kills the corn-borer larvae. These so-called biopesticides are used to improve our food supply and to reduce our dependence on commonly used chemical pesticides. No one knows yet what the long-term consequences of bioengineered foods, both positive and negative, will be. But, we’ve already seen **genetic drift** of corn pollen from biotech corn to other corn crops. Once the genes are released into the environment via wind and pollinators, there is no getting them back.

Human activities influence evolution in many other ways. During the last 50 years, over 500 species of insects and mites have become resistant to pesticides. Scientists are now using evolutionary principles to slow down the evolution of **pesticide-resistant insects** and to develop alternative methods of pest control. Our destruction of habitats has endangered species and reduced populations so that their genetic diversity has decreased, and so too their ability to adapt to environmental changes. The list goes on and on. Our use of technology is allowing us to alter the evolution of many species besides our own. We have a responsibility to continue to learn how to use our knowledge of evolution wisely to minimize the deleterious effects we have on the **biosphere**.



Topic	Keyword
antibiotic resistance	EG27A
tuberculosis	EG27B

KNOW MORE

Web Sites

www.rci.rutgers.edu/~ecolevol/fulldoc.html (Comprehensive report on evolution, science, and society sponsored by the National Science Foundation and the A.P. Sloan Foundation)

www.fda.gov/fdac/features/795_antibio.html (FDA site with article on how antibiotic resistance develops)

www.who.int/emc/amr.html (WHO site on anti-infective drug resistance, including report on resistant TB worldwide)

http://www.healthsci.tufts.edu/apua/Products/pamphlet_01.html (Alliance for the Prudent Use of Antibiotics pamphlet)

www.pbs.org/wgbh/gmfoods/ (Provides articles, interviews, interactive activities, and resources related to *NOVA/ Frontline* show: “Harvest of Fear”)

www.bio.org/about.html (Offers the Biotechnology Industry Organization’s position on food and agricultural biotechnology)

<http://www.accessexcellence.org/AB/> (Comprehensive site about biotech including issues and ethics, applications, and careers)

www.ucsus.org/ (Union of Concerned Scientists’ view on genetically engineered crops and reasons for modifications as well as information on antibiotic resistance)

endangered.fws.gov/hcp/index.html (U.S. Fish and Wildlife site on endangered species and habitat conservation)

esa.sdsc.edu/invas3.htm (Ecological Society of America’s fact sheet on invasive species)

Books

Chadwick, D. J. and J. Goode, (eds.). *Antibiotic Resistance: Origins, Evolution, Selection and Spread*. John Wiley & Sons, 1997.

Ewald, Paul. *Evolution of Infectious Disease*. London: Oxford University Press, 1996.

Levy, Stuart B. *The Antibiotic Paradox: How Miracle Drugs Are Destroying The Miracle*. New York: Plenum Publishers, 1992.

McHughen, Alan. *Pandora’s Picnic Basket: The Potential and Hazards of Genetically Modified Foods*. London: Oxford University Press, 2000.

Nesse, Randolph M., and George C. Williams. *Why We Get Sick: The New Science of Darwinian Medicine*. New York: Vintage Books, 1994.

Palumbi, Stephen R. *The Evolution Explosion: How Humans Cause Rapid Evolutionary Change*. New York: W. W. Norton, 2001.

Wilson, Edward O. *The Diversity of Life—College Edition*. New York: W.W. Norton, 1992.

Articles

“Drug Resistance: The New Apocalypse.” Special Issue of *Trends In Microbiology*, Vol. 2, No. 10 (October 1, 1994): 341–425.

Glausiusz, Josie. “The Great Gene Escape.” *Discover* (May 1998): 90–97.

Levy, Stuart. “The Challenge of Antibiotic Resistance.” *Scientific American*, see www.sciam.com/1998/0398issue/0398levy.html

Schultz, T. “Ants, Plants, and Antibiotics.” *Nature* 398 (1999): 747–748.

“Seeds of Change.” *Consumer Reports* (September 1999): 41–46.

Specter, Michael. “The Pharmageddon Riddle: Did Monsanto just want more profits, or did it want to save the world?” *The New Yorker* (April 10, 2000): 58–71.

Video

“The Mouse That Laid the Golden Egg.” (*Secrets of Life*, David Suzuki)

CD-ROM

Wilson, E.O., and D.L. Perlman. *Conserving Earth’s Biodiversity* (Interactive CD ROM) Washington, DC: Island Press, 2000.

pbs.org/evolution

ACTIVITIES



ONLINE STUDENT LESSON 6: *Why Does Evolution Matter Now?*

Students discover how evolutionary theory helps us reap greater harvests, fight disease, and protect the Earth.

Back to the Future to

TEACHER'S GUIDE WEB RESOURCES

Evolution Library

Outside Resources

The Web, old magazines, photographs, drawings

1. Photojournalists can tell vivid stories through photo essays. Ask students to create a pictorial representation (using magazine pictures, photographs, drawings, paintings, video, or downloaded photos) depicting a chain of events impacting a particular species because of changes in the environment (e.g., habitat destruction; introduction of non-native predator, pest, or competitor). Have students base their representation on research and evidence about the species and environmental change they have chosen. Ask students to include a prediction of how the environmental change might affect future evolution of the species.
2. Before students' presentations are final, ask students to pair up and review each other's presentations. Each partner will write or tell a story that describes what he or she sees in the other's work. Then students will compare their partner's story to their intended result and revise their picture if the meaning was unclear.
3. Finally, have students put their pictures on display, presenting to each other key highlights of their story.

TAKE IT FURTHER

Online Course for Teachers

Session 5: "How Did Humans Evolve? Is Evolution Still Happening?"

Web Features

- "Microbe Clock"
- "Babies by Design"
- "A Modern Mass Extinction?"
- "The Evolving Enemy"

Extensions

For a decision-making activity related to habitat destruction of rain forests, see www.accessexcellence.org/AE/AEPC/WWC/1991/rainforest_role.html.

When An Apple A Day Isn't Enough

TEACHER'S GUIDE WEB RESOURCES

Video Resources

- "Cholera: Domesticating Disease"
- "Double Immunity"

Evolution Web Feature

- "The Evolving Enemy"

1. Have students watch the video segments "Cholera: Domesticating Disease" and "Double Immunity" in the **TEACHER'S GUIDE WEB RESOURCES**.

2. Raise the following questions during a class discussion:

How does an understanding of evolution help doctors manage infectious diseases?

What factors affect the evolution of disease organisms to make them become more virulent?

What is the relationship between HIV resistance and the Black Death?

How have disease organisms coevolved with humans?



VIDEO 6 FOR STUDENTS

Why Does Evolution Matter Now?

Have your students watch this to learn about the transmission of tuberculosis and why the evolution of multi-drug resistant strains of TB in Russia affects us all.

Discussion questions:

How does the misuse of antibiotics affect the evolution of disease-causing bacteria like TB? Describe in terms of natural selection.

What is responsible for the evolution of TB strains that are resistant to multiple drugs?

Why is the Russian prison system considered to be "ground zero" in the fight against TB?

How does globalization affect the transmission of diseases? Give an example that includes the way TB is transmitted.

Evolution in the News

TEACHER'S GUIDE WEB RESOURCES

Evolution Library

Outside Resources

Newspaper and magazine articles

1. Evolution is in the news more often than most people realize. Many news stories based on evolutionary concepts never mention the word *evolution*. Ask students to collect newspaper and magazine articles related to evolution. Before they do, brainstorm the kinds of topics that might be related to evolution so they will know what to look for. Examples include:

- Dinosaur fossils
- Human fossils
- Antibiotic-resistant pathogens
- Habitat destruction
- Oil spills
- Endangered species
- Biotech corn in food
- Genetically modified animals
- Teaching evolution in schools
- Comets and dinosaur extinction
- Domestication of animals
- Breeding new plant varieties

2. Ask each student to select a single article and to write an essay describing how it is related to evolution. Have students make as many links as possible and be specific in their explanations, using the vocabulary of science and evolution (e.g., mutation, evidence, natural selection, variation, common ancestor, etc.).

3. Discuss the articles in class.

4. Post students' articles on a bulletin board and have students cluster articles with like topics and then give the category a title.

5. Have students create a class concept map of the evolutionary concepts they are finding in the news, showing the links and relationships between topics. (See Online Teacher Course Session 1 for information on creating concept maps.)

6. Have students continue to bring in and discuss evolution articles over a month's time to help them understand the relevance of evolution to their daily lives.



IN-DEPTH INVESTIGATION

Big Decisions to

Science must work in the context of society. No matter what the scientific evidence, people make decisions based on a variety of criteria, including economics, health, aesthetics, politics, and ethics. These decisions can ultimately affect the evolution of organisms.

Objective:

Students learn different perspectives in a situation that can have possible evolutionary implications.

Materials:

- Resource materials related to topic you choose (See the “Know More” section to begin)
- Copies of the “Evaluating Internet Information” pages available at <http://www.lib.vt.edu/research/libinst/idle/evaluating.html>
- Copies of story “A Sound of Thunder” by Ray Bradbury (in his book *R is for Rocket*). Also available at <http://www.sba.muohio.edu/snavey/415/thunder.htm>

Procedures

Preparation: Gather resources relevant to the topic you choose. Make copies of the “Evaluating Internet Information” pages and “A Sound of Thunder.”

1. Divide students into teams of four or five.
2. Give students a situation (such as pesticide use on lawns or crops, use of biotech foods, habitat destruction and endangered species, introduction of a non-native predator competitor, etc.).
3. Give each student in the team a different role (e.g., environmental activist, farmer, parent with young children, doctor, biotech company CEO, politician). Ask each student to define the point of view for his or her role and to seek out scientific arguments and evidence that might support or refute it.
4. As students find information to support their role’s point of view, have them consider the evolutionary, economic, health/medical, environmental, political, and ethical implications of the situation. Students may use the Web, library, and other resources. Give students pointers on evaluating the reliability of sources. (See “Evaluating Internet Information” Web site referenced above.)
5. Have students dress in their roles for a “town meeting” to discuss the implications of the situation from each point of view. Have the town make a decision on the situation after listening to all sides.
6. Ask students to write an article for a newspaper that compares and weighs each point of view. (Or have students write a paper that describes what they learned and what their actual point of view is now.)
7. Have students read the short story “A Sound of Thunder” by Ray Bradbury and have a class discussion about how this story (which describes how the ripple effect can have major impact over time) relates to human intervention and the effect on future evolution.

See Assessment Rubric on p. 35.

