

SUGGESTED REFERENCES

- *21st Century Complete Medical Guide to Antibiotics and Antibiotic Resistance, Drug-Resistant Bacteria, Antimicrobial Susceptibility, Authoritative CDC, NIH, and FDA Documents, Clinical References, and Practical Information for Patients and Physicians.* **PM Medical Health News.**
- **The Antibiotic Paradox. How the Misuse of Antibiotics Destroys Their Curative Powers** (Second Edition), Stuart B. Levy, M.D., 2002, Perseus Publishing, Cambridge, MA.
- *DMBD - Antibiotic Resistance - Home:*
<http://www.cdc.gov/drugresistance/community/>
- *Alliance for the prudent use of Antibiotics (APUA):*
<http://www.tufts.edu/med/apua/index.html>
- *Scripps Research Institute*
www.scripps.edu

NATIONAL SCIENCE EDUCATION STANDARDS

5 - 8

Life Science

Structure and Function in Living Systems
Diversity and Adaptation of Organisms

History and Nature of Science

Nature of Science

9 - 12

Life Science

Biological Evolution
The Interdependence of Organisms

Science in Personal and Social Perspectives

Personal and Community Health

*Source: *National Science Education Standards, 1996, National Academy Press*

CREDITS

The producers thank the Australian Broadcasting Corporation, Content Sales, for materials used in this program.

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VOLUME 35 ISSUE 2

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SYNOPSIS

This program explores the role of bacteria in disease. Humans attempt to control bacterial diseases through the use of antibiotics. Over time these antibiotics have gradually become less effective. The reasons behind this loss of effectiveness are explored.

Students will learn how two major theories in Biology, Germ Theory and Natural Selection play a role in bacterial resistance to antibiotics. The application of these theories provides a chance for students to understand how our actions may be doing us as much harm as good.

CURRICULUM UNITS

- BIOLOGY
- ECOLOGY
- ENVIRONMENTAL SCIENCE
- HEALTH

RUNNING TIME

13:22

BACKGROUND

Bacteria are the oldest known forms of life on earth. Although they are only single-celled and contain no membrane bound organelles, bacteria are capable of living in environments that are far more severe than any other kind of organisms.

Up until the 20th century, humans suffered from bacterial diseases such as Staph and Strep throat. We had no drugs to treat these diseases and the mortality rate from some, like the Bubonic Plague, was extremely high. Then, in 1928 Fleming discovered a fungus that effectively killed bacteria. It wasn't until the 1940's that large-scale production of penicillin was begun, but right away, the number of people killed by bacterial infections dropped dramatically.

Soon afterwards, scientists began to notice that the bacteria were developing a resistance to the antibiotics being used. Initially the resistance was limited and increasing the dosage of the antibiotic or changing to a different antibiotic was sufficient to eliminate the bacterial infection. However, scientists also noted that it was possible that the bacteria could eventually develop resistance to all antibiotics. Over the next fifty years, scientists developed new antibiotics and doctors were able to keep the incidence of disease quite low.

Antibiotics are not only being used on humans. When livestock or pets get sick, they are given antibiotics as well. This is an appropriate use of antibiotics since some bacterial infections can be passed from animals to humans. Farmers began using antibiotics on healthy livestock when it was shown that the animals would gain weight faster with less feed. This lowered the cost of production and increased profits. It also increased the amount of antibiotics in the environment and exposed more bacteria.

Natural Selection predicts that in any population some individual organisms will have variations that allow them to survive a change in the environment. These individuals will pass on this variation to the next generations. When we expose bacteria to antibiotics, we are changing the environment. When exposed to the antibiotic, most bacteria die, but some do not. The ones that do not are resistant. Every use of an antibiotic then selects for the variants that are resistant to the antibiotic. The more antibiotics used, the more likely the bacteria will become resistant to it.

When antibiotics are used for purposes other than defeating bacterial infections, they are being misused. In addition to giving antibiotics to healthy livestock, some companies produce consumer products such as antibacterial soap. This soap has little or no effectiveness compared to regular soap. Doctors also routinely give out antibiotics to people suffering from viral infections. Although sometimes the viral infection can cause a secondary bacterial infection, doctors usually prescribe the antibiotic to appease the patient who wants something to take home.

Many scientists think that our overuse of antibiotics is leading to bacteria that are now resistant to all antibiotics. VRE is one such bacterial strain. It is resistant to vancomycin, the most powerful antibiotic we have. Patients often get infected with these bacteria in the hospitals because of poor infection control. Once the infection begins, doctors must quarantine the patient to avoid infecting other patients.

The mechanism by which bacteria develop resistance is described in the program. Although this is appropriate for high school level, many middle school students may have questions about this process. Most students have the misconception that the antibiotic changes the bacteria. In fact, either the bacteria are resistant or they are not. Bacteria can acquire the resistance from other bacteria, but cannot develop it on their own.

The stages of infection are described. Most students are vaguely aware that bacteria live on their bodies. These bacteria have colonized their skin, and most times it is harmless unless it can penetrate the skin. Once it has done that, infection begins with an immune response from the body. Most students are aware of the signs of infection (fever, swelling, etc...), but few realize that if an infection progresses far enough, tissue death may occur. If an infection is not controlled, doctors may have no choice but to amputate the infected tissue.

ADVANCED ORGANIZERS

Prior to showing this video, students should have some understanding of the following benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 5: The Living Environment

Section A - The diversity of Life

Know by Grade 12

- The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions, and a great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment.

Section F - Evolution of Life

Know by Grade 8

- Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.

Know by Grade 12

- Heritable characteristics can be observed at molecular and whole-organism levels-in structure, chemistry, or behavior. These characteristics strongly influence what capabilities an organism will have and how it will react, and therefore influence how likely it is to survive and reproduce.
- Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.

**Benchmarks can be found at www.project2061.org/tools/bencho/bolintra.htm*

CRITICAL THINKING EXERCISES

1. Explain how bacterial infections begin.
2. Describe how antibiotic resistance can develop in bacteria.
3. Discuss methods that hospitals can take to reduce the number of antibiotic resistant bacteria.
4. Explain how antibiotics are misused.
5. Design an experiment to test the effectiveness of antibacterial soap compared to hand soap at killing the bacteria found on the hand.

VOCABULARY

Antibiotics	MRSA	Resistant
Colonization	Natural Selection	Sepsis
Colony	Phagocytes	Triclosan
Germ Theory	Pili	Vancomycin
Infection	Plasmids	VRE

CAREER POSSIBILITIES

- BIOLOGIST
- BIOTECH RESEARCHER
- PHYSICIAN
- MEDICAL TECHNOLOGIST
- NURSE
- PHYSICAL THERAPIST