CREDITS

Executive Producer
Anson W. Schloat

Producer
Cochran Communications

Director
Peter Cochran

Teacher's Guide Writer
Jennifer Wallace

Program Consultant
Frank Lowy, M.D.

Our Appreciation for the Assistance of
Stuart Levy, M.D.
Director of the Center for Adaptation Genetics and
Drug Resistance
Tufts University School of Medicine

CONTENTS

Introduction

Consider the difference in size between some of the very tiniest and the very largest creatures on Earth. A small bacterium weighs as little as 0.00000000001 gram. A blue whale weighs about 100,000,000 grams. Yet a bacterium can kill a whale...Such is the adaptability and versatility of microorganisms as compared with humans and other so-called "higher" organisms, that they will doubtless continue to colonize and alter the face of the Earth long after we and the rest of our cohabitants have left the stage forever. Microbes, not macrobes, rule the world.

—Bernard Dixon, physician (as quoted in ***The Coming Plague*** by Laurie Garrett)

Humans have the tendency to see ourselves as superior to other life forms. In actuality, we are just one species among many complex organisms, all sharing the same global ecosystem. Some organisms, like bacteria and viruses, cause deadly diseases which have sometimes overpowered *Homo sapiens*. Small pox weakened the entire Aztec civilization. Epidemics like bubonic plague, tuberculosis, and Spanish influenza killed hundreds of millions. New diseases like AIDS and Ebola—and the reemergence of old diseases like tuberculosis—are startling reminders of the threat still posed to humans by bacteria and viruses.

This program focuses on the interaction of disease-causing microbes with human beings. It explores the discovery of bacteria and viruses, advances in sanitation and medical science, as well as the ways in which tiny microbes have adapted to our advances. Finally, newly emerging diseases are discussed as is the impact of recent human actions in the global ecosystem.

Introduction

continued

We are learning more about the causes and effects of infectious diseases. We are also learning that while humans may be skilled at altering the equation between ourselves and the tiny microbes, we probably will never conquer them.

Objectives

After viewing the video, students should be able to:

- ✓ describe the reasons for this century's earlier progress against infectious diseases
- ✓ describe how microbes evolve in reaction to changes caused by humans
- ✓ describe how human actions against infectious agents often have the unintended effect of promoting them
- ✓ explain how bacteria develop resistance to antibiotics
- ✓ describe factors leading to the emergence of viral diseases like AIDS and Ebola

Program Summary

The program opens with a discussion of the history of disease-causing microbes. For example, it is believed that one of the reasons the Aztecs were so quickly conquered by the Spanish in the 1500's was because of small pox, a viral disease brought to the New World by the Spanish and against which the Aztecs had no natural defenses. Bubonic plague is another example of an infectious disease with far-reaching consequences. The plague decimated one-third of Europe's population between 1346 and 1350. It took several generations to recover from the famine and the economic and political instability that followed.

It was not until the late 1800's that scientists discovered the links between infectious diseases and microorganisms. The biggest culprits seemed to be bacteria—one-celled, plantlike microorganisms causing illnesses such as staph infections, pneumonia, tuberculosis, and malaria. Initial experiments with bacteria identified the "mechanics" of how diseases spread from person to person and scientists focused on steps to prevent infection from occurring. While improved cleanliness and use of antiseptic chemicals limited widespread epidemics, bacterial disease continued to kill many people.

A medical breakthrough occurred in 1929 when Scottish bacteriologist Alexander Fleming discovered a toxin in mold that killed staphylococcus bacteria. The discovery of penicillin and the rise of antibiotic drugs changed the nature of medicine. Antibiotics, which actually killed bacteria, were hailed as "miracle drugs"—able to strike at the "root" cause of diseases like tuberculosis, malaria, syphilis, gonorrhea, and strep.

Program Summary

continued

However, it soon became apparent that our optimism was premature. Only five years after doctors started using penicillin, strains of staphylococcus bacteria appeared that no longer reacted to the drug. Since then, scientists have learned that virtually every type of disease-causing bacteria is resistant to at least one kind of antibiotic. Some strains cannot be treated by any drug.

Dr. Stuart Levy, Director of the Center for Adaptation Genetics and Drug Resistance at the Tufts University School of Medicine, examines the resurgence of antibiotic-resistant bacteria, particularly those that cause diseases that were once easily treatable, but are now more difficult to treat—staph infections, ear infections, meningitis, some pneumonias, urinary tract infections—all of which have become antibiotic resistant.

The phenomenon of resistance is of major importance to medical science. We are learning that bacteria—like other living organisms—are capable of adapting to their environment. This is particularly important when it comes to treating bacterial diseases with drugs. Most bacteria die when treated with antibiotics. However, some do not. These more virulent bacteria survive to reproduce. They, in turn, pass their resistant genes onto their descendants, eventually producing a population of bacteria that can survive even the strongest drugs. As a consequence, diseases we once thought were eradicated—like tuberculosis, bacterial pneumonia and gonorrhea—have begun to appear again.

Resistance to antibiotics is also linked to their misuse by people. Many patients do not take the full course of antibiotic treatment and consequently kill only the weakest bacteria, leaving the strongest to reproduce. Other people are too quick to take antibiotics when the best course might be to strengthen their own immune systems. Misuse of antibiotics by the agricultural industry is another way some strains of bacteria become resistant.

Dr. Levy states that the impact of antibiotic-resistant bacteria on our lives is and will be broad and devastating. People will die of infections which we could have cured with antibiotics that are now no longer effective.

Bacteria are not the only disease-causing microorganisms. Viruses are many times smaller than bacteria but they are also deadly. In contrast to bacteria, which reproduce by splitting in half, viruses cannot reproduce by themselves. Their survival depends on their ability to invade a living cell and to use the cell's genetic material to divide and multiply. Viruses cause chicken pox, measles, and AIDS, among other diseases. Because viruses are different than bacteria, they do not respond to antibiotic treatment.

Vaccines have been the biggest scientific advance against viral diseases. Vaccines are based on an understanding of how the body's immune system responds to invasion by a virus. When attacked by the measles virus, for example, the body defends itself by making antibodies that attack the virus. Scientists discovered that injecting dead or weakened forms of a virus into the body causes the immune system to manufacture antibodies that remain in the bloodstream, attacking subsequent viruses before they can cause harm. Vaccines have been effective in fighting

Program Summary

continued

polio, small pox, measles, chicken pox, and other viral illnesses.

However, in recent years humans have witnessed the emergence of new deadly viruses like HIV, Ebola, and Hanta. We have learned that there are many unknown microbes causing diseases for which there is no cure or vaccine.

Scientists believe a clue to the emergence of new diseases lies in the ecological interrelationships between organisms (human, microbes and other animals). Research shows that viruses have coexisted in balanced ecosystems for years. However, changes occur when the balance is upset. For example, some viruses have been confined to host animals who are unharmed by the existence of viruses in their bodies. But, as human settlements expand and these animals come into increased contact with people, the viruses can infect humans who have not built up a natural resistance.

The danger of transference from person to person is greatly increased by added mobility of populations from rural areas to cities where there are larger concentrations of people. Additional factors include disruption or termination of sanitation and health care as well as poverty in underdeveloped but heavily populated areas. Other dangers include changes in social mores, like increased frequency of sexual contacts, and intravenous drug use.

In conclusion, since the discovery of penicillin nearly 70 years ago, we have learned more about the adaptability and opportunistic character of microbes. Even our advances, which looked like solutions, have unintended side effects. We have learned above all that health issues are a global concern and cannot be separated from social and environmental issues.

As Lewis Thomas observed in his book, ***The Lives of a Cell: Notes of a Biology Watcher***, "We must embrace complexity, seek ways to describe and comprehend an ever-changing ecology we cannot see, but, nonetheless, by which we are constantly affected."

Video Script

Narrator

We human often pride ourselves on our intelligence and our mastery over our own fates, but throughout our existence, the human species has been greatly affected by much smaller living things—disease-causing microorganisms such as bacteria and viruses.

For a while, it seemed like we had gained the upper hand in an ongoing struggle against these microbial pests. No longer. With the resurgence of old diseases like tuberculosis and gonorrhea, and the emergence of a new diseases like AIDS and Ebola, our confidence has been shaken. The microbes which we once thought we were close to conquering have proved more adaptable and more tenacious than we ever imagined.

Chapter One:
Disease and History: The Rise of Medical Science

Narrator

The Aztec Empire (in what is now Mexico) was once one of the world's great civilizations. The Aztecs built complex cities with pyramids rivaling those of ancient Egypt. Yet in 1536, a tiny band of Spanish soldiers, led by Hernando Cortez, conquered this great civilization.

Cortez and his followers triumphed not because they were more daring. Nor could the Spaniards claim victory because of their superior weapons. They won because they had unknowingly brought with them to the New World small pox, a disease against which the Aztecs had no natural defenses. When Cortex mounted his final attack on the Aztec capital, there were few Aztec soldiers alive or healthy enough to resist.

Disease-causing microbes have often turned the course of human history. In 1347, the plague caused by the deadly *Yersinia pestis* bacteria quickly spread throughout Europe. The bacteria produced pus-filled boils and caused massive damage to different organs. Eventually the victims became mad. Doctors resorted to elaborate costumes and masks in the mistaken belief that these would protect them from becoming infected. Perhaps one third of Europe's population died between 1346 and 1350.

Up until relatively recently, people had little understanding of the causes of diseases like the plague and small pox. They knew they could catch a disease from others but not why. Doctors were helpless when confronted with infectious diseases. They could try to make a patient more comfortable, but a patient's survival mostly depended on the natural defenses of his own immune system. When doctors did intervene, they often did more harm than good. Many thought that bleeding victims would help by purging them of "bad" blood.

Only in late 1800s did scientists make a connection between microorganisms and infectious disease. As the link between microbes and disease became more evident, improvements in health care followed. Hospitals took greater care that their wards were cleaner. Doctors were more careful about washing their hands before and after examining a patient, and antiseptic chemicals were used to kill bacteria to prevent infection from wounds or surgery.

The biggest medical breakthrough, however, began in 1929 when the Scottish bacteriologist Alexander Fleming accidentally discovered that a mold killed the *staphyloccoccus bacteria* he was studying in his lab. Fleming dubbed the chemical produced by his mold **penicillin**.

Penicillin works by attacking the cell walls of bacteria, causing them to burst. It was the first of a series of antibacterial drugs called **antibiotics**. Antibiotics were first widely used in World War II. Until that time, soldiers were more apt to die of the infections resulting from their wounds than from the damage done by the wounds themselves.

<u>Newsreel</u>

"Allied casualties in Normandy receive the most expert medical care science can provide. Two modern treatments, penicillin and blood transfusions, have cheated death in thousands of cases. Thousands of men, thanks to penicillin and plasma, will come home to their thankful families. A whole world of peace to come will reap the benefits of this great wartime medical discovery. Science has won another victory over death."

<u>Narrator</u>

Antibiotics changed the nature of medicine. Before antibiotics, doctors could try to make a patient suffering from bacterial pneumonia more comfortable, but they could do nothing to cure the disease except wait and hope. But with the development of penicillin, doctors could wipe out the disease-causing bacteria that cause the pneumonia.

Before antibiotics, tuberculosis was a major health problem. To treat the disease, special sanitariums imposed a variety of regimens including bed rest, exercise, exposure to fresh air, and unusual diets. Antibiotics made such treatments obsolete.

continued

After the war, the production of antibiotics increased. Antibiotics became known as "miracle drugs" that could cure syphilis, gonorrhea, strep throat, and other diseases caused by bacteria.

Antibiotics, along with the development of vaccines, seemed to spell the end of the threat of infectious diseases. Medical science was ready to declare victory over infectious diseases and focus its attention on chronic illnesses like cancer and heart disease. But this optimism was premature. Bacteria had ways of fighting back.

Chapter Two:
Bacteria Make a Comeback: The Threat of Antibiotic Resistance

Narrator

Soon after antibiotics were introduced, bacteria began to develop resistance to these drugs. Take *staphylococcus*. Within a short time after doctors first started using penicillin, a strain of *staphylococcus aureus* appeared that was resistant to the antibiotic.

This is Doctor Stuart Levy, director of the Center for Adaptation Genetics and Drug Resistance at the Tufts University School of Medicine. Dr. Levy is a leading authority on antibiotic use and resistance.

Dr. Stuart Levy

Staphyloccoccus aureus is a common cause of very difficult-to-treat infections that can be fatal. We developed a miracle drug, penicillin, to treat it and were quite successful until this organism developed resistance to that drug. We then came up with methicillin—we being the pharmaceutical houses—and the organism became resistant to methicillin. Over the period of very few decades, from the 1940s to now in the 90s we have continually added new antibiotics to treat this organism, and it has repeatedly answered with a resistant mechanism.

Narrator

Today, there are strains of *staphylococcus* that are resistant to every known antibiotic except one, vancomycin. And *staphylococcus* is by no means unique.

Dr. Stuart Levy

There are dozens of bacterial infections that we could have treated before that we're having trouble treating now. We have things like tuberculosis. We have *pneumococcus* which causes ear infections in children and meningitis, which is inflammation of the brain. We have pneumonias caused by *pneumococcus*, by *e-coli*, by *pseudomonus*. We have urinary tract infections. I could go on and on. All of these bacterias are ones we could have treated, and have treated very successfully in the past, but now they're here with resistance to not one antibiotic or two but to four, five, six different antibiotics. In so many instances we're left with one drug to treat a very common infection.

Narrator

The problem is that bacteria are extraordinarily skillful in adapting to whatever weapons we use against them. Bacteria are stars of evolutionary prowess. When a colony of bacteria is treated with an antibiotic, most die. However, there may be a few individuals that have a mutant gene that makes them resistant to the antibiotic. Without the competition from the nonresistant bacteria, these bacteria then rapidly reproduce and pass on their resistance to their descendants.

Bacteria can reproduce extremely quickly by simply dividing in two. Under the right conditions, some can divide this way every twenty minutes. One becomes two, two become four and so on. In this way a single resistant bacterium can have millions of descendants in less than 24 hours.

A resistant bacterium can also pass on the gene responsible for its resistance to another bacterium. Most of the bacterium's genes are located on a single chromosome, but some are contained on small rings of DNA called **plasmids**.

In a process called **conjugation**, a bacterium can send out a filament that attaches to another bacterium. The first bacterium makes a copy of its plasmid and transfers this copy through the filament to the other microbe. The plasmid copy may contain a gene for resistance to an antibiotic. With its new gene, the second bacterium becomes resistant to the antibiotic, too, and so do all the bacteria that descend from it.

What particularly worries doctors is that even different kinds of bacteria can transfer their resistant genes. There is a strain of *enterococcus* that is resistant to all antibiotics. Doctors fear that sometime an *enteroccocus* bacterium will transfer genes to *staphylococcus aureus*, making it resistant even to vancomycin, the only drug that is now effective against this strain. This would be a medical disaster, making this kind of staph infection in hospital untreatable.

Doctors would once again be reduced to simply watching their patients and hoping that their immune systems kick in quickly enough and powerfully enough to take care of the infections.

Video Script

continued

<u>Dr. Stuart Levy</u>

The consequences of not being able to treat *staph aureus* will be broad and devastating. People will die of an infection we could have cured with penicillin or many of the other drugs, if we don't have another drug to treat it with. That's where we're at now if we lose vancomycin.

<u>Narrator</u>

The problem of resistant bacteria has become even greater because of the way patients misuse antibiotics. People will stockpile old antibiotics and take them without a prescription for illnesses such as the flu or the common cold that are caused by viruses. But antibiotics have no effect on viruses. They only work against bacteria.

Even when an antibiotic is properly prescribed, patients often don't correctly use them. After a couple of days, the patient may feel better and may stop taking the medication rather than completing the full course that was prescribed. But the antibiotics may have had time to kill only the least resistant bacteria. If there are any resistant bacteria that haven't been killed, these will quickly multiply.

Even when antibiotics are used properly, their widespread use can have unintended effects in the long run. Ear infections, a common affliction of young children, are one example. Before antibiotics, parents and doctors would provide pain relievers and usually the child would eventually improve as her own immune system fought the infection. But now antibiotics are commonly prescribed, particularly amoxycillin. Even if a doctor doesn't want to prescribe an antibiotic, parents will ask for it to relieve their child's suffering. Bacteria have responded by becoming more resistant to amoxycillin, and doctors often have to prescribe more powerful antibiotics.

Another problem with antibiotics, particularly the more powerful ones, is that they often kill bacteria that are actually helpful, including bacteria that actually protect us against bad bacteria.

<u>Dr. Stuart Levy</u>

We have lots of good bacteria keeping out ones that are resistant or could cause harm. We treat with an antibiotic when we don't need it. We destroy the good bacteria that are there, and the resistant ones or the ones that could be harmful and are resistant have lots of room to spread. So, in fact, the good bacteria, the bacteria that are out there helping us, keep infections away from us. They are a barrier to infections. And if we use antibiotics sloppily or casually, we destroy that barrier and we set ourselves up for infection.

Video Script

continued

<u>Narrator</u>

The extensive use of antibiotics in agriculture is another problem. Farmers use antibiotics to treat infections in chicken, cattle, and other livestock. But the main reason farmers use antibiotics is that by keeping the animals healthy, they help the animals grow faster. When antibiotics first appeared, they seemed like a gift from heaven for farmers, as this old newsreel attests.

<u>Newsreel</u>

"Turkeys, acres of them, and every one of the 15,000 birds on this Long Island, New York farm is bigger and meatier than you'd expect at its age. Feeding provides the secret to their miraculously rapid, healthy growth. In each ton of feed goes about one-third of an ounce of a new wonder drug, teramycin. This antibiotic makes turkeys disease-free as well as bigger."

<u>Narrator</u>

Today, the use of antibiotics in agriculture continues to be widespread. But just as with people, resistant strains of bacteria develop. These can end up in meat sold to consumers. While cooking can kill these bacteria, the bacteria can infect people if the meat is undercooked. The widespread use of antibiotics in agriculture and medicine has stimulated an unusually rapid evolutionary change in bacteria.

<u>Dr. Stuart Levy</u>

In a decade when reemerging infections is now accepted as a true public health problem, antibiotic resistance is probably the main foundation of that problem. The bacteria coming back—and I'm talking globally, this is all over the world—are the ones that we could have treated, and have treated in the past, but now they have reemerged with resistance to the very drugs we have treated them with in the past.

Chapter Three:
Emerging Viral Diseases

<u>Narrator</u>

Viruses, against which antibiotics are useless, present other kinds of challenges to world health. Viruses come in many shapes. They are many times smaller than a bacteria. A virus is not even a cell. A virus is simply a protein coat surrounding a piece of genetic material. Viruses can't reproduce by themselves. They take over a cell's metabolic machinery to produce more viruses. In the process, a cell may be killed or damaged.

There are vaccines that are effective in preventing many viral diseases from taking hold. Vaccines contain dead or weakened forms of a virus that stimulate the body's immune system to manufacture protective proteins called **antibodies**. If a person is exposed to a full-strength virus later, these antibodies attack the virus before it can cause any harm.

In the twentieth century, enormous progress was made in developing vaccines against a variety of viral diseases, including polio and measles. In the 1960's and 70's, the World Health Organization began a campaign to eliminate small pox by vaccinating everybody who could be exposed to it. This Somali man was the last recorded case of naturally-occurring small pox. Except in a couple of laboratories where the virus was being stored for research purposes, the small pox virus had been eliminated from the face of the earth. It was one of medical science's greatest triumphs.

But vaccinations don't provide protection against all viruses, particularly some new viral diseases that have emerged in the last twenty-five years. In 1980, doctors in San Francisco first began to notice a number of patients who suffered from a rare kind of pneumonia called *Pneumocystis carinii pneumonia* and a cancer called *Karposi's sarcoma*. For most people, their immune systems prevent these diseases from taking hold. But the immune systems of these patients were so weak that they couldn't fight them off.

These patients had AIDS. AIDS is caused by a virus called HIV, or *Human Immunodeficiency Virus*. HIV causes its havoc by slowly destroying white blood cells that play a crucial role in the body's immune system. Because of their weakened immune systems, people with AIDS are susceptible to diseases that, under normal circumstances, would not pose a threat.

By 1994, more than 16 million people worldwide had been infected with HIV. We now know of several strains of this virus, which was unknown a little more than ten years earlier. AIDS is only one of several recently-emerging viral diseases that pose threats to human health.

Ebola is another particularly frightening example. This virus attacks the tissues and organs of the body, essentially liquefying them. While it takes, on average, over ten years for a person infected with HIV to become sick with AIDS, Ebola acts within days. More than 80% of those infected die.

Why is it that HIV, Ebola, and other viruses that were unknown thirty years ago are now becoming a threat? There is no single answer to this question. Scientists think that many of these viruses have been around for a long time, but they were isolated in tropical rainforests where humans were not likely to come in contact with them.

Probably, the viruses were harbored by animals that are unharmed by the microbes. As long as people didn't come in contact with the viruses and their animal hosts, there was little danger.

However, in recent decades, as the human population has rapidly increased, large tracts of rainforests have been cut down to create pasture and farmland and to provide timber. Health officials fear that as the remaining forests are cut or burned, other up-to-now unknown viruses will emerge.

There is another factor that has changed. In the past people in many parts of the world lived mainly in isolated villages. When people became sick, they were unlikely to spread the disease beyond their immediate area. But in the last twenty-five years, many previously rural areas have become highly urbanized as millions of people jammed into cities. The danger of an infectious disease spreading is much greater.

Improved transportation is another facet of modern life that makes it easier for disease to spread. It is now possible for someone to become infected with a highly-contagious disease, hop onto a plane, and be halfway around the world before he or she feels any symptoms of the disease.

Another factor that contributes to the spread of disease is the turmoil caused by war. As people are displaced by war, they frequently are crowded into refugee camps that lack basic forms of sanitation, and where health care is limited.

Finally, changes in lifestyle play a role in the spread of infectious diseases. People today are more sexually active. Not only are they having sex at an earlier age, they are more apt to have multiple partners. The result has been the spread of AIDS and other sexually-transmitted diseases.

Chapter Four:
What Have We Learned?

Narrator

What have we learned from all these experiences? One thing is that we are now less arrogant about our own power to control the forces of nature. We've learned that microbes are very adaptable. As we change, they change in response. In essence, these tiny, brainless organisms can outwit us through their extraordinary ability to rapidly evolve and reproduce.

Video Script

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We've learned that our actions often have unintended effects. While antibiotics have—at least temporarily—freed us from the fears of many kinds of bacterial infections, their widespread use has led to the proliferation of powerful, resistant bacteria.

We've learned that it is impossible to separate health issues from social and environmental issues. The cutting down of rainforests increases the risks of exposing ourselves to previously-unknown viruses. Urbanization, war, and poverty are all conditions that affect the spread of disease.

We are not helpless. We know much more than we used to about the causes and effects of infectious diseases. It is unlikely that we will ever return to the dark ages that descended on Europe in the years of the plague. New advances in medicine may once again help us keep pace with the evolution of both new and old diseases, but it is doubtful that we will ever totally conquer the disease-causing microbes with which we share our environment.

We may only be able to find better ways to coexist with them.

Student Sheets

Student Activity 1

Some people argue that ours is a drug-oriented culture. This video documents the misuse of antibiotics. As negative information about antibiotics mounts, many people are turning to herbal remedies as alternatives.

Research some of the 50 antibacterial herbs such as peppermint (an ingredient found in many toothpastes), garlic, licorice, and echinacea. How have cultures used these and other medicinal plants? Contact several physicians and homeopathic practitioners. Compare their opinions: Do they feel that bacteria build the same resistance to herbs as they do to more powerful antibiotic drugs?

Student Activity 2

The cause of infectious diseases is linked to bacteria and viruses. However, according to French physiologist Claude Bernard, "The pathogen is nothing, the milieu is everything." We are learning that it is not the presence or absence of microorganisms, but rather the state of our defense mechanisms that determines the likelihood of infection.

Research the ways our immune system works and develop a personal plan for staying in good health.

Student Activity 3

Not all bacteria are harmful. While some are pathogens, others help keep nitrogen in the soil or perform decomposition functions making them essential players within ecosystems. Others are needed to produce foods like cheese, milk, and yogurt.

Research the kingdom *Monera* and identify the different kinds of bacteria and their respective roles in the biosphere.

Student Activity 4

Contact the following organizations and ask them for their position on the agricultural use of antibiotics:

Alliance for Prudent Use of Antibiotics
P.O. Box 1372
Boston, MA 02117-1372
(617) 956-6765

Natural Resources Defense Council
40 W. 20th Street
New York, NY 10011
(212) 727-4400

National Cattleman's Association
P.O. Box 3469
Englewood, CO 80155
(303) 694-0305

Poultry Science Association
309 W. Clark Street
Champaign, IL 61820
(217) 356-3182

National Pork Producers Council
P.O. Box 10383
Des Moines, IA 50306
(515) 223-2600

Student Activity 5

Interview your family doctor to get his or her point of view about the use and misuse of antibiotics.

Has he/she seen a change in diseases like strep throat over the last five years?

Does he/she see a connection to bacterial resistance?

What are his/her suggestions regarding the use of antibiotics?

Student Activity 6

Stage a mock international conference to investigate the effects of global population growth on the emergence of new diseases. Include discussion on urbanization, global warming and shifts in predator/prey relationships. Examine the problem from each of these perspectives:

MEDICAL

ECOLOGICAL

PUBLIC HEALTH

HISTORICAL

INTERNATIONAL RELATIONS

ECONOMIC

RELIGIOUS

Student Activity 7

Explore the relationship between *per capita* income, population, housing, urbanization and the rise of infectious disease in the following countries: United States, Egypt, Brazil, Mexico, China, Japan and India.

How do improvements in housing, sewage, water quality, insect control and garbage collection impact the spread of disease?

How are these measures made difficult by the economics of Third World countries?

Student Activity 8

Write an essay on the meaning of this quote by microbiologist René Dubos:

> *When the tide is receding from the beach it is easy to have the illusion that one can empty the ocean by removing water with a pail.*

What is its relevance to our scientific efforts to halt the spread of infectious disease?

Glossary

ADAPTATION—evolutionary changes (genetic modifications, including changes in structure, function or behavior) that allow populations to be better able to exist under prevailing environmental conditions.

AIDS—Acquired Immune Deficiency Syndrome. A fatal sexually transmitted infection caused by the HIV virus. The virus slowly destroys the function of the body's immune protective system, leading to uncontrollable infections, brain damage and other destructive body processes.

AMOXYCILLIN—an antibiotic commonly prescribed for children's ear infections.

ANTIBIOTICS—A chemical substance with the ability to inhibit or destroy bacteria and other harmful microorganisms.

ANTIBODIES—special substances formed by our bodies to help fight off foreign invaders such as viruses.

BACTERIA—one-celled plantlike microorganisms often classified by shape (spherical, spiral, rod like, or comma shaped). Some bacteria perform essential decomposition functions within ecosystems. Others can enter the body and cause infections and diseases.

BUBONIC PLAGUE—an infectious disease transmitted by bacteria carried by fleas; it wiped out 1/3 of Europe's population between 1346 and 1350.

CHROMOSOMES—groups of molecules within the cell nucleus that contain hereditary material (DNA and RNA; directing an organism's size, shape, growth and function.

CONJUGATION—the process through which bacterium attaches to another bacterium, making a copy of genetic material which may have the genes for resistance to antibiotics.

DNA—deoxyribonucleic acid. A complex substance found in every cell of the body, containing all the genetic material necessary for guiding all gene-directed processes in a living thing.

EBOLA—a virus attacking the body's tissues and organs.

ENTEROCOCCUS—a type of bacteria resistant to all antibiotics.

EPIDEMIC—an outbreak of disease spreading rapidly and affecting a large portion of a population at one time.

GENE—portions of DNA molecules which carry a "code" of information passed on from one generation of the cell to the next.

GERMS—microscopic organisms such as bacteria and viruses.

GONORRHEA—a sexually transmitted disease transferred by bacteria.

HIV—the virus that causes AIDS.

Glossary

continued

IMMUNE SYSTEM—a system of the body composed of various white blood cells, proteins, antibodies and other chemicals that recognize foreign substances in the body and attack them to immobilize or destroy them; the body's first and main line defense against infections.

INFECTION—a harmful inflammatory condition caused by the entrance of disease-producing germs into body tissues.

KAPOSI'S SARCOMA—a type of skin cancer associated with AIDS.

MALARIA—an infectious disease transmitted by mosquitoes carrying tiny parasites attacking the body's red blood cells.

MICROBE—a microorganism, an organism that can only be seen with the aid of a microscope, especially a bacterium producing disease.

MUTATION—an inheritable change in a cell or virus caused spontaneously or by known outside influences.

PENICILLIN—first in a series of antibiotics, antibacterial drugs that work by attacking the cell wall of bacteria, causing it to burst.

PLASMIDS—small rings of DNA.

PNEUMOCYSTIS CARNII—a rare kind of pneumonia associated with AIDS.

PROTOZOANS—single-celled animal-like microorganisms that can cause diseases such as malaria, dysentery, African Sleeping Sickness.

RESISTANCE—an adaptive change in certain bacteria, through the presence of a mutant gene, that makes them unresponsive to antibiotic drugs.

SALMONELLOSIS—common infectious disease in US, called food poisoning, caused by salmonella bacteria.

SMALL POX—infectious disease spread through touch or respiration, believed to have been present as early as A.D. 165 and credited with the decline of the Aztec civilization because New World cultures had not developed an immunity to the disease.

STAPHYLOCOCCUS—a virulent bacteria that has become resistant to antibiotics.

VACCINATION—injection of weakened or killed virus or bacterium which stimulates an immune response and works to prevent the disease.

VACCINE—a fluid containing a weakened form of a particular virus, which is injected into the body to give immunity from disease caused by that virus.

VIRUS—the simplest living organisms, tiny particles lacking cell structure and consisting only of genetic material encased in protein. Viruses can only reproduce inside a host cell and are capable of manipulating the host cell to promote their own reproduction. Many infectious diseases—AIDS, polio, rabies and smallpox—are caused by viruses.

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