Lesson Overview

20.3 Diseases Caused by Bacteria and Viruses
THINK ABOUT IT

We share this planet with prokaryotes and viruses, and most of the time we are never aware of our relationships with them.

Often, these relationships are highly beneficial, but in a few cases, sharing simply doesn’t work—and disease is the result.
Bacterial Diseases

How do bacteria cause disease?
Bacterial Diseases

- How do bacteria cause disease?

  - Bacteria cause disease by destroying living cells or by releasing chemicals that upset homeostasis.
Bacterial Diseases

Microorganisms—viruses and prokaryotes—that cause disease are called **pathogens**.

At the present time, all known prokaryotic pathogens are bacteria. However, in the future scientists may discover archaea associated with disease.

Louis Pasteur helped to establish what has become known as the *germ theory of disease* when he showed that bacteria were responsible for a number of human and animal diseases.
Disease Mechanisms

Bacteria produce disease in one of two general ways.

Some bacteria destroy living cells and tissues of the infected organism directly, while some cause tissue damage when they provoke a response from the immune system.

Other bacteria release toxins (poisons) that interfere with the normal activity of the host.
Disease Mechanisms

Some common human bacterial diseases are shown in this table.

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Damaging Host Tissue

One example of a bacterial pathogen that damages host tissue is the bacterium that causes tuberculosis.

This pathogen is inhaled into the lungs, where its growth triggers an immune response that can destroy large areas of tissue.

The bacterium also may enter a blood vessel and travel to other sites in the body, causing similar damage.
Releasing Toxins

Bacteria that produce toxins include the species that causes diphtheria, and the species responsible for a deadly form of food poisoning known as botulism.

Diphtheria has largely been eliminated in developed countries by vaccination, but outbreaks of botulism still claim many lives.
Controlling Bacteria

Although most bacteria are harmless, and many are beneficial, the everyday risks of any person acquiring a bacterial infection are great enough to warrant efforts to control bacterial growth.

Various control methods are used.
Physical Removal

Washing hands or other surfaces with soap under running water doesn’t kill pathogens, but it helps dislodge both bacteria and viruses.
Disinfectants

Chemical solutions that kill bacteria can be used to clean bathrooms, kitchens, hospital rooms, and other places where bacteria may flourish.
Food Storage

Low temperatures, like those inside a refrigerator, will slow the growth of bacteria and keep most foods fresher for a longer period of time than possible at room temperature.
Food Processing

Boiling, frying, or steaming can sterilize many kinds of food by raising the temperature of the food to a point where bacteria are killed.
Sterilization by Heat

Sterilization of objects such as medical instruments at temperatures well above 100° Celsius can prevent the growth of potentially dangerous bacteria.

Most bacteria cannot survive such temperatures.
Preventing Bacterial Diseases

Many bacterial diseases can be prevented by stimulating the body’s immune system with vaccines.

A *vaccine* is a preparation of weakened or killed pathogens or inactivated toxins.

When injected into the body, a vaccine prompts the body to produce immunity to a specific disease.

Immunity is the body’s ability to destroy pathogens or inactivated toxins.
Treating Bacterial Diseases

A number of drugs can be used to attack a bacterial infection. These drugs include antibiotics—such as penicillin and tetracycline—that block the growth and reproduction of bacteria.

Antibiotics disrupt proteins or cell processes that are specific to bacterial cells. In this way, they do not harm the host’s cells.

Antibiotics are not effective against viral infections.
Viral Diseases

How do viruses cause disease?
Viral Diseases

How do viruses cause disease?

Viruses cause disease by directly destroying living cells or by affecting cellular processes in ways that upset homeostasis.
Viral Diseases

Like bacteria, viruses produce disease by disrupting the body’s normal homeostasis.

Viruses produce serious animal and plant diseases as well.
Viral Diseases

Some common human viral diseases are shown in the table.

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<td>Sneezing, sore throat, fever, headache, muscle aches</td>
<td>Contact with contaminated objects; droplet inhalation</td>
</tr>
<tr>
<td>Influenza</td>
<td>Body aches, fever, sore throat, headache, dry cough, fatigue, nasal congestion</td>
<td>Flu viruses spread in respiratory droplets caused by coughing and sneezing.</td>
</tr>
<tr>
<td>AIDS</td>
<td>Helper T cells, which are needed for normal immune-system function, are destroyed.</td>
<td>Contact with contaminated blood or bodily fluids; mothers can pass it to babies during delivery or during breastfeeding.</td>
</tr>
<tr>
<td>Chicken pox</td>
<td>Skin rash of blisterlike lesions</td>
<td>Virus particles are spread in respiratory droplets caused by coughing and sneezing; highly contagious</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>Jaundice, fatigue, abdominal pain, nausea, vomiting, joint pain</td>
<td>Contact with contaminated blood or bodily fluids</td>
</tr>
<tr>
<td>West Nile</td>
<td>Fever, headache, body ache</td>
<td>Bite from an infected mosquito</td>
</tr>
<tr>
<td>Human papillomavirus (HPV)</td>
<td>Genital or anal warts, also cancer of the cervix, penis, and anus</td>
<td>Sexual contact</td>
</tr>
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Disease Mechanisms

In many viral infections, viruses attack and destroy certain cells in the body, causing the symptoms of the associated disease.

Poliovirus, for example, destroys cells in the nervous system, producing paralysis.

Other viruses cause infected cells to change their patterns of growth and development, sometimes leading to cancer.
Preventing Viral Diseases

In most cases, the best way to protect against most viral diseases lies in prevention, often by the use of vaccines.

Many vaccines have been developed in the last three centuries. Today, there are vaccines against more than two dozen infectious diseases.
INNOVATIONS IN VACCINES

1769 Edward Jenner performs the first inoculation against smallpox, using the less harmful but similar cowpox virus.

1880s Louis Pasteur develops vaccines against anthrax and rabies.

1923 Albert Calmette and Camille Guerin develop a vaccine against tuberculosis.

Before vaccine development, the Red Cross made the public aware of the threat of tuberculosis using posters such as this one, circa 1919.
INNOVATIONS IN VACCINES

1950s Jonas Salk develops a polio vaccine that uses killed viruses. Albert Sabin develops a polio vaccine that uses weakened viruses.

Before the advent of the polio vaccine, hospitals were filled with polio-stricken children in machines called iron lungs, which helped them breathe.
INNOVATIONS IN VACCINES

1981 A vaccine against hepatitis B that uses recombinant DNA gains government approval.

2006 A vaccine against human papillomavirus, a virus known to cause certain cancers, gains approval.
Preventing Viral Diseases

Recent studies show that cold and flu viruses are often transmitted by hand-to-mouth contact.

Effective ways to help prevent infection include washing your hands frequently, avoiding contact with sick individuals, and coughing or sneezing into a tissue or your sleeve, not into your hands.
Treating Viral Diseases

Unlike bacterial diseases, viral diseases cannot be treated with antibiotics.

In recent years, limited progress has been made in developing a handful of antiviral drugs that attack specific viral enzymes that host cells do not have.

These treatments include an antiviral medication that can help speed recovery from the flu virus and another that may—in certain instances—prevent HIV.
Emerging Diseases

Why are emerging diseases particularly threatening to human health?
Emerging Diseases

Why are emerging diseases particularly threatening to human health?

The pathogens that cause emerging diseases are particularly threatening to human health because human populations have little or no resistance to them, and because methods of control have yet to be developed.
Emerging Diseases

If pathogenic viruses and bacteria were unable to change over time and evolve, they would pose far less of a threat than they actually do.

Unfortunately, the short time between successive generations of the pathogens allows them to evolve rapidly, especially in response to human efforts to control them.

An unknown disease that appears in a population for the first time or a well-known disease that suddenly becomes harder to control is called an **emerging disease**.
Emerging Diseases

This map shows locations worldwide where specific emerging diseases have broken out in recent years.

In recent years, new diseases, such as severe acute respiratory syndrome (SARS) in Asia, have appeared. At the same time, some diseases thought to be under control have come back.
Emerging Diseases

Changes in lifestyle and commerce have made emerging diseases even more of a threat.

High-speed travel means that a person can move halfway around the world in a day.

Huge quantities of food and consumer goods are now shipped between regions of the world that previously had little contact with each other.

Human populations that were once isolated by oceans and mountain ranges are now in close contact with more developed parts of the world.

The possibility of the rapid spread of new diseases is a risk of every trip a person takes and every shipment of food or goods.
Emerging Diseases

Because of their sudden appearance and resistance to existing control methods, emerging diseases are of particular concern.

Deeper understanding of the functions of the molecular structures and genetics of bacteria and viruses will be one key to defending against them.
“Superbugs”

When first introduced in the 1940s, penicillin, an antibiotic derived from fungi, was a miracle drug. Patients suffering from life-threatening infections were cured almost immediately by this powerful new drug.

Within a few decades, however, penicillin lost much of its effectiveness, as have other, more current antibiotics.

The culprit is evolution.
“Superbugs”

The widespread use of antibiotics has led to a process of natural selection that favors the emergence of resistance to these powerful drugs.

Physicians now must fight “superbugs” that are resistant to whole groups of antibiotics and that transfer drug-resistant genes from one bacterium to another through conjugation.
“Superbugs”

An especially dangerous form of multiple drug resistance has recently appeared in a common bacterium. Methicillin-resistant *Staphylococcus aureus*, known as MRSA, can cause infections that are especially difficult to control.

MRSA skin infections can be spread by close contact, including the sharing of personal items such as athletic gear, and are especially dangerous in hospitals, where MRSA bacteria can infect surgical wounds and spread from patient to patient.
“Superbugs”

Infection by MRSA can be very serious or fatal for people in hospitals and nursing homes who have weakened immune systems.

This table shows the incidence of MRSA infections in U.S. hospitals during a 13-year period.

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<tr>
<th>Year</th>
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<tbody>
<tr>
<td>1993</td>
<td>1900</td>
</tr>
<tr>
<td>1995</td>
<td>38,100</td>
</tr>
<tr>
<td>1997</td>
<td>69,800</td>
</tr>
<tr>
<td>1999</td>
<td>108,600</td>
</tr>
<tr>
<td>2001</td>
<td>175,000</td>
</tr>
<tr>
<td>2003</td>
<td>248,300</td>
</tr>
<tr>
<td>2005</td>
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New Viruses

Because viruses replicate so quickly, their genetic makeup can change rapidly, sometimes allowing a virus to jump from one host species to another.

Researchers have evidence that this is how the virus that causes AIDS originated, moving from nonhuman primates into humans.
New Viruses

Public health officials are especially worried about the flu virus.

Gene shuffling among different flu viruses infecting wild and domesticated bird populations has led to the emergence of a “bird flu” that is similar in many ways to the most deadly human versions of flu.

Only very slight genetic changes may be needed for the bird flu virus to make the jump to humans, where there would be little natural resistance to it.
Prions

In 1972, Stanley Prusiner became interested in scrapie, an infectious disease in sheep, the exact cause of which was unknown.

Experiments revealed clumps of tiny protein particles in the brains of infected sheep. Prusiner called these particles prions, short for “protein infectious particles.”

Prions are misfolded proteins in the brain that cause a chain reaction of misfolding in other normal proteins they contact, eventually clogging the brain tissue and causing disease.

Many animals, including humans, can become infected with prions.
Prions

How prions cause disease is similar in some ways to a viral infection.

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