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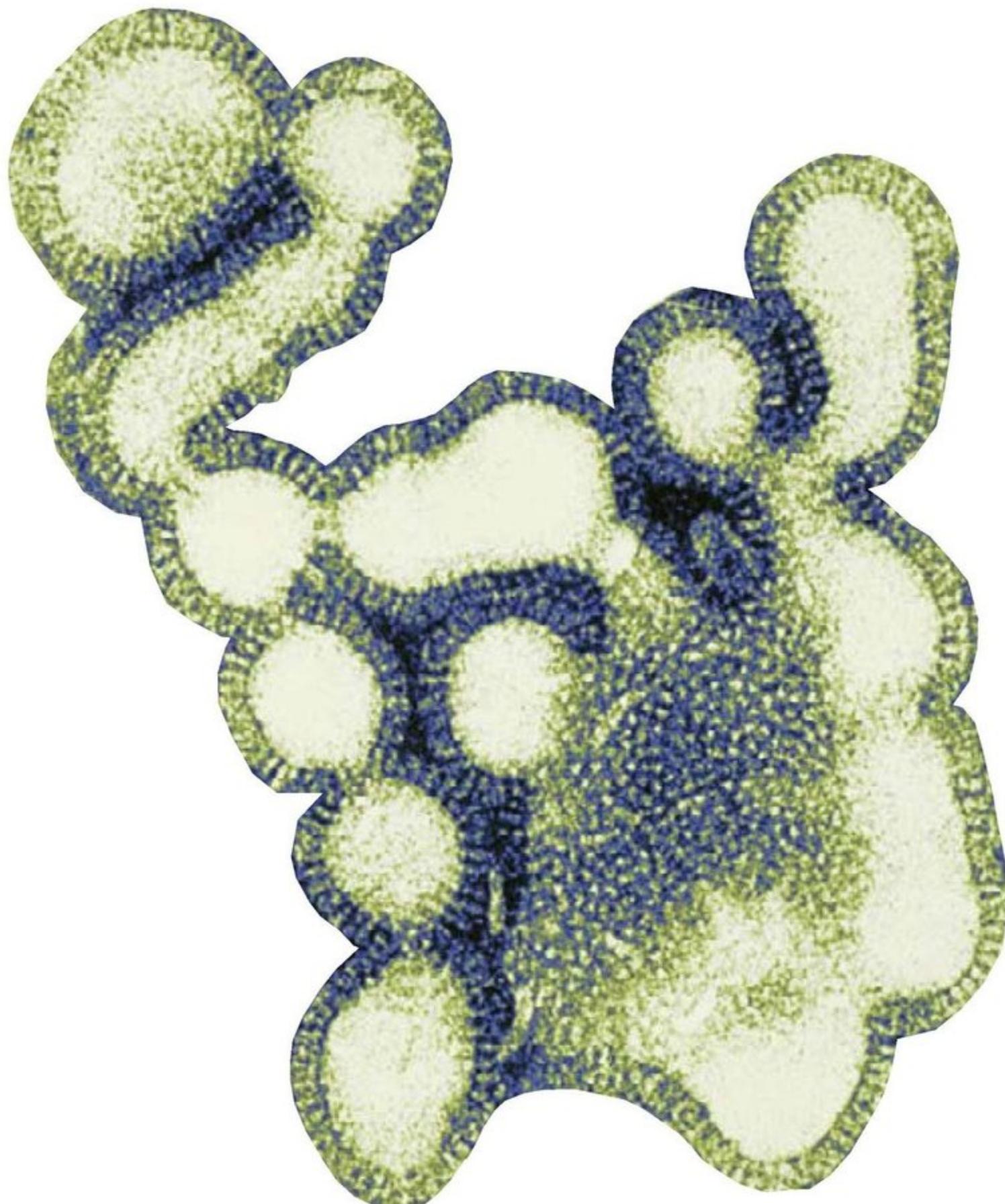
# Microbes: Friend or Foe?



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Written by Lisa Ing  
Illustrated by Cende Hill

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Air coming out of the mouth from a sneeze may travel as fast as 120 kph (75 mph).

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## Introduction

*Achoo!* A sudden sneeze is often the first sign, or **symptom**, that you're getting sick. But it isn't just the sneezing. You're also coughing, you're tired, and your throat is sore. Whatever your symptoms are, they have probably been caused by an **infection** from a type of tiny **microbe**—a germ. But how did you “catch this bug,” or become infected—and what's a microbe, anyway?

Long ago, every sickness was a mystery. Doctors and medical schools didn't exist, and people often died from a simple illness, a minor injury, or a mild infection. Before scientists began to study disease and health, many superstitious people imagined they were being cursed by a witch or punished for something. Because no one knew about, or understood, what really caused any illness or how it was spread, no one knew how to prevent, or treat, a **disease**.

After years of scientific research and discovery, we now know that a variety of microbes can make us sick. But what are these microbes? Where are they found? Are all microbes bad? Can learning about them help us to stay healthy and prevent diseases?



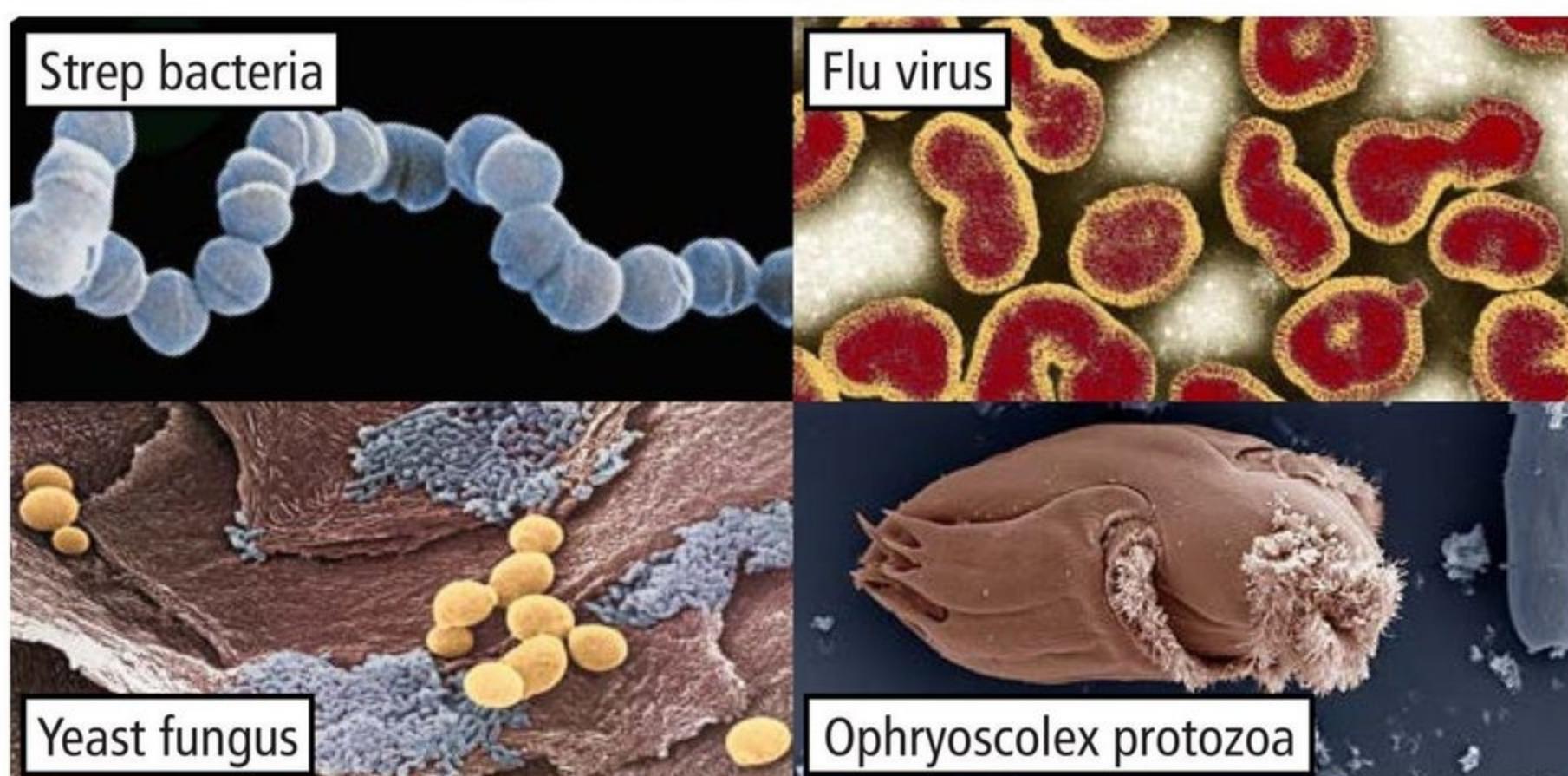
Doctors often used leeches to treat illnesses.

## What Are Microbes?

Microbes are tiny, almost invisible, living **organisms**. They are so small that they can only be seen with a powerful **microscope**. These tiny organisms exist all around us. They are riding on the air we breathe, clinging to every surface we touch, sitting on our skin and on our shoes, and hiding inside of our bodies. They are everywhere!

Microbes multiply quickly inside our bodies, in our cells. **Cells** are small units of living matter that help us to stay healthy and grow. Our cells join together, almost like pieces of a puzzle. We have blood cells and bone cells, stomach cells, skin cells, and muscle cells. There are trillions of cells inside of us, and they all have important, health-protecting jobs to do. An unwelcome invasion of microbes can interfere with our cells' functions—and some can cause disease.

### Different kinds of microbes



# Louis Pasteur

Modern medicine owes a lot to Louis Pasteur (pas-TUR). He proved the Germ Theory of Disease, which states that contact with harmful microbes is the cause of disease.

Pasteur's most important discovery was that heating a sealed canister filled with food to a specific temperature for a certain length of time would kill many organisms inside. This heating process is called *pasteurization*. Today it is used on fresh milk and canned food.


$$1 = 3 + 5 + 2 = 10 - 4 + 10 \div 2 = 14 \times 2 - 3 = 25 - 5 - 5 \times 2 = 17 + 3 \times 2 - 20 \div 2 - 1$$

## Math Minute

To pasteurize milk, the milk is heated to 145 degrees Fahrenheit (62.8°C) for 30 minutes, or to 163 degrees Fahrenheit (72.8°C) for 15 seconds. How much quicker in seconds is it to pasteurize milk at the higher temperature?

# The Immune System

Our body's **immune system** is designed to protect us from harmful microbes. It's made up of individually important parts that work together as a unified defense. It's a cooperative collection of all the different types of cells, glands, and tissues that form the structure of our bodies.

## Math Minute

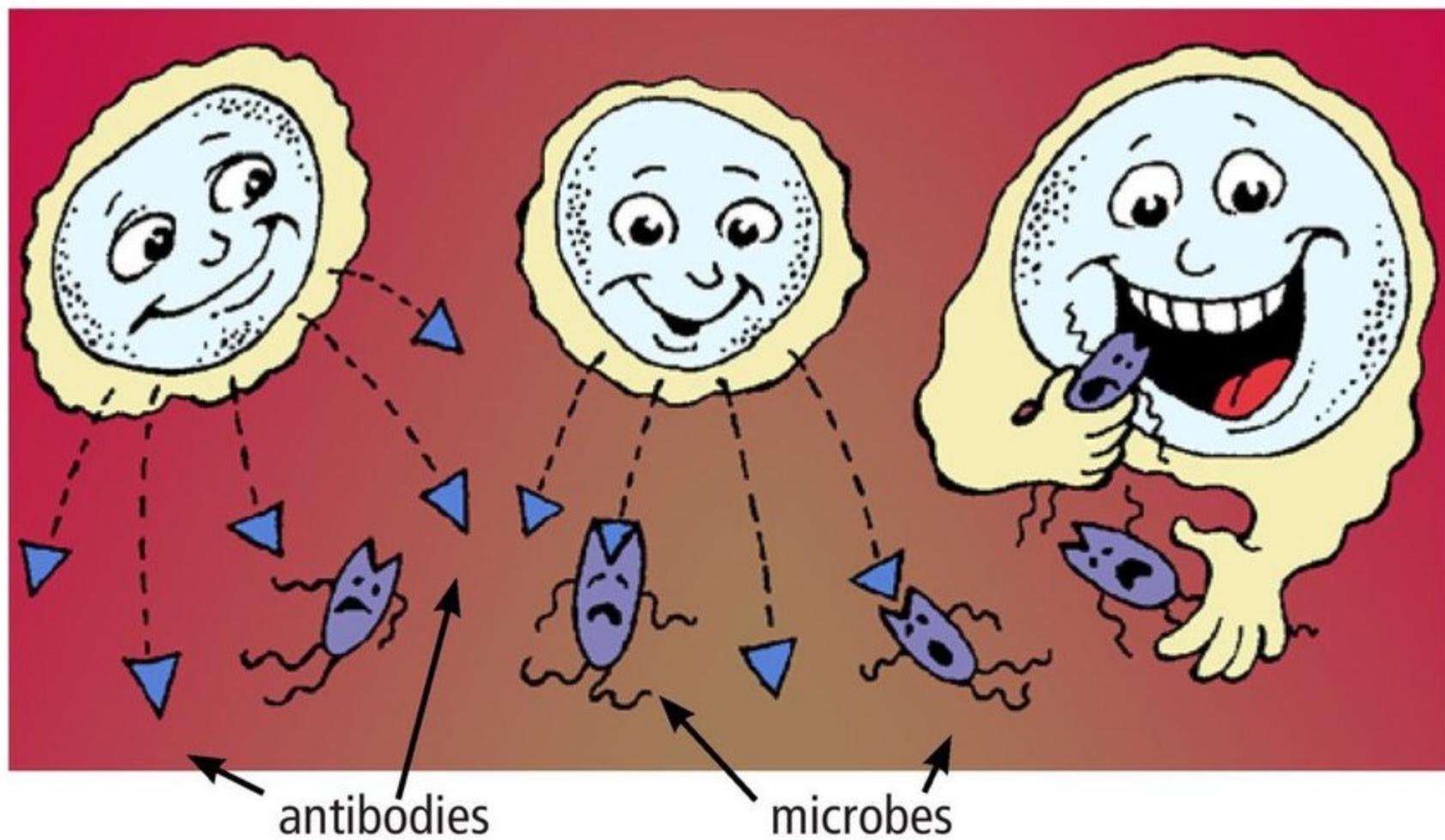
Some microbes can double their population every 20 minutes. If you start out with 1 microbe, how many microbes will you have after 4 hours?

*Hint: Start with 1 microbe at 0 minutes.*

Its ability to “remember” microbes is our immune system’s best weapon against them. The immune system knows which microbes it’s looking for. It recognizes the ones that cause problems. It remembers what defenses worked against them the last time they attacked—and fights them off. If you had the mumps or the measles when you were younger, your immune system has remembered those microbes. It’s unlikely that you will get sick from mumps or measles a second time.

## Do You Know?

One drop of blood contains between 7,000 and 25,000 white blood cells. These cells attack invading microbes in different ways. Some white blood cells produce antibodies that cancel out the microbe's chemicals, while others surround the microbe and destroy it.



So, how do our immune systems manage to keep out the troublemaking microbes? Outside, our skin forms a protective shield that covers us completely. It's important to clean, disinfect, and bandage cuts or scrapes to our skin so microbes can't enter the cut and cause an infection. Underneath our skin, there are microbe-hunting white blood cells that travel through our blood vessels. They find and destroy millions of harmful, **invading** microbes every day. White blood cells are the natural enemy of disease-causing microbes.

## Four Groups of Microbes

### *Bacteria*

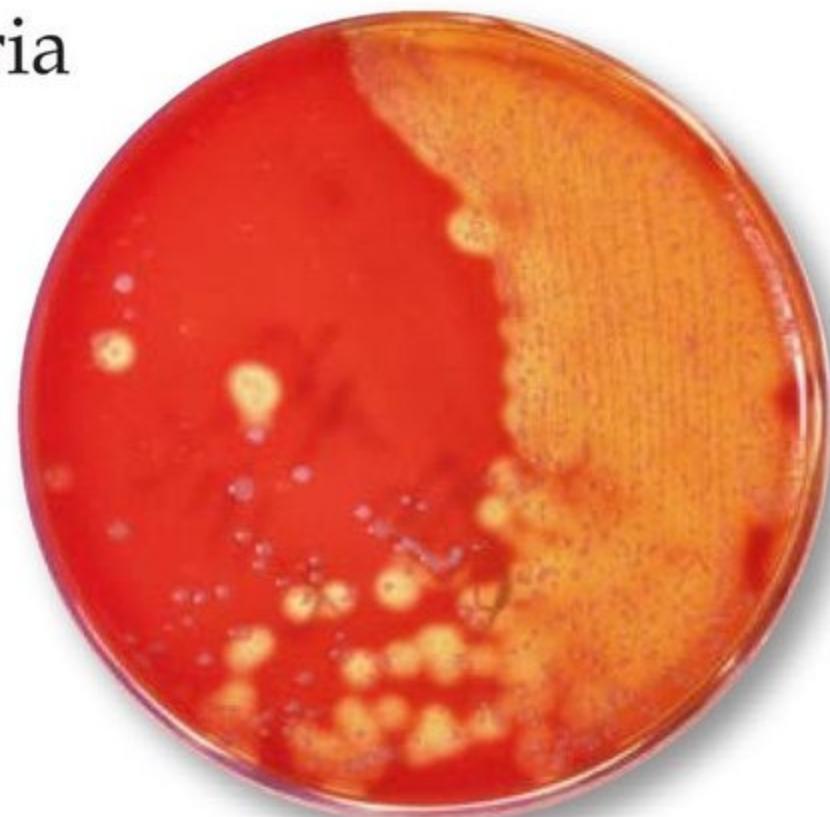
Bacteria (back-TEER-ee-uh) are everywhere and on everything—and they're tough. Some can thrive in barren ice, others in extreme heat. As with other microbes, some bacteria are good for us, and some aren't. There are more types of bacteria than there are types of any other organisms on Earth. By sheer population count, bacteria rule!



#### Fun Food Fact

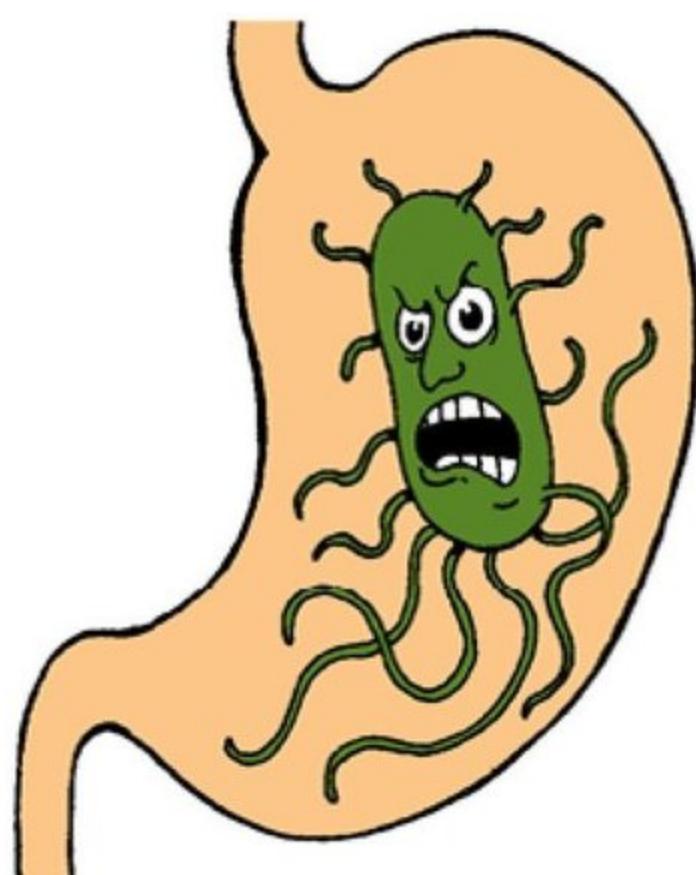
Several types of bacteria help change milk into yogurt and sour cream. These bacteria eat lactose, or milk sugars, and release lactic acid, which curdles the milk and makes it more solid. The lactic acid gives yogurt and sour cream a tangy, sour flavor.

One type of good bacteria lives in our intestines. It helps to break down and digest the food we eat, and we couldn't live without it. Nasty strep throat bacteria can cause a painful sore throat, a fever, a headache, an upset stomach, and tender, swollen glands in the neck. White spots of pus appear on the back of the throat.



Scientists sometimes grow bacteria on purpose so that they can study them. Here, strep throat bacteria grow in a dish filled with a liquid that provides food and a safe environment.

Food poisoning can make us very sick, as well. It's usually caused by harmful bacteria that live on, or in, many uncooked foods. Cooking food to the right temperature kills those bacteria. But there are other bacteria that live on the surfaces where we prepare food every day, and on our hands. Food poisoning often causes an upset stomach, vomiting, and diarrhea.

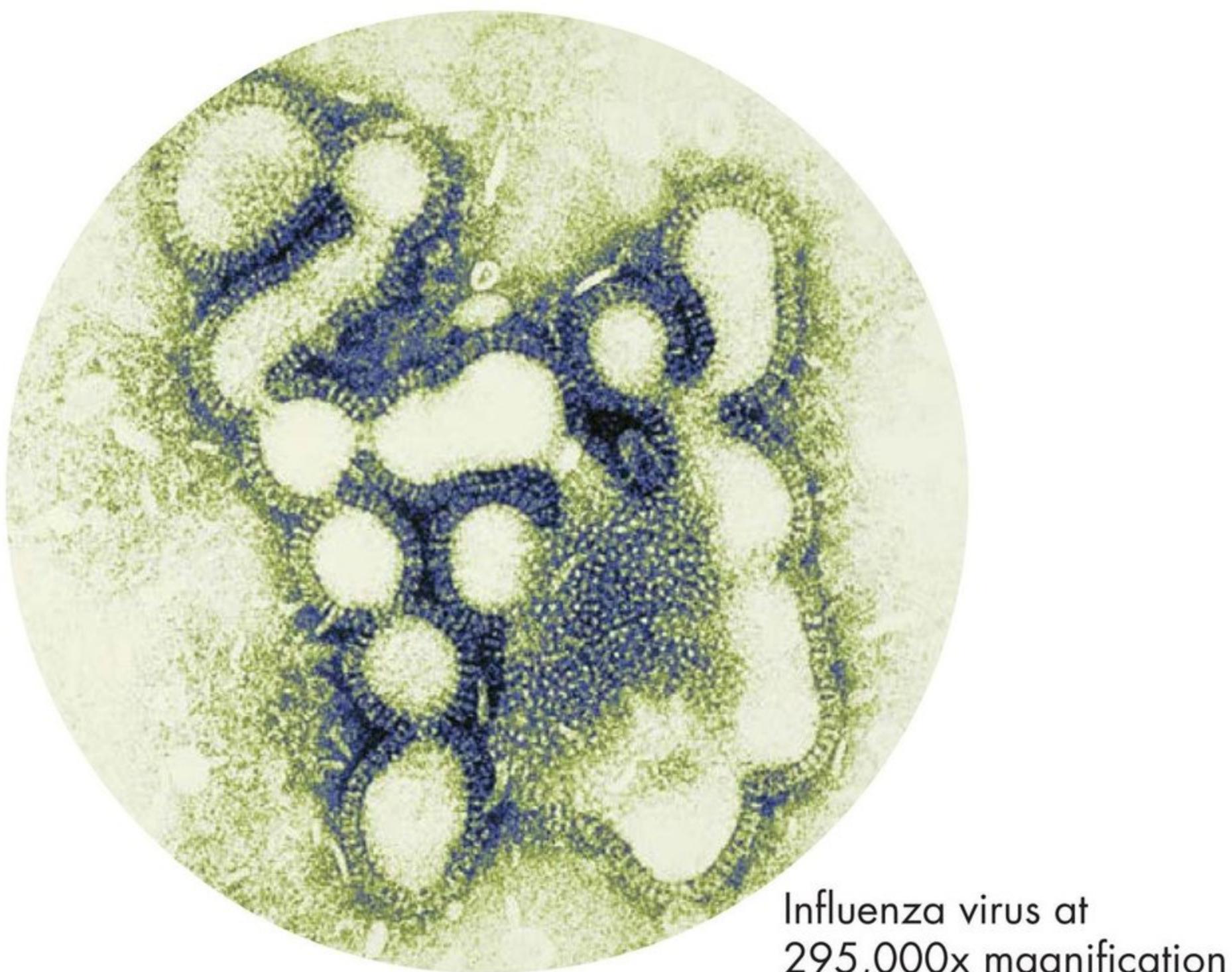


Salmonella is the bacteria responsible for many cases of food poisoning.

## *Viruses*

**Viruses** (VY-russ-es) can be difficult to get rid of. A virus will invade the cells of people or other animals and spread quickly from cell to cell, causing an infection. Viruses not only make people sick, some viruses can cause death. And sometimes a virus can avoid detection by our watchful immune system.

A virus has the ability to **mutate**, or change its identity, to avoid being noticed. This ability to change makes it more difficult to find the virus and stop it. The flu, chicken pox, HIV, and the common cold are each caused by a virus.



Scientists are looking at ways to use viruses to help people get healthy, too. Viruses take control of the cells they invade and tell them what to do. If a cell started multiplying out of control, a scientist might be able to use a virus to tell the cell to slow down its growth. This treatment is being studied as a way to fight cancer, a disease in which cells grow out of control.

### Do You Have a Common Cold or the Flu?

| Symptoms                    | Common Cold  | Flu                               |
|-----------------------------|--------------|-----------------------------------|
| Headaches                   | No           | Yes                               |
| Fever                       | None or Mild | High Fever,<br>102–104°F for days |
| Muscle Aches<br>& Tiredness | Sometimes    | Yes                               |
| Sore Throat                 | Yes          | Sometimes                         |
| Runny Nose                  | Yes          | Sometimes                         |
| Sneezing                    | Yes          | Sometimes                         |
| Coughing                    | Yes          | Yes                               |
| Chills                      | No           | Yes                               |

## *Fungi*

There are many different types of fungi (FUN-guy). Some, like mushrooms, look like plants. But the microscopic type of harmful fungi that invade our body cause irritating, common infections like ringworm and athlete's foot. Ringworm causes a wormlike, itchy, red ring to appear on the skin. Athlete's foot fungi attack the bottoms of feet and area between the toes, causing the irritated skin to itch, crack, and peel.

## *Protozoa*

Protozoa (pro-toe-ZOE-uh) are simple, single-celled organisms that often live in streams, ponds, and dirty water. We need to be careful about the water we drink. If protozoa get into your body, they can cause nausea, vomiting, and mouth infections.

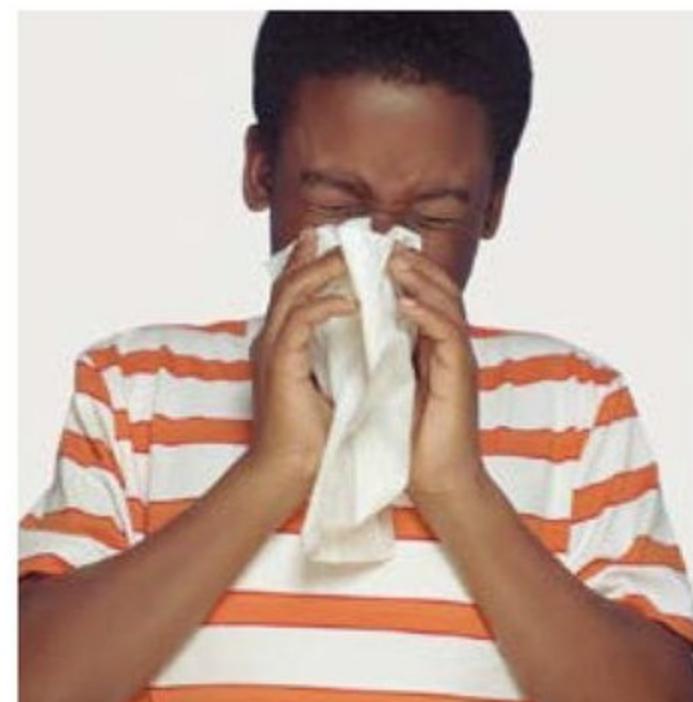


Mosquitoes can transfer diseases like malaria and West Nile virus from person to person.

One serious protozoa infection is spread by saliva from the bite of an infected mosquito. This protozoa microbe enters the person's blood, through the bite, and causes a disease called malaria. Malaria occurs most often in areas that have hot, tropical climates. This infection causes a high fever, weakness, and delirium, and it kills a million people every year.

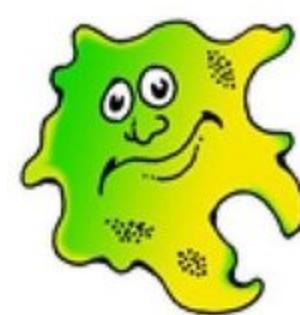
## How Do Microbes Spread Infection?

Think about the times when you have been in a crowded place, near someone who is sneezing or coughing. You know they are spreading germs, and you wish they'd stayed at home. Most diseases are spread by our contact with an infected, or sick, person. Many infection-causing microbes live in bodily fluids such as saliva, blood, and nasal mucus. These fluids make it easy for microbes to transfer an infection from one person to another. Besides the germs that are coughed into the air, you can pick up germs if you handle something that has been touched and **contaminated** by someone who is sick.



There are also several harmful microbes that can infect an insect or other animal first; then that infection can be passed to a human. We can get rabies from infected mammals such as dogs, raccoons, and skunks; and salmonella may be on chickens, birds, fish, and reptiles. Besides malaria, infected mosquitoes can also give us West Nile virus. Sick birds can transfer a serious avian flu, and Lyme disease comes from the bite of an infected tick.

Tissues help keep germs from spreading.



## Outbreaks and Epidemics

Diseases can be spread quickly. One sick person can infect dozens—and dozens of sick people can then infect hundreds more. It's even possible for people to infect others long before they know that they themselves are sick. A person who shows no signs of a disease, but who still infects others, is sometimes referred to as a “healthy carrier” and can be hard to find, isolate, and treat.

When a small group of people in the same place all get the same disease, it's called an **outbreak**. When an outbreak of disease rapidly spreads to a large number of people, it's called an **epidemic**. When an epidemic quickly spreads to infect larger groups of people around the world, it's called a **pandemic**.

A local outbreak of a disease is no longer expected to stay in one place. Disease-carrying microbes are hitchhikers, and they go wherever people go. Modern transportation, such as buses, trains, and airplanes, carry both people and their germs quickly. Sick travelers can infect any person they encounter during their trip. Then the people they just infected can start a separate outbreak in another place.

## Fighting Microbes with Vaccines

No one likes to get shots but they're important. A **vaccine** treatment is a way to plan ahead to prevent a disease. The job of a vaccine is to help build up our immune system's ability to recognize and fight off a disease-causing microbe. Many of these powerful vaccines are made from weakened, tiny bits of the harmful virus or bacteria itself.

### Do You Know?

When Europeans and Africans carried smallpox microbes to the Americas, none of the Native Americans had ever been exposed to the disease. They had no immunity to it. As a result, smallpox killed millions. In South and Central America, nine out of ten people in the largest native cities died from smallpox.

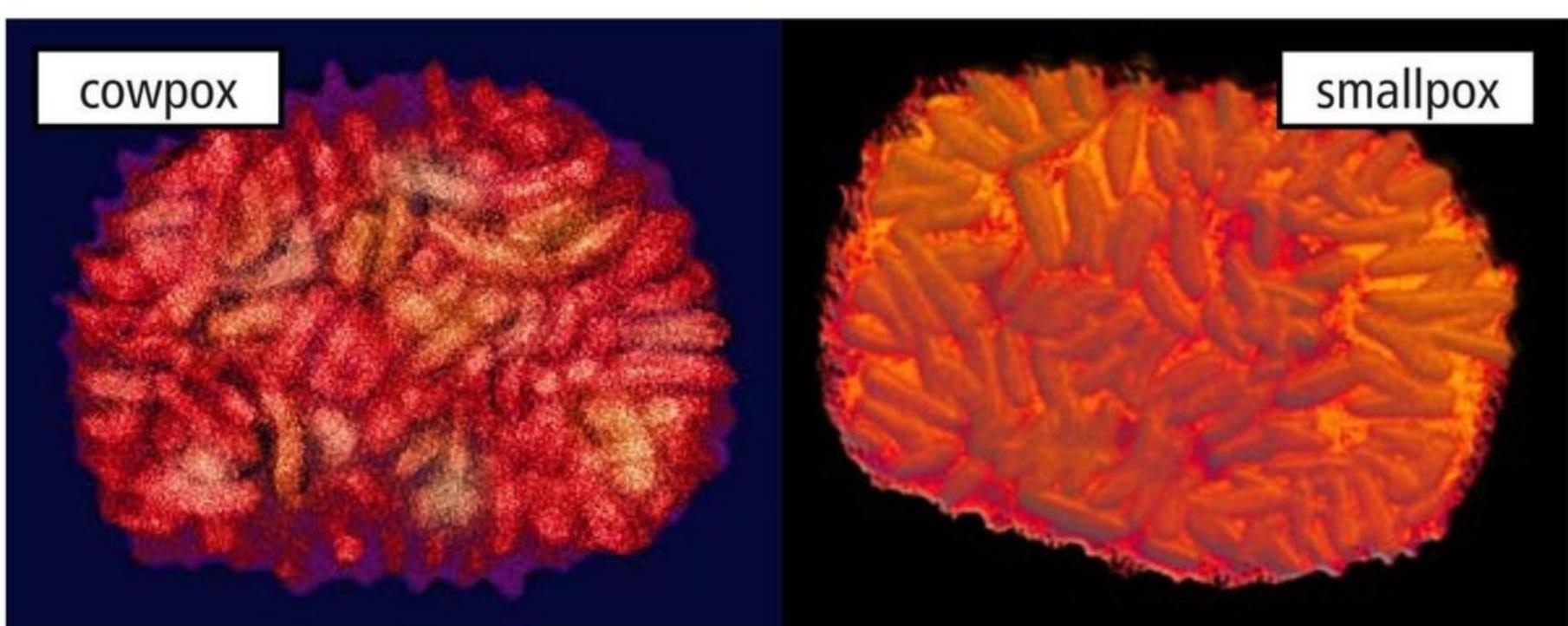
The idea of using a virus to prevent a disease, or to use a mild disease to prevent a worse disease, was first thought of about two hundred years ago in England. Dr. Edward Jenner treated many farm workers who caught a mild pox disease called cowpox. He also treated severe cases of deadly smallpox. Over time, Dr. Jenner noticed that people who had once been sick with cowpox never got the other pox disease, smallpox. But why? Smallpox is one of the deadliest diseases in the world, and it is highly infectious. Epidemics of smallpox killed many thousands of people.



Dr. Edward Jenner

Dr. Jenner realized that cowpox and smallpox must be related diseases, like being cousins from the same family. He became certain that having a case of cowpox must somehow provide some kind of natural immunity against getting smallpox. He thought that if he purposely gave the weaker disease to people before they were exposed to smallpox, it might reduce the number of people who were dying from it.

To test his idea, he would have to ask healthy people to volunteer to become sick with cowpox—and then wait to see what happened. Amazingly, people volunteered to help him. The people he gave cowpox to were mildly sick for a while, but they recovered quickly. While they were sick, their immune systems were learning about the pox microbe and developing a way to fight it.





Vaccines can be given as shots or taken by mouth.

Jenner's idea about the relationship of the two diseases was correct. The people in his test who were given the cowpox virus as a preventive treatment did not get the deadly smallpox virus later. His use of a weak version of a disease to stop a stronger version of a similar disease saved thousands of lives. Dr. Jenner is credited with stopping smallpox around the world.

About seventy-five years after Dr. Jenner's remarkable test, Louis Pasteur discovered how to weaken microbes and introduce them into the immune system. Then, as happened with the cowpox test, the immune system had the chance to learn about that microbe. It had its defense ready if the real disease attacked. Pasteur's experiments using weakened microbes led to the creation of several preventive vaccines—such as the flu shot—that could be given to large populations of people.

## Antibiotics: The Magic Bullet

Scientists discovered that some microbes naturally fight and kill other types of microbes. They can do this without harming either healthy cells or other, helpful microbes. These special killer microbes naturally produce strong medicines called **antibiotics**. The antibiotics directly attack only the targeted infection.

Antibiotics are strong. But scientists were concerned to discover that the very strongest microbes sometimes survived an antibiotic treatment. Their research revealed several reasons why an antibiotic can fail. Sometimes the tough microbes change their identity just enough to hide from the antibiotic. In other cases, some antibiotics have become so overused, or misused, that microbes have developed a **resistance** to them. The microbe has learned to fight back. Scientists continue to research microbes and antibiotics. They try to produce new, different,

and more effective antibiotics to fight stronger, deadlier microbes.

### Do You Know?

In 1928, Dr. Alexander Fleming discovered that a common bread mold would kill bacteria. This discovery led to the world's first antibiotic, penicillin, which is still the world's most widely used antibiotic.

# Don't Spread Disease

Microbes like to travel. Microbes like crowds of people. Remember that when you're sick, it's important to stay home. Stay away from other people and rest. Doing both of these things helps your body fight harmful microbes. At the same time, it also keeps you from infecting other people.

Remember to cover it—and toss it! When you have a cold, always cover your mouth and nose with a tissue if you sneeze or cough. Then throw away the tissue in a trash can. If you don't have a tissue, cough into the side of your arm or cover your nose and mouth with your cupped hands; then wash your hands as soon as you can. If you are sick, avoid sharing food, cups, or plates with other people.



Germs, or harmful microbes, spread easily in crowded places.

# Staying Healthy

## Keep your immune system healthy

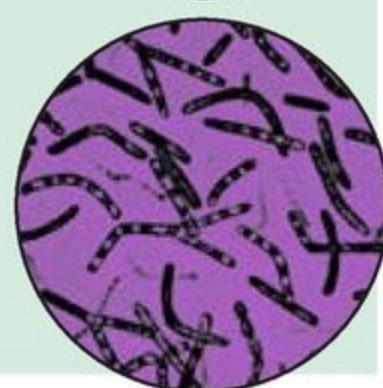
- In order to stay healthy, you must keep your immune system strong. Eat a balanced diet of nutritious foods, including fruits and vegetables, and drink lots of water. Get fresh air, exercise, and enough sleep each night.

## Preparing food

- Wash knives and cutting boards with water and soap after cutting raw meat, and never let raw meat touch cooked foods.
- Do not eat food from dented or swollen cans.
- Do not eat food that has fallen onto the floor.

## Keeping clean

- The most important microbe-fighting action is staying clean with soap and water. Eighty percent of diseases are transmitted through touch because many people do not wash their hands. If everyone washed his or her hands, we could cut down the spread of disease.
- Wash your hands after you go to the bathroom, after touching animals, and before and after you make and eat food. Wash with soap for at least fifteen seconds, or as long as it takes to hum the song “Happy Birthday” twice. Rub soap lather all over your hands, even under your fingernails. Then rinse your hands and dry them on a clean towel.



## Take care of your teeth

- Brush and floss your teeth to remove bits of food. Mouth bacteria cause cavities and feed on rotting food. Infections can easily get into your bloodstream through your mouth.

## See a doctor regularly

- A healthy person should see a doctor once a year.

Getting a regular checkup can prevent problems before they begin. Make sure you get all of your shots.

## Outdoor safety

- When you go outside, do not touch wild animals. They may bite or scratch, or they may have disease-carrying bugs on them. Wear insect repellent to keep mosquitoes and ticks away when camping or hiking.
- Don't drink water that has not been purified and chlorinated.

## Conclusion

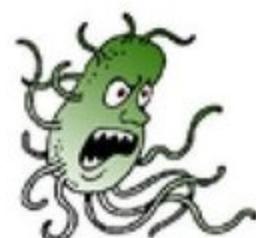
Microbes live in, on, and around almost everything. Most microbes are harmless, but some of them can cause disease—and a disease can spread quickly. Some methods for preventing disease, such as the use of vaccines and antibiotics, are the result of over two hundred years of scientific discovery, medical research, and modern medical practices.

Many countries, organizations, and individual doctors are coordinating their efforts to control and even **eradicate** many diseases. Even with all of this effort, we will never be able to wipe out all of the world's harmful microbes. But we can learn how they cause infection and can help to control them. We can learn how to be healthier.

## Glossary

|                           |   |
|---------------------------|---|
| <b>antibiotics</b> (n.)   | medicines made from microbes to fight infections in the body (p. 19)        |
| <b>cells</b> (n.)         | the smallest independently functioning units in organisms (p. 5)            |
| <b>contaminated</b> (v.)  | made something unusable or unsafe (p. 14)                                   |
| <b>disease</b> (n.)       | a condition that changes the way the body normally functions (p. 4)         |
| <b>epidemic</b> (n.)      | the rapid spread of a disease within a community (p. 15)                    |
| <b>eradicate</b> (v.)     | completely destroy (p. 22)  |
| <b>immune system</b> (n.) | system that moves antibodies through your body to fight infection (p. 7)    |
| <b>infection</b> (n.)     | illness caused by microbes (p. 4)   |
| <b>invading</b> (adj.)    | aggressively entering to conquer, weaken, or injure (p. 8)                  |
| <b>microbe</b> (n.)       | a microscopic organism, especially one that transmits disease (p. 4)        |
| <b>microscope</b> (n.)    | a device used to view tiny objects (p. 5)                                   |
| <b>mutate</b> (v.)        | to permanently change (p. 11)   |
| <b>organisms</b> (n.)     | living things, including people, other animals, plants, and microbes (p. 5) |
| <b>outbreak</b> (n.)      | the quick spread of a disease (p. 15)                                       |
| <b>pandemic</b> (n.)      | the rapid, worldwide spread of  |

|                                 |   |
|---------------------------------|---|
|                                 | a disease (p. 15)   |
| <b>resistance</b> ( <i>n.</i> ) | the ability to fight against something (p. 19)  |
| <b>symptom</b> ( <i>n.</i> )    | a telltale sign of an illness (p. 4)  |
| <b>vaccine</b> ( <i>n.</i> )    | a medicine made of a weak or dead disease that teaches the body to fight stronger forms of the same disease (p. 16) |
| <b>viruses</b> ( <i>n.</i> )    | microscopic organisms that infect the body; diseases caused by viruses (p. 11)                                      |



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