

Bacteria Basics

By Gina Riazi



What are bacteria and why should I care?

Did your mom ever make you drink a thick, overly sweet, sort of grape-flavored liquid twice a day for about a week? Were you told that the doctor said you had to drink all of it to feel better? I hope so because that was the truth; of course, that doesn't make it any more pleasant.

This "drink" is a medicine; specifically, an antibiotic. Antibiotics are a special group of medications that have one job – kill every single bacterium that is making you sick. Drinking it probably seemed pretty gross, but in reality, you are very lucky. Almost no one had the luxury of such a medicine to make them feel better, and possibly save their life, before the 1940s.

Without you knowing it, bacteria are very much a part of your daily life. For example, people in your life aren't telling you to wash your hands and use hand sanitizer just to be annoying; rather, they are trying to protect you from transferring bacteria from your hands to your food.

Did you eat yogurt or cheese recently (like parmesan or cheddar)? Perhaps you ate some kimchi, miso or olives. If so, then you were enjoying some delicious foods made with bacteria. In some of these foods the bacteria are still alive as you eat them, and after you eat them.

Have you ever had an ear infection or strep throat – two common childhood bacterial infections? This would be when you had to drink all of your medicine. Have you had vaccinations? Some of those are to prevent illnesses caused by bacteria, such as whooping cough and tetanus.

Here's a handy little fact – about half of the cells within your body are not yours, and they are not human either. They are bacteria. They live mostly inside your intestines. Lots are on your skin too. All of the time. And you can't make them go away. Ever.

A single bacterial cell is called a bacterium; bacteria is the plural form. The word has a Greek and Latin origin – "bac" means rod or staff. This prefix was used because the first bacteria ever viewed were rod-shaped. Later we learned that bacteria can be spherical or spiral-shaped too.

A basic description is that bacteria are microscopic, single-celled prokaryotic organisms. There are more of them on Earth than all other life forms combined. Archaea are similar organisms, but have a different biochemistry and an evolutionary history that puts them in their own kingdom. You have some of those living inside you as well (yeah!).

Bacteria are prokaryotic because their cells lack some of the complex structures found in the cells of plants, animals, fungi and protists. This means that bacteria do not have nuclei or other parts such as mitochondria and endoplasmic reticula.

All cells have DNA and bacteria have a single circular strand that is in an area of the cytoplasm called the nucleoid. Most bacteria have a cell wall and some have another outer layer called a capsule. The capsule makes it harder for immune cells and cleaning products to kill them, which is why a lot of disease-causing bacteria have them.

Many bacteria also have pili, which are hair-like extensions surrounding the capsule that allow the bacterium to stick to surfaces, such as the inside of your intestines. Bacteria that use energy from the sun have whip-like extensions called flagella that they use to move toward light.

Research suggests that bacteria developed in oceans about 3.5 billion years ago. They now occur nearly everywhere on the planet – deep in the soil, within rock and ice, in hot and acidic waters, and high up in the clouds. They live on your skin, and in your digestive tract. Actually, they are believed to live in the digestive tract of all animals that have one.

Bacteria are often referred to as germs – microorganisms (or microbes) that can cause disease.

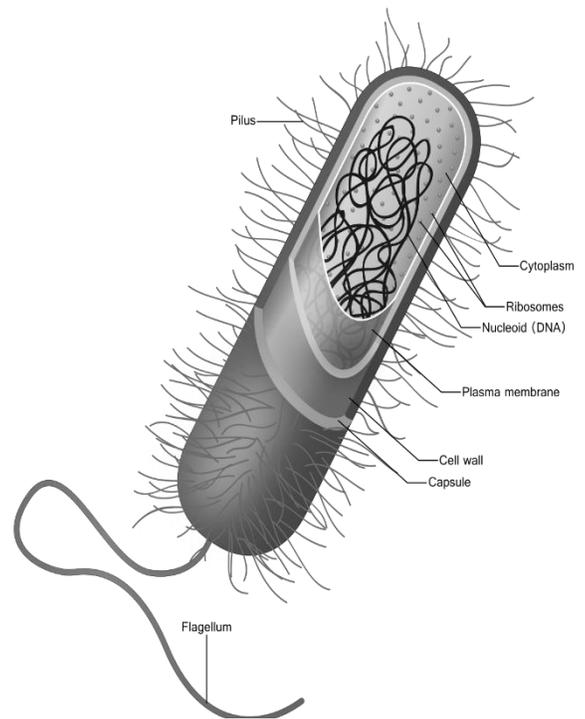
In reality, most of the bacteria species in the world do not cause diseases in humans and are very beneficial to us. This article discusses both.

What should I know about disease-causing bacteria?

Disease-causing bacteria are called pathogens. Pathology is the study of pathogenic (disease-causing) organisms. Viruses and fungi can also be pathogens. There are some bacterial pathogens that can make us very sick or kill us. Really bad bacterial infections can give us really gross symptoms such as bloody vomit and watery diarrhea. They can make you cough up thick lung mucus and a few types can eat away at your skin.

If a single pathogenic bacterium enters your body and begins to reproduce you have an infection. However, not all infections result in you feeling sick. Your immune system may kill off the bacterium and its descendants before it can do enough damage for you to have any clue that they were ever there.

You will feel sick if the invading bacterium has reproduced enough to cause many of your cells to become damaged. Bacteria do not damage cells because they are mean and don't like you; rather, they are just trying to have a meal.



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Your cells are made of organic compounds (proteins, carbohydrates, nucleic acids and fats) and water. Bacteria need these compounds to grow, function and reproduce just like all other living things. They breakdown your cells into organic compounds so that they can absorb them. This gives the bacterium the energy and building blocks it needs to reproduce through cell division. Now you have even more bacteria inside you which leads to more of your cells being destroyed. Some of the symptoms we experience, such as a fever, headache and rash, indicate you might have an infection. While unpleasant, the symptoms are signs that your immune system has gone to war against the invader.

Your immune system might be able to kill off the infection on its own, and after a week or so you feel better. However, with a bacterial infection you might need those bacteria-killing medications, antibiotics. The bacteria may multiply so fast or produce toxins that can make people very sick or kill them without antibiotic treatment. Unfortunately, there are times when no treatment works and people die from the infection.

Pathogenic bacteria can enter any opening in the body, often through your mouth, nose or a wound. Some are transmitted straight into your skin or blood by animals such as fleas and ticks. Some diseases you may have heard of, or even had, are food poisoning, Lyme disease, and pneumonia. There are many more and a bacterial infection can occur anywhere in the body.

Enough about that, what about good bacteria?

Thankfully, way more bacteria are beneficial to humans than harmful. Many are decomposers that break down dead organisms and recycle nutrients that will make up the bodies of future living things. Some we have put to work in the making of tasty, nutritious food and alcoholic drinks.

It might be a surprise to learn that trillions of bacteria are living in your intestines. Don't worry – these bacteria are not damaging your cells. Instead, they gain energy and nutrients from the same food you eat as it passes through your digestive tract. Most are helping you out by digesting plant matter, breaking down the lactose in dairy and synthesizing vitamins. These new found friends may also help protect your large intestine from an invasion of bad bacteria. In return, you are providing a nutrient rich environment for them without much effort on your part.

The bacteria that use the cells of other living (or once-living) things for energy are called heterotrophs. But many bacteria are also autotrophs – organisms that can make their own food. All plants are autotrophs as they use photosynthesis to combine carbon dioxide and water molecules into carbohydrates. In the process of photosynthesis, oxygen gas is released into the air. Many bacteria can do this too. In fact, ancient photosynthetic bacteria are responsible for the Great Oxidation Event, which is when the amount of free oxygen in Earth's atmosphere greatly increased to the amount there is today (21%).

When did humans begin to learn about bacteria?

Humans have been affected positively and negatively by bacteria since the beginning of our species, but our knowledge of their existence only extends back to the 1600s. The first person to ever see a bacterium was the self-taught and unlikely scientist, Antoni van Leeuwenhoek (he was Dutch). Even though Antoni was a fabric merchant he developed an interest in making lenses. Likely inspired by news of the first microscope (made by Robert Hooke in England), Antoni made superb lenses for his own personally designed microscopes. They were the best and strongest microscopes at the time.

He observed bacteria and many other aquatic microscopic organisms that people had no clue even existed. When he told others about his findings, they did not believe him at first. Eventually enough university professors took the time to look in pond water, as Antoni did, with their own microscopes and had to admit that Antoni was right!

Another 200 years had to go by before we began to realize that bacteria caused some of the diseases that plagued humankind for 1000s of years (including the actual plague). So many men and women have gotten us to where we are today in terms of preventing and treating bacterial diseases. However, in this short story, only two of the greats that got us started will be discussed.

Every student learns about the famous French chemist/biologist [Louis Pasteur](#) somewhere along the way. Pasteur was like Sherlock Holmes. He didn't just accept the beliefs of the day about disease, he wanted proof and he investigated biological mysteries in the way a detective investigates a crime. Follow the evidence. For example, he put an end to the myth that microbes just spontaneously appear in foods and drinks. His experiments proved that the microbes were in the air and drifted into containers left open. Pasteur solved many other mysteries about microbes and along the way he developed several vaccinations. He also developed the earliest method for killing pathogens in food, a process we call pasteurization. Go check out a carton of milk or juice – it will likely say that the product is “pasteurized”.

Louis Pasteur can seem superhuman because of his incredible accomplishments. You might even assume that he feared nothing and did everything perfectly and never failed. Wrong! Pasteur was just as human as the rest of us. As a matter of fact, his homesickness was so strong that he left school to go back to his parents. Pasteur wasn't the best test-taker either. He failed his graduate school entrance exams twice.

The German physician, Robert Koch, was also studying bacteria at the same time as Pasteur. Koch was younger and gained some of his knowledge by reading about Pasteur's work. Koch (and his lab students) developed methods for making cultures of bacteria so he could identify those that caused diseases. For example, he discovered the bacteria that causes the terrible lung disease of tuberculosis, along with the bacteria that cause deadly anthrax and cholera.

Together, these two men founded the field of medical bacteriology. That is, understanding how bacteria cause disease so we can figure out how to prevent them. Unfortunately, the two men were not friends and did not get along. The [story](#) told is that their rivalry was in part due to a mistranslation of Pasteur's French into Koch's German language. Pasteur referred to Koch's collection of work (on bacteria) in his speech, but the translator told Koch that Pasteur referred to Koch as being arrogant (due to the words sounding similar in French). Koch was not amused and apparently did not forgive and forget. Ever.

Koch and his lab technicians needed to solve the puzzle of figuring out a solid substance on which bacteria would grow for long-term studies. The breakthrough came from [Angelina Fanny Hesse](#). She recommended the substance [agar-agar](#) rather than gelatin because it remains solid at high temperatures (and turned out to be resistant to the feeding habits of most bacteria). It was on this new substance that Koch was able to isolate and identify the bacterium causing tuberculosis.

Is there more to know about bacteria?

We may seem to know quite a lot, and we do, but most species of bacteria have never been studied. Bacteria mutate quickly and become immune to our antibiotics. When we think we've got their number they mutate and fight back.

Humans figured out how to make bacteria work for us at least 10,000 years ago in the production of cheese. This is pretty interesting considering we didn't know they existed! Today we are coming up with more ways to get bacteria to work for us. For example, we use some to produce the antibiotics that kill other bacteria by manipulating their DNA. We use them to break down the oil in an oil spill and we use them to produce genetically-modified plants.

We are just starting to understand how they positively affect our health. What are those trillions of cells in our guts doing for us and to us? There's research into how they affect everything from our immune system to our emotions.

Nobody wants a bacterial infection and you may not want to think about them being in some of the food you eat, but denial won't make them go away. Rather, get to know them, the good and the bad. You can even make a career out of getting to know them. Bacteriologists are needed in many industries – food, biotech, cosmetics, pharmaceuticals, to name a few. Maybe you will invent a life-saving drug or a tastier cheese.

In 1928, scientists elected [Alice Evans](#) to be the president of the Society of American Bacteriologists for her extraordinary work in preventing disease. Born in 1881, she earned degrees in bacteriology and then worked for the U.S. Department of Agriculture. She used her education to prove that regular pasteurizing of milk prevents a serious bacterial disease called brucellosis. She even contracted and suffered from the disease herself.

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