BACTERIA

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Introduction

Bacteria are single-celled organisms called prokaryotes that do not have a nucleus (the control center of a cell) or other membrane-bound organelles (the internal structures of a cell), as eukaryotes do. Bacteria are so small that they can only be seen using a microscope. Among the oldest living organisms, bacteria are usually found in the ground, the water, and other living organisms. Some can cause diseases, but not all are harmful.

Classification

Scientists use a system of organization to group and name different organisms. The different groups begin large but become small and specific:

Domain > Kingdom > Phylum > Class > Order > Family > Genus > Species

Bacteria are prokaryotes that belong to the Kingdom Bacteria.
Evolution

Animal Evolution

Some bacteria that carry out aerobic respiration are thought to have become a part of plant and animal cells. At around the same time that cyanobacteria were being embedded into plant cells, aerobic bacteria were being taken into larger cells and becoming mitochondria.

Plant Evolution

The cyanobacteria carried out a process called photosynthesis. A product of this process was oxygen gas, which was released into the air. Because the events occurred very early in Earth’s history, the atmosphere now contains about 20 % oxygen. Some cyanobacteria did not remain free living, but rather became embedded in the cytoplasm of larger cells. They continued to carry photosynthesis, providing the larger cell with nutrients. Many scientists believe that chloroplasts originated in free-living cyanobacteria.

Bacteria have been present on Earth for millions of years. The two main types of bacteria, cyanobacteria and non-photosynthetic bacteria, have continued to evolve in this time, but their overall structures have not changed much. Bacteria are able to respond quickly to changes in the environment, allowing them to inhabit many different locations.
Inside Bacteria

The bacterium is a type of prokaryotic cell. These cells are single-celled organisms that do not have a true nucleus. Instead, they have nucleoids that house the genetic material. In addition, the prokaryotic cell has both a cell wall and a plasma membrane whereas the eukaryotic only has one of the two. The prokaryotic cell also has only one long strand of DNA, rather than the many chromosomes found in eukaryotic cells.

**Cytoplasm:** The fluid enclosed by the cell wall  
**Capsule:** a slime layer that encases the cell wall  
**Nucleoid:** Where the genetic material is located  
**Pili:** short tubes that stick out over the surface; they are used to transfer bacterial plasmids from one bacterial cell to another.  
**Plasmid:** A circle of double-stranded DNA that is separate from the chromosomes, and which is found in bacteria and protozoa  
**Flagellum:** moves the bacterial cell  
**Ribosomes:** these read off the instructions of the DNA and make bacterial proteins which attach to genetic material  
**Cytoplasmic Membrane:** located just inside the cell membrane, this lets nutrients, dissolved oxygen, and waste in and out of the cell.
Where do they live in soil?

Bacteria live in water-filled pore spaces between clumps of soil. They are usually found on the surfaces of mineral or organic material. They also tend to group around particles of decaying plant and animal matter. Because bacteria live in water, many of their movements depend on water flow in the soil.

What do they do?

Bacteria are able to perform many functions in soil. For example, they break down organic material, suppress diseases, and transform nutrients in roots. Generally, bacteria are the organisms in the soil that transform inorganic particles from one chemical to another. Because bacteria use a system of external digestion, other organisms such as plants can use the chemicals released by the external enzymes (proteins that speed up processes). The bacteria can then gain nutrients and energy from the chemicals released from those processes.
Azotobacter bacteria function in the nitrogen cycle. They live in the soil and take nitrogen from the air and change it into compounds that the plants can use.

Several different bacteria (including Achromobacter and Pseudomonas) that live in the soil change the nitrogen-containing molecules from dead animals and plants into nitrogen molecules that the plants can use. These bacteria break down dead plants and animals and garbage and release the nitrogen, carbon, and other elements. Without these bacteria, we’d be surrounded by dead organisms and garbage.
What are they?
Antibiotics are drugs used to treat bacterial infections or to kill parasites. They act specifically on bacteria and usually do not cause many side effects because they are made to target prokaryotic cells. They used to be made from other microorganisms and now can be chemically synthesized. They are classified by the way they act, their chemical structure, their molecular mechanisms of action, and whether they act on many bacterial species or just a few.

How they work
Antibiotics stop bacterial growth and cure infection through two main methods:

- **bactericidal antibiotics** kill the bacteria causing the infection through a direct action, such as causing the cells to split open (lyse);
- **bacteriostatic antibiotics** act on the internal workings of the bacterial cell to stop its dividing and to slow down the infection.
Normal Flora

Friendly Bacteria...
Not all bacteria are bad for humans. In fact, humans would not be able to live if not for normal flora, or friendly bacteria.

...in the gut
Bacteria in the gut produce enzymes that digest material in plant cell walls. Without these enzymes, we would be unable to receive much of the nutritional value of vegetables. In addition to digesting certain foods for us, some bacteria in the gut also produce vitamin K and vitamins from the B group. These vitamins are difficult to get from food and can’t be made by humans.

...on the skin
Bacteria on the skin mainly protect against other harmful bacteria. Staphylococcus epidermidis prevents bacteria from sticking to skin cells to invade them. Other strains of this bacterium produce proteins that kill pathogenic species of related bacteria.

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Did you know?
The human body contains more bacteria cells than it does human cells.
“Pathogen” is a broad term that is used to describe any agent that causes some sort of disease. The rest of this book focuses on pathogenic bacteria, or bacteria that cause various forms of disease in humans. However, those discussed here are not the only bad bacteria. There are countless more.
Leprosy

History
Leprosy has been around since about 1500 B.C. In the past it was considered a curse and those who fell victim to the disease were put in leper colonies separate from the rest of society. They were treated like animals: forced to ring bells when they entered a room so everyone would know a leper was present and they had to wear special clothes and inform people of their condition. Today fewer people suffer from leprosy, but it is still found in over 120 countries including the U.S., and some cultures still consider it a curse. It wasn’t until 1873 that Gerhard Henrik Armauer Hansen identified *Mycobacterium leprae* as the bacteria that cause leprosy.

What is it?
Leprosy causes nodules to form on the skin. As the condition progresses, the nerves around the nodules are deadened so the patients have no feeling around the area. This poses further danger to them because they are more prone to personal injury because they can’t feel anything. These injuries are the perfect breeding ground for more bacteria. Disfigurement is often associated with leprosy.

Treatment
A highly effective treatment of three antibiotics to be taken together has been developed. It stops the infection but can’t reverse the damage that had been done before the drugs were administered.
Tuberculosis

History
Tuberculosis, or TB, has been widespread since at least 7000 years ago. It is estimated that in the last 200 years, over a billion people have died from TB. Over a century ago, *Mycobacterium tuberculosis* was discovered to cause the disease, and 70 years ago the discovery of antibiotics known as sulfa drugs helped greatly to decrease the number of deaths due to TB.

What is it?
TB spreads very easily because all it takes is a sneeze from someone who is infected to pass it on to someone else. It’s hard to diagnose based on early symptoms and can easily be misdiagnosed as a common flu. Most often people don’t seek medical attention until they experience sharp chest pains when coughing or are coughing up blood. Once treatment begins full recovery is very possible. It requires several drugs and close monitoring, but most patients recover.

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Scalded Baby Syndrome

The Name
Scalded Baby Syndrome has several different names including Scalded Skin Syndrome (SSS), Ritter disease, and Lyell’s disease and is most commonly referred to as SSS.

What is it?
SSS is possible in children under the age of five and more commonly found in newborns. The infection makes the skin look as though it has been soaked in scalding water; it’s red and peels off easily but looks much worse than it is. It is rare to die from SSS.

The Cause
The bacterium responsible for SSS is called *Staphylococcus aureus*. This bacteria produces toxins in the body that cause the cells in the outer layers of skin to separate more quickly than they should, leaving under layers red, exposed, and tender.
The Plague

What is it?
The plague, which is sometimes referred to as black death, is famous for the mass outbreaks between the 1300s and 1800s. The first record of the plague was in the 1340s, and it killed 75 million people in Europe and the Middle East. At the time, that was about a quarter of the world population.

Who gets it and how?
The plague is not nearly as common as it was centuries ago. While it is still around, it is rarely found outside of the overcrowded parts of Africa south of the Sahara desert. The bacteria that causes the plague (Yersinia pestis) is carried by fleas. The fleas infest rodents and transmit it to them through the blood stream where the disease lives, dormant, until another flea bites the rodent and is then infected. Eventually a reservoir for the bacteria develops. When the fleas bite humans, the bacteria are passed on in such large numbers that they cause infection.
Three Types

There are three types of the plague and all of them are caused by the same bacterium: *Yersinia pestis*.

Pneumonic Plague is a case in which the bacteria infect the lungs. It causes a cough, a fever, chest pains, and extreme physical exhaustion. Its most fatal symptom is the destruction of the alveoli in the lungs which causes intense bleeding. About half of all people who catch this form of the plague die and without medical attention, almost one hundred percent would die.

The Bubonic Plague replicates within the lymph nodes causing them to swell. It’s not as deadly as the Pneumonic Plague but still requires immediate antibiotics to survive.

In the Septicaemic Plague, the bacteria spreads from either the lungs or the lymph nodes into the bloodstream, travelling through all the organs destroying them. It is fatal in most cases.
The condition caused by flesh eating bacteria, necrotizing fasciitis, is very rare even though it’s caused by several types of common bacteria, including *Streptococcus pyogenes*, *MRSA*, and *Clostridium perfringens*. The bacteria have to break through the skin to get to the tissue below. This muscle and fat start to die when the bacteria cells replicate and produce deadly toxins. The infection is usually mild unless the person has a poorly functioning immune system.

The scariest part of necrotizing fasciitis is how fast it spreads. Within hours of the infection, the cut or wound where the bacteria first entered the body becomes red, hot, and swollen, and the person develops a fever and diarrhea. This is usually when the person would go to the doctor as it is the first sign of real trouble. Unfortunately within a few more hours the infection will spread further into the body, and the person becomes disfigured because so much tissue has died.
Strep Throat

What is it?
Strep throat is an extremely sore throat caused by Streptococcus pyogenes (which you read about on the previous page). It’s most common in people under the age of 15 and highly contagious. It can be spread through the air and by way of commonly used items such as kitchen appliances and toys.

Symptoms and Treatment
When examined, an infected throat looks very red, and sometimes yellow and white patches will be present signifying pus. The throat can also bleed. It makes swallowing incredibly difficult and painful.

Once diagnosed, the patient will be put on antibiotics for at least ten days, and for the first three he or she should stay home from school so as not to infect the other students. If not treated, the bacteria can spread and infect more of the body and cause more severe complications, including scarlet fever, brain damage, and kidney failure.
Salmonella

Causes

*Salmonella* is a genus of bacteria that causes **food poisoning**. It’s extremely common, and it can be found in a variety of foods: eggs, meats, dairy products, and processed foods. It can also be contracted directly from pet lizards, turtles, and rodents. When the bacteria find their way into processed foods, they tend to cause large outbreaks because large batches of the products are contaminated in the manufacturing process. Contamination of other foods can also occur if they touch any raw meats that contain the bacteria.

Effects

Within the next few days someone who has ingested Salmonella experiences the following symptoms: nausea, vomiting, lack of appetite, abdominal cramps, diarrhea, chills, and **lethargy**. The only true danger is that of dehydration. Children and the elderly tend to lose more water than they consume when suffering food poisoning, and if they lose too much water then the condition can become fatal.

Precautions

*Salmonella* bacteria can’t live in conditions that have temperatures above 150.8 degrees Fahrenheit or below 39.2 degrees Fahrenheit so to make sure your food isn’t contaminated, make sure it is cooked well. For example: cook your hamburgers well-done so the inside gets hot enough too, and put any eggs you’re cooking with in boiling water for 5 seconds before breaking them.
Lyme Disease

Transmission

Lyme disease is an infection caused by one of several bacteria from the genus *Borrelia*, which are transmitted to humans by tick bites. Only about one percent of tick bites actually result in Lyme disease because the tick has to be in the person for at least twenty-four hours; otherwise there isn’t enough bacteria to do any damage.

Symptoms and Treatment

The symptoms of Lyme disease are vague and can easily be mistaken for other illnesses. Within the first ten days after being bitten, the victim can develop extreme tiredness, depression, and headaches. They also develop a characteristic “bulls eye” rash, which is usually what helps to identify the disease.
What is it and how do you get it?

Bacterial meningitis is a bacterial infection caused by *Neisseria meningitidis* that affects the thin membranes called meninges, which surround and protect the brain and spinal cord. The fluid there becomes full of actively growing bacteria. The infection is very dangerous and is considered a medical emergency. Bacterial meningitis is not very infectious but can be transmitted directly between very close contacts. The viruses that contain bacterial meningitis are more likely to pass between people, but a small number of them actually develop into the disease.

Symptoms

A person who has bacterial meningitis can become seriously ill within hours of getting it. The early signs include: a bad headache, a high temperature, a stiff neck, nausea, vomiting, and confusion. If the infection progresses too much, then the bacteria will enter the bloodstream and release toxins that break down the walls of blood vessels, causing a rash.

Treatment

Antibiotics are more effective the earlier they are given to a person with bacterial meningitis. Children and the elderly should get vaccinated from the disease because they are most at risk for developing it.
Cholera

The Infection

Cholera is an infection transmitted through drinking water contaminated with *Vibrio cholerae* that enters the digestive tract and produces a toxin which enters the cell membranes of the lining of the small intestine. It increases the flow of water through the small intestine, causing explosive diarrhea.

The Danger

It’s not the actual bacterial infection that is dangerous when it comes to cholera. Instead, it’s the dehydration that inevitably accompanies the disease. Within an hour of the onset of symptoms, a person can become severely dehydrated and be dead by the end of twelve hours. Since the first cholera pandemic in 1816, the dehydration from the infection has claimed millions of lives.

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Did you know?

Q-fever is known to exist all over the world except New Zealand. However, that is the first place where it was described. Also, humans only need to breathe in one bacterium to initiate Q-fever.

What is it?

Q-fever is a bacterial infection caused by Coxiella burnetii that is found all over the world. It is extremely rare and is transmitted from the body fluids of infected animals or through the air.

Symptoms

About three weeks after contracting Q-fever, the victim develops a flu-like illness with fever, headache, general aches in muscles and joints, chills, and mental confusion. Nausea, vomiting, and diarrhea can also occur, and the illness itself can last up to two weeks. Q-fever can also lead to respiratory problems and liver damage if severe.

Treatment

Q-fever is passed from infected animals, so farmers and vets especially must avoid infected body fluids of animals. There is a Q-fever vaccine, but it is only offered in Australia.

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GLOSSARY:

**aerobic respiration**: one of the key ways a cell gains useful energy.

**antibiotics**: drugs used to stop the growth of bacteria and cure infection.

**carbon**: abundant element that is in all living things; necessary for life.

**cell membrane**: thin layer that wraps around a cell holding it together and controlling what enters and leaves it.

**chloroplasts**: organelles found in plant cells.

**cyanobacteria**: a phylum of bacteria that obtain their energy through photosynthesis.

**cytoplasm**: the part of a cell that is enclosed within the cell membrane.

**dormant**: not active.

**eukaryotes**: an organism whose cells contain complex structures inside the membranes.

**food poisoning**: sickness involving vomiting and/or diarrhea due to ingestion of contaminated food.

**immune system**: a system within the body that helps fight off sickness.

**lethargy**: extreme physical fatigue.

**meningitis**: inflammation of the protective membranes covering the brain and spinal cord.

**nitrogen**: this element makes up about 78% of the atmosphere.

**pathogen**: an agent that causes some sort of disease.

**prokaryotes**: single celled organisms that do not have a nucleus.
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