Discovery File
Pathogens Cause Disease

If someone asks you what causes disease, most of you will probably say pathogens. And by pathogens you mean microorganisms—tiny living things so small we can't see them. As obvious as it seems to us, the idea that pathogens cause disease was very controversial when it was first proposed.

The old idea was that diseases—and some larger living things like insect larvae—just appear. Their sudden appearance was called spontaneous generation. Some people thought that invisible particles might cause some diseases. But it wasn't until microorganisms were discovered that the relationship between pathogens and disease was taken seriously.

In 1668, an Italian doctor named Francesco Redi proved that spontaneous generation does not happen. He wondered why maggots (fly larvae) appear on meat as it rots. So, Redi did an experiment. He placed pieces of meat in jars. Half of the jars were left open to the air. The rest were tightly covered. What do you think happened?

Not everyone believed he had proved that spontaneous generation was wrong. They were convinced that air was needed for the spontaneous generation to take place. He repeated the experiment with one change. This time he divided his jars into three groups. The first group was tightly covered, the second group was left open to the air, and the third group was covered with some gauze.

After a few days, Redi again saw that maggots were crawling over the meat in the open jar. The jar covered with gauze also had maggots. But its maggots were on the surface of the gauze. How do you think he explained this?
Another Italian scientist, Agostino Bassi, stated the pathogen theory of disease for the first time. In 1835 Bassi was studying the strange deaths of silkworms. Bassi blamed the deaths of the silkworms on a contagious, living agent that he could see as a powdery substance. The powder particles were tiny spores of a fungus. Bassi said that these tiny *pathogens* were killing the silkworms.

John Snow contributed to the pathogen theory when he traced the source of the 1854 cholera outbreak in part of London. Snow found that drinking water was the source of the disease. The cholera only struck families who got their water from the Broad Street pump. And this pump was at the center of the cholera outbreak.

Between 1860 and 1864, a French chemist named Louis Pasteur again disproved spontaneous generation. Pasteur knew that when freshly boiled broths were left to stand in the open air they would spoil. So he did something different. He exposed broth to air but he used filters to stop all dust particles from entering the broth. The broth did not spoil.

Pasteur also found that he could prevent spoilage of the broth without a filter. As long as the air had to travel through a long and twisted tube that did not allow dust particles to enter, nothing grew in the broths. Pasteur concluded that any living organisms that grew in broth came from outside. They entered on dust, rather than coming from the broth itself.

A German doctor named Robert Koch was the first to actually state rules for the Germ Theory of Disease. Koch’s Postulates (say *pos-too-lets*) were first used in 1875 to demonstrate that anthrax was caused by a bacterium. His postulates are still used today to help determine whether a particular germ causes a newly discovered disease.

Koch’s Postulates:

1. The germ must be found in all people suffering from the disease, but not in healthy people.
2. The germ must be isolated from a sick person and grown in pure culture.
3. The germs from that culture should cause the disease when introduced into a healthy person.
4. The same germ must be found in the person who is made sick by the cultured germ.
Discovery File
What Is a Vector-Borne Disease?

Some diseases cannot pass directly from person to person. The pathogen that causes the disease must be picked up and carried to a new host. These are called vector-borne diseases.

Most vector-borne diseases (like Lyme disease) live in an animal called the intermediate host. They wait there, growing and multiplying in number until another animal, called a vector, picks them up and carries them to us.

Some vector-borne diseases (like malaria) can be picked up from one person and given to another person. In both cases, vectors carry the pathogens without getting sick themselves.

Most vectors are arthropods—insects and arachnids. When arthropods bite or sting us they directly affect our health. When they act as vectors, they indirectly affect our health.

The best arthropod vectors are bloodsuckers, like ticks (arachnids) and mosquitoes (insects).

But not every mosquito or tick carries a pathogen. When mosquitoes and ticks first hatch they are not yet infected. Only after they bite a host animal do mosquitoes and ticks become pathogen carriers.

Several things must be in place before any vector-borne disease can thrive in a human population:

1. enough vectors and intermediate hosts;
2. enough of the disease-causing pathogens;
3. pathogens that work well with the vectors and the human or animal host;
4. the proper conditions (especially temperature and humidity); and
5. poor health and low immunity of the human population.

This list gives us some clues about how we can protect ourselves. Read about this in other Discovery Files.

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**Discovery File**

**Zoonoses**

Zoonoses are not what you think they are. They are not the funny animal noses you see at the zoo. And if you didn’t see the word but heard it pronounced, you might not think of a zoo at all. **Zoonoses** is pronounced zoh-uh-

**Zoonoses are a special group of diseases**—also called zoonotic (say zoh-uh-not-ic) diseases.

They are caused by pathogens (pathogens) that are passed from animals to humans. Zoonoses can come from wild animals, farm animals, pets, or even animal products.

Both bacteria and viruses cause zoonotic diseases. Humans are infected by these diseases in different ways. Some infections result from direct contact, some from indirect contact, and some are vector-borne.

Zoonoses have been known for thousands of years. The Bible mentions plague, which is a bacterial zoonosis (the singular form of zoonoses) that is transmitted to humans by fleas from the mice and rats that are their hosts. Some zoonoses—yellow fever and rabies—are well known today. But many others are less well known. And some probably haven’t even been discovered yet.

Some of our greatest concerns about human diseases are zoonoses. Scientists are especially worried about the ones we don’t know about yet.

For example, before 1982 no one knew about AIDS. It began as a zoonosis in chimpanzees, but when it adapted to human-to-human transmission it became a real problem.

In 1918, a bird flu virus moved from a deadly zoonosis to a human-to-human serial killer. This flu pandemic of 1918-1919 killed between 20 and 40 million people around the world. It has been called the most devastating epidemic in history.

Here are some other examples of zoonoses:

- Lyme disease: a bacterial disease transmitted by the bite of an infected tick
- Ebola: a viral disease spread by infected blood, tissues, secretions, or excretions
- Hantaviral disease: a viral disease contracted by breathing air contaminated with the infected waste from rodents

**A pandemic** is a disease outbreak that affects a large geographical area and a large portion of the population.
• Leptospirosis (say lep-to-spy-\textbf{row}-sis): a bacterial disease usually transmitted to humans through contact with urine from infected animals
• Brucellosis (say brew-sell-\textbf{oh}-sis): a bacterial disease contracted by drinking unpasteurized milk
• Cat-scratch disease: a bacterial disease passed to humans by bites or licks from infected cats

There are some zoonoses that we thought were under control. Guess what, we were wrong!

Some of them are back. And new zoonotic diseases have appeared, too. This happened due to the following reasons:

1. changes in the environment that have affected the spread of animal host species and vectors;
2. growing human populations which led to increased contact between humans and infected animals;
3. changes in food processing and consumer eating habits;
4. increased human travel and increased trade in animals and animal products;
5. decreased monitoring and control of some of the major zoonoses; and
6. changing global climate that has allowed the spread of both arthropod vectors and the vertebrate hosts in which some zoonoses live.

Sometimes, zoonoses that seem to be new diseases have actually been around for a long time. For example, hantaviruses are transmitted by rodents such as deer mice. They cause the disease known as \textit{hantavirus pulmonary syndrome}. This disease has likely been around for decades, if not centuries, but human cases were first reported in 1993.

Many zoonoses can be treated with \textbf{antibiotics}, but there are few medicines that can be used to treat viral zoonoses.

\textbf{Vaccines} are available for a small number of zoonoses, such as Japanese encephalitis and yellow fever. Antimalarial drugs are recommended for travelers to malaria hot zones.

How can you reduce the risk of catching a vector-borne zoonosis?

• Avoid areas infested by arthropods.
• Use insect repellents.
• Wear clothing that exposes as little skin as possible.
• Do not drink untreated water or unpasteurized milk.

What can your town or community do?

• Reduce the risk of zoonotic diseases by decreasing the number of rodents and other hosts.
• Clean and disinfect areas containing animal waste that may be contaminated.
Is my risk the same as your risk?

Some people have a greater risk for contracting zoonoses. If you have a job working with animals—veterinarian, farmer, and slaughterhouse worker—you have a high risk! Outdoor recreational activities—hiking, hunting, and camping—also put people at greater risk.

Knowledge is your best defense against contracting zoonoses. Be aware of the zoonoses in your environment and the times of year of greatest risk for contracting them.

Good luck!
A group of organisms belonging to the same species that live in the same place at the same time is called a population.

A mutation is a mistake that changes the information in the genetic material of a single organism in a population. This may not cause the organism a problem. Or it can cause damage or even death.

Here's a helpful way to think about this. Imagine that you are trying to copy this poem on your computer: “Roses are red, violets are blue, sugar is sweet and so are you.” But while you are typing, you change the first letter to an “n” by mistake. Now the poem reads, “Noses are red, violets are blue...” It’s silly, but you can still read it and it’s still a poem.

But what happens if you are typing the poem and all your fingers are on the wrong keys? You might end up typing something like this: “Tpwrd str trf; bop;ryd str n;it...” This is not a readable message at all! In the same way, a DNA mutation can cause a big problem or no problem at all.

Every once in a while, a mutation makes a change that helps an organism survive in its environment. When the environment changes, some members of a population may survive and reproduce better than others. Over a number of generations this results in organisms that are better adapted to the environment. We call this adaptation.

Adaptations help an organism “fit” its environment. Have you ever heard the phrase “survival of the fittest?” In biology, being fit doesn’t have anything to do with working out or following a healthy diet. It means that the organisms that survive are the ones that are better adapted to the environment. Generally, better fit organisms will reproduce more offspring than less fit organisms.

Other species in a community are part of the environment, too. Sometimes, changes in one species can lead to evolutionary changes in the other species it interacts with. The term coevolution is used when two (or more) species affect each other’s evolution.

The leaf cutter ant from Central America is a part of a cool coevolution story. These ants collect pieces of leaves that are poisonous to them. In fact, the ants can’t eat most of the leaves that grow in the rain forest. What do the ants do with these leaves? They feed them to a fungus that they grow in little underground “farms.” What happens then? The fungus uses the leaves to make food for the ants! The ants and the fungus have coevolved over time. Their relationship is so close that neither the ants nor the fungus can survive without the other.

Vector-borne pathogens and their vectors and hosts have coevolved, too. This is one reason that getting rid of these diseases can be so tricky.