

Lyme Disease

THE FACTS THE CHALLENGE



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
National Institutes of Health

National Institute of Allergy and Infectious Diseases
National Institute of Arthritis and Musculoskeletal and Skin Diseases



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Introduction

In the early 1970s, a mysterious clustering of arthritis cases occurred among children in Lyme, Connecticut, and surrounding towns. Puzzled medical experts eventually labeled the illness as a new disease, which they called Lyme disease. By the mid-1970s, scientists were busy describing signs and symptoms of Lyme disease to help doctors diagnose patients. Scientists eventually learned that antibiotics were an effective treatment, and that the bite of the deer tick was the key to the spread of disease.

None of these findings, however, happened overnight. In fact, it wasn't until 1981—through a bit of puzzle solving and keen recollection—that the cause of Lyme disease was identified and the connection between the deer tick and the disease was discovered.

Lyme disease is still mistaken for other illnesses, and it continues to pose many other challenges, including the following:

- It can be difficult to diagnose.
- It can be hard to treat in its later phases.
- A number of different ticks can transmit diseases with symptoms like Lyme disease.
- Deer ticks can pass on diseases other than Lyme disease.

This booklet presents the most recently available information on the diagnosis, treatment, and prevention of Lyme disease.

Note: Words in **bold** are defined in the glossary near the end of this booklet.

How Lyme Disease Became Known

Lyme disease was first recognized in 1975 after researchers tried to find out why unusually large numbers of children were being diagnosed with juvenile rheumatoid arthritis in Lyme, Connecticut, and two neighboring towns. After considering several possible causes, such as contact with germs (**microbes**) in water or air, researchers focused their attention on deer ticks. They realized that most of the affected children lived and played near wooded areas.

Researchers knew that the children's first symptoms typically started during summer—the height of tick season. Several of the children reported having a skin rash just before developing their arthritis. Many of them recalled being bitten by a tick where the rash appeared.

Before Lyme Disease Became Known

Around the same time, about 2,500 miles away from Lyme, Willy Burgdorfer, Ph.D., was conducting research at Rocky Mountain Laboratories (RML) in Hamilton, Montana, part of the National Institute of Allergy and



Ticks that most often transmit *B. burgdorferi* in the United States:

Ixodes scapularis—most common in the Northeast and Midwest. Also found in the South and Southeast.

Ixodes pacificus—found on the West Coast.

These two ticks look quite similar.

Infectious Diseases (NIAID). Dr. Burgdorfer was studying Rocky Mountain spotted fever, which is also caused by the bite of a tick.

In the summer of 1977, Allen C. Steere, M.D., was investigating the Lyme disease cases for the Yale University School of Medicine in Hartford, Connecticut. During conversations with Dr. Burgdorfer, Dr. Steere mentioned the deer tick as the likely carrier for Lyme disease.

Researchers in Europe had written about a skin rash similar to that of Lyme disease in medical literature dating back to the turn of the 20th century. Dr. Burgdorfer wondered if the European rash, called erythema migrans, and Lyme disease might have the same cause.

As Dr. Burgdorfer and his RML colleague Alan Barbour, M.D., continued to study spiral-shaped bacteria, or spirochetes, from infected deer ticks, they eventually achieved success. In late November 1981, the scientists found the cause of both Lyme disease and the European skin rash. The spirochete was later named *Borrelia burgdorferi* in honor of Dr. Burgdorfer for his role in discovering it.

Although Lyme disease may have spread from Europe to the United States in the early 1900s, health experts only recently recognized it as a distinct illness.

Deer Ticks

Small rodents and deer play an important role in a deer tick's life cycle. Today, scientists who study Lyme disease are learning much more about that role.

Both nymphs (immature ticks) and adult ticks can transmit Lyme disease-causing bacteria. The recent increase of the deer population in the Northeast, and of housing developments in rural areas where deer ticks are commonly found, probably have contributed to the spread of the disease.

The numbers of cases of Lyme disease and of geographic areas in which it is found have increased. Healthcare providers have seen cases of Lyme disease in nearly all states in the United States. However, most reported cases are concentrated in the coastal Northeast, the mid-Atlantic states, Wisconsin, Minnesota, and northern California. Lyme disease is also found in large areas of Asia and Europe.



- Deer ticks lay eggs that turn into larvae that feed on mice and other small mammals.
- The larvae then develop into immature ticks called nymphs.
- The nymphs then feed on small mammals and humans.
- Adult deer ticks usually feed on deer during the adult part of their life cycles.

Symptoms of Lyme Disease



Erythema Migrans

Erythema migrans (EM) is usually the first symptom of Lyme disease.

- The telltale rash starts as a small red spot at the site of the tick bite.
- The spot gets larger over a period of days or weeks and forms a red rash shaped like a circle or an oval.

Sometimes the rash looks like a bull's eye, appearing as a red ring surrounding a clear area with a red center. The rash, which can range in size from that of a small coin to the width of your back, appears within a few weeks of a tick bite and usually at the place of the bite. As infection spreads, rashes can appear at different places on the body.

Other symptoms that often appear with EM can include:

- Fever
- Headache
- Stiff neck
- Body aches
- Tiredness

Although these symptoms may be like those of common viral infections such as the flu, Lyme disease symptoms tend to continue longer or may come and go.

Arthritis

After several months of infection with Lyme bacteria, slightly more than half of people not treated with antibiotics develop recurrent attacks of painful and swollen joints. These attacks last a few days to a few months. The arthritis can move from one joint to another. The knee is most commonly affected.

About 10 to 20 percent of people who have not taken antibiotics will go on to develop chronic (long-lasting) arthritis.



Neurological Symptoms

Lyme disease can also affect your nervous system, causing symptoms such as the following:

- Stiff neck and severe headache (meningitis)
- Temporary paralysis of your facial muscles (Bell's palsy)
- Numbness, pain, or weakness in your limbs
- Poor muscle movement

Lyme disease can also cause more subtle changes such as

- Memory loss
- Difficulty with concentration
- Change in mood or sleep habits

Neurological problems usually develop several weeks, months, or even years following untreated infection. These symptoms often last for weeks or months and may return.

Less commonly, people who have not taken antibiotics may develop heart or other problems weeks, months, or even years after they were infected with Lyme bacteria.

Heart Problems

Fewer than 1 out of 10 people with Lyme disease develop heart problems, such as irregular heartbeat, which can start with dizziness or shortness of breath. These symptoms rarely last more than a few days or weeks. Such heart problems generally show up several weeks after a person is infected with Lyme bacteria.

Other Symptoms

Less commonly, Lyme disease can cause eye **inflammation**, hepatitis (liver disease), and severe fatigue. None of these problems, however, is likely to appear without other Lyme disease symptoms being present.

How Lyme Disease Is Diagnosed

Your healthcare provider may have difficulty diagnosing Lyme disease because many of its symptoms are similar to those of other illnesses. In addition, the only symptom that is unique to Lyme disease is the rash. That rash is absent in at least one-fourth of the people who become infected.

The results of recent research studies show that an infected tick must be attached to the skin for at least 2 days to transmit Lyme bacteria. Although a tick bite is an important clue for diagnosis, many people cannot recall having been bitten recently by a tick. This is not surprising because the deer tick is tiny, and a tick bite is usually painless.

If you have Lyme disease symptoms, but do not develop the distinctive rash, your healthcare provider will rely on a detailed medical history and a careful physical exam for clues to diagnose it. You will also be given laboratory tests to help diagnose the disease.

Medical History

If you don't have the EM rash, your healthcare provider will diagnose Lyme disease based on

- Whether your symptoms first appeared during the summer months when tick bites are most likely to occur
- Whether you were outdoors in an area where Lyme disease is common
- Whether you have been bitten by a tick
- Whether you have other symptoms of Lyme disease

In addition, your healthcare provider will rule out other diseases that might be causing your symptoms.

Lab Tests



It is difficult for healthcare providers to find the bacterium that causes Lyme disease in lab tests of body **tissues** or fluids. Therefore, most look for evidence of **antibodies** against *B. burgdorferi* in the blood to confirm that the bacterium is causing the symptoms.

Healthcare providers cannot always find out whether Lyme disease bacteria absolutely are causing symptoms. In the first few weeks following infection, antibody tests are not reliable because your **immune system** has not produced enough antibodies to be found. Antibiotics given early during infection may also prevent antibodies from reaching levels that a test can find, even though Lyme disease bacteria are causing your symptoms.

The antibody test most often used is called an ELISA (enzyme-linked immunosorbent assay) test. The Food and Drug Administration (FDA) has approved two antibody tests:

- Prevue B, a rapid test, can give results within an hour.
- The C6 Lyme Peptide ELISA is very sensitive and specific.

If your ELISA is positive, your healthcare provider should confirm it with a second, more specific test called a Western blot.

If you have nervous system symptoms, you may also get a spinal tap. Using this test, your healthcare provider

can find any inflammation in your brain and spinal cord and can look for antibodies or genetic material of *B. burgdorferi* in your spinal fluid.

FDA has not approved tests for Lyme disease that use urine or some other body fluids to diagnose infection caused by Lyme bacteria.

New Tests Being Developed

Healthcare providers need tests to tell apart people who have recovered from previous Lyme infection and those who continue to suffer from active infection.

To improve the accuracy of diagnosing Lyme disease, National Institutes of Health (NIH)-supported researchers are re-evaluating current tests. They are also developing a number of new tests that promise to be more reliable than those currently available.

NIH-supported scientists are developing tests that use the highly sensitive genetic engineering technique known as PCR (polymerase chain reaction) as well as **microarray** and **high-throughput genomic sequencing technology** to detect extremely small quantities of the genetic material of the Lyme disease bacterium or its products in body tissues and fluids.

A bacterial protein, outer surface protein (Osp) C, is proving useful for detecting specific antibodies early in people with Lyme disease. Because researchers have determined the **genome** of *B. burgdorferi*, there are now new avenues for improving their understanding of the disease and its diagnosis.

How Lyme Disease Is Treated

Using antibiotics appropriately, your healthcare provider can effectively treat your Lyme disease. In general, the sooner you begin treatment after you have been infected, the quicker and more complete your recovery.

Antibiotics such as doxycycline, cefuroxime axetil, or amoxicillin, taken orally for a few weeks, can speed the healing of the EM rash and usually prevent symptoms such as arthritis or neurological problems.

Doctors usually treat Lyme disease in children younger than 9 years, or in pregnant or breast-feeding women, with amoxicillin, cefuroxime axetil, or penicillin. They do not use doxycycline in these groups because the antibiotic can stain the permanent teeth developing in young children or unborn babies.

Arthritis

If you have Lyme arthritis, your healthcare provider may treat you with oral antibiotics. If your arthritis is severe, you may be given ceftriaxone or penicillin intravenously (through a vein). To ease any discomfort and to help with healing, your healthcare provider might also do one of the following:

- Give you anti-inflammatory drugs
- Draw fluid from your affected joints
- Perform surgery to remove the inflamed lining of those joints

In most people, Lyme arthritis goes away within a few weeks or months following antibiotic treatment. In some, however, it can take years to disappear completely. Some

people with Lyme disease who are untreated for several years may be cured of their arthritis with the proper antibiotic treatment.

The disease, however, does not always go away with treatment. If it has lasted long enough, it may permanently damage the structure of your joints.

Neurological Problems

If you have neurological symptoms, your healthcare provider will probably treat you with the antibiotic ceftriaxone given intravenously once a day for a month or less. Most people recover completely.

Heart Problems

Healthcare providers prefer to treat people with Lyme disease who have heart symptoms with antibiotics such as ceftriaxone or penicillin given intravenously for about 2 weeks. People with Lyme disease rarely have long-term heart damage.

Problems After Treatment

Following treatment for Lyme disease, you might still have muscle aches, and neurological problems such as tiredness and trouble with memory and concentration.

NIH-sponsored researchers are doing research to find out the cause of these symptoms and the best ways to treat them. Research studies suggest that people who suffer from post-Lyme disease symptoms may be **genetically predisposed** to develop an **autoimmune** response that contributes to their symptoms. Researchers are now examining the significance of this finding in greater detail.

Researchers also are trying to find out the best length of time to give antibiotics for the various symptoms of Lyme disease.

Unfortunately, having a bout with Lyme disease once is no guarantee that you will not get the illness again. It can strike more than once if you are reinfected with Lyme disease bacteria.

How Lyme Disease Is Prevented

Avoid Ticks

At present, the best way you can avoid Lyme disease is to avoid deer ticks. Although generally only about 1 percent of all deer ticks are infected with Lyme disease bacteria, in some areas more than half of the ticks have the microbes.

More people with Lyme disease become infected during the summer, when immature ticks are found most often. In warm climates, deer ticks thrive and bite during the winter months as well.

- Spray insect repellent with 20 to 30 percent DEET (a chemical) on exposed skin and clothing to prevent tick bites.
- Spray clothing with permethrin, a repellent commonly found in lawn and garden stores. Permethrin kills ticks on contact. You should not apply permethrin directly to your skin.
- Wear long pants, long sleeves, and long socks to keep ticks off your skin. Light-colored clothing will help you spot ticks more easily. Tucking pant legs into socks or boots and tucking shirts into pants help keep ticks on the outside of your clothing. If you'll be outside for a long time, tape the area where your pants and socks meet to prevent ticks from crawling under your clothes.

Source: Centers for Disease Control and Prevention, National Center for Zoonotic, Vector-Borne, and Enteric Diseases

Deer ticks are most often found in wooded areas and nearby shady grasslands, and are especially common where the two areas merge. Because adult ticks feed on deer, areas where deer are seen frequently are likely to have large numbers of deer ticks.

If you are pregnant, be especially careful to avoid ticks in Lyme disease areas because you can pass on the infection to your unborn child.

Repellants, although highly effective, can cause some serious side effects, particularly when you put high concentrations on your skin over and over again. Infants and children especially may suffer from bad reactions to insect repellants containing DEET. If you repeatedly apply such repellants with concentrations of DEET higher than 15 percent, you should wash your skin, and any clothing, with soap and water.

Check for Ticks

The immature deer ticks most likely to cause Lyme disease are only about the size of a poppy seed, so they are easily mistaken for a freckle or a speck of dirt.

Once indoors

- Check for ticks, particularly in the hairy regions of your body.
- Wash all clothing.
- Check pets for ticks before letting them inside.

Pets can carry ticks into the house. These ticks could fall off without biting the animal and then attach to and bite people. In addition, pets can develop symptoms of Lyme disease.

Studies by NIH-supported researchers suggest that a tick must be attached to the body for at least 48 hours to transmit Lyme disease bacteria. Promptly removing the tick could keep you from getting infected.

The risk of developing Lyme disease from a tick bite is small, even in heavily infested areas. Most healthcare providers prefer not to use antibiotics to treat people bitten by ticks unless they develop symptoms of Lyme disease.

Remove a tick from your skin as soon as you notice it. Use fine-tipped tweezers to firmly grasp the tick very close to your skin. With a steady motion, pull the tick's body away from your skin. Then clean your skin with soap and warm water. Throw the dead tick away with your household trash.

Avoid crushing the tick's body. Do not be alarmed if the tick's mouthparts remain in the skin. Once the mouthparts are removed from the rest of the tick, it can no longer transmit Lyme disease bacteria. If you accidentally crush the tick, clean your skin with soap and warm water or alcohol.

Don't use petroleum jelly, a hot match, nail polish, or other products to remove a tick.

Source: Centers for Disease Control and Prevention, National Center for Zoonotic, Vector-Borne, and Enteric Diseases

Get Rid of Ticks



Deer provide a safe haven for ticks that transmit *B. burgdorferi* and other disease-causing microbes. You can reduce the number of ticks, which can spread diseases in your area, by clearing trees and removing yard litter and excess brush that attract deer and rodents.

In the meantime, researchers are trying to develop an effective strategy for ridding areas of deer ticks. Studies show that spraying pesticides in wooded areas in the spring and fall can substantially reduce for more than a year the number of adult deer ticks living there. Spraying on a large scale, however, may not be economically feasible and may prompt environmental or health concerns.

Researchers also are testing pesticide-treated deer and rodent feeders as a possibly safer alternative for the environment. Tests done by the Centers for Disease Control and Prevention suggest that at least one commercial product reduced the number of ticks in the landscape by 80 percent during the first year of use and 97 percent by the second year.

Successful control of deer ticks will probably depend on a combination of tactics. Before strategies for wide-scale tick control can be put into practice, there needs to be more research.

Research: The Key to Progress

NIH conducts and supports biomedical research aimed at meeting the challenges of Lyme disease. Part of this research continues at NIAID's Rocky Mountain Laboratories, where Dr. Burgdorfer performed his original work.

Scientists are gaining a better understanding of the human **immune response** that leads to Lyme disease. For example, they are uncovering what causes treatment-resistant Lyme arthritis. Improved understanding of the human immune response may lead to better diagnostic and **prognostic** tools. For example, the *B. burgdorferi* immune complex assay, a test being developed, shows active Lyme disease infection earlier than current antibody tests.

Because Lyme disease is difficult to diagnose and may not respond to treatment, researchers are trying to create a vaccine that will protect people from getting infected. Vaccines work in part by prompting the body to make antibodies. These custom-shaped **molecules** lock onto specific proteins made by a virus or bacterium. Often, those proteins lodge in the microbe's outer coat. Once antibodies attach to an invading microbe, other immune system defenses are called upon to destroy it.

Although Lyme disease poses many challenges, they are challenges the medical research community is well equipped to meet. New information on Lyme disease is accumulating at a rapid pace, thanks to the scientific research being conducted around the world.

Glossary

antibody—a molecule tailor-made by the immune system to lock onto and destroy specific germs

autoimmune—when the immune system mistakenly attacks the body’s own organs and tissues

gene—a unit of genetic material that carries the directions a cell uses to perform a specific function

genetic predisposition—when a person has alterations in the genes of his or her cells which increase the risk of developing a disease

genome—the sum of all the genetic materials in any organism

high-throughput genomic sequencing—a biomedical process used to rapidly determine the order of nucleotides (parts of DNA and RNA) in multiple DNA samples. (DNA and RNA are molecules that contain genetic information.)

immune response—the reaction of the immune system to foreign substances such as bacteria

immune system—a complex network of specialized cells, tissues, and organs that defends the body against attacks by “foreign” invaders

inflammation—a process of the immune system, with signs like redness and swelling, often seen at the site of an injury such as a tick bite

microarray—a tool used by scientists to analyze genomic information to understand how large numbers of genes are expressed or how they undergo changes to specific genetic sequences

microbe—the smallest forms of life, including bacteria, viruses, fungi, and parasites

molecule—a building block of a cell, such as proteins, fats, and carbohydrates

prognostic—having the ability to predict or forecast the outcome (prognosis) of a disease

tissue—a group of similar cells joined to perform the same function

More Information

You can get more in-depth information on Lyme disease from your local library or a healthcare provider. Other sources of information include

National Institute of Allergy and Infectious Diseases

National Institutes of Health

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866-284-4107 or 301-496-5717

www.niaid.nih.gov

**National Institute of Arthritis and
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Information Clearinghouse

National Institutes of Health

1 AMS Circle

Bethesda, MD 20892-3675

877-22-NIAMS (877-226-4267) or 301-495-4484

www.niams.nih.gov

National Institute of Neurological Disorders and Stroke

National Institutes of Health

P.O. Box 5801

Bethesda, MD 20824

800-352-9424 or 301-496-5751

www.ninds.nih.gov

National Library of Medicine

MedlinePlus

8600 Rockville Pike

Bethesda, MD 20894

888-FIND-NLM (888-346-3656) or 301-594-5983

www.medlineplus.gov

Centers for Disease Control and Prevention

1600 Clifton Road

Atlanta, GA 30333

800-311-3435 or 404-639-3534

www.cdc.gov

Food and Drug Administration

5600 Fishers Lane

Rockville, MD 20857

888-INFO-FDA (888-463-6332)

www.fda.gov

Photo Descriptions and Credits

Front cover—Old growth cedar and ferns.

Stockphoto: Photodisc/Getty Images

Inside front and back covers—*Borrelia burgdorferi*, the bacteria that cause Lyme disease. National Institute of Allergy and Infectious Diseases

Page 2—*Ixodes scapularis* (enlarged), most common tick vector in the Northeastern and Midwestern United States. Dr. Willy Burgdorfer, National Institute of Allergy and Infectious Diseases

Page 4—Mouse. Stockphoto: Getty Images

Page 5—Erythema migrans rash. National Institute of Allergy and Infectious Diseases

Page 6—Swollen knees due to Lyme arthritis. Courtesy of Dr. Alan Steere, Massachusetts General Hospital, Boston

Page 9—Chemist performing a scientific experiment. Stock photo: Photodisc/Getty Images

Page 17—Deer are common carriers of ticks that can transmit Lyme disease to humans and animals. National Institute of Allergy and Infectious Diseases



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