

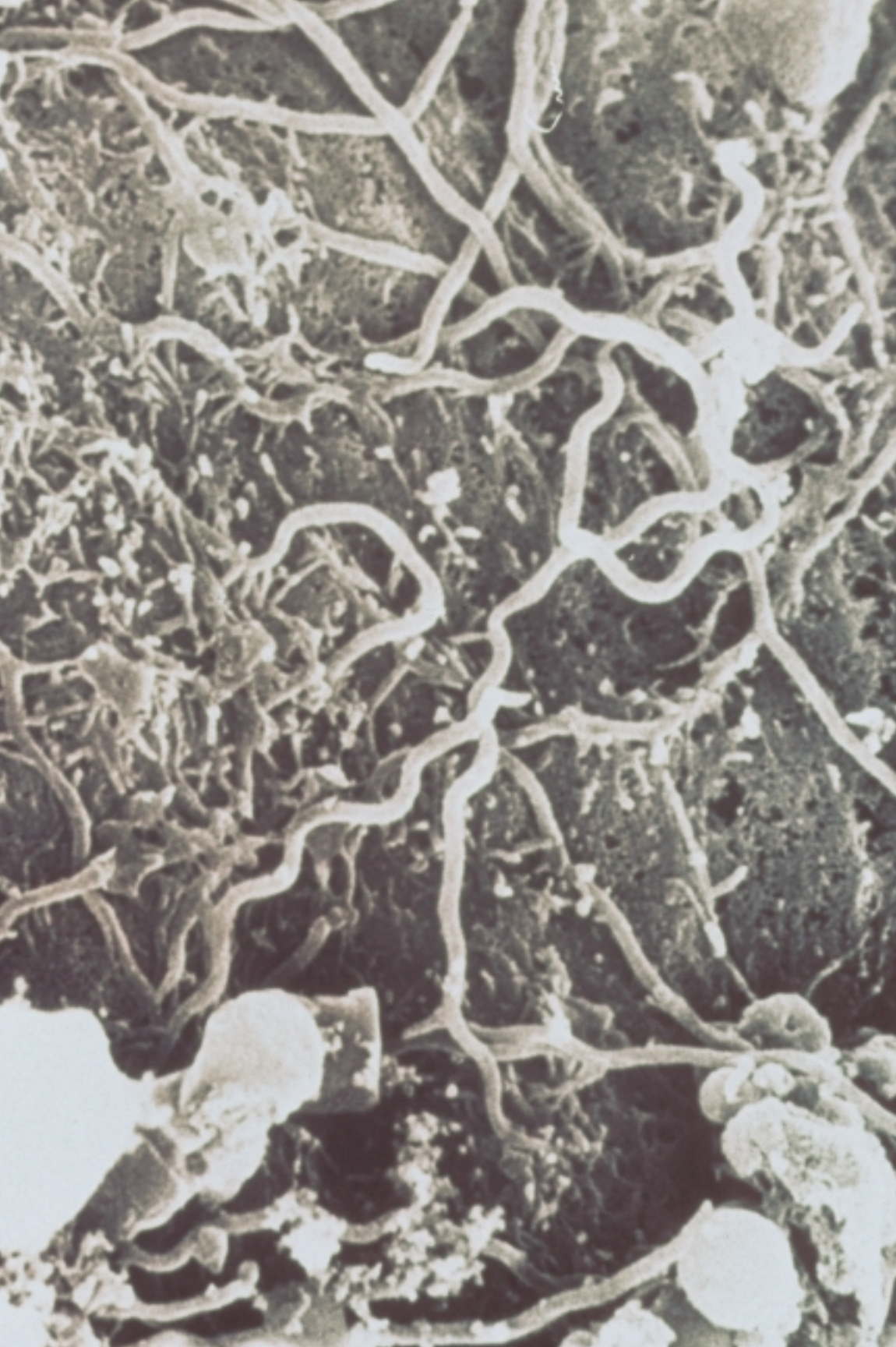
Lyme Disease

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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How Lyme Disease Became Known

Lyme disease was first recognized in 1975 after researchers investigated why unusually large numbers of children were being diagnosed with juvenile rheumatoid arthritis in Lyme, Connecticut, and two neighboring towns. The researchers discovered that most of the affected children lived and played near wooded areas where ticks live. They also found that the children's first symptoms typically started in the summer months, the height of the tick season. Several of the patients interviewed reported having a skin rash just before developing their arthritis, and many also recalled being bitten by a tick at the rash site.

Further investigations discovered that tiny deer ticks infected with a spiral-shaped bacterium or spirochete (which was later named *Borrelia burgdorferi*) were responsible for the outbreak of arthritis in Lyme.

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 ticks look quite similar.)



In Europe, a skin rash similar to that of Lyme disease had been described in medical literature dating back to the turn of the 20th century. Lyme disease may have spread from Europe to the United States in the early 1900s, but health experts only recently recognized it as a distinct illness.

Small rodents and deer play an important role in a deer tick's life cycle.



- 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.

Both nymphs 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 contributed to the disease's increased spread.

The number of reported cases of Lyme disease as well as the number of geographic areas in which it is found have been increasing. Lyme disease has been reported in nearly all states in the United States, although more than 98 percent of all reported cases are concentrated in the coastal Northeast, mid-Atlantic states, Wisconsin and Minnesota, and northern California. Lyme disease is also found in large areas of Asia and Europe.

Symptoms of Lyme Disease

Erythema Migrans

Usually, the first symptom of Lyme disease is a red rash known as erythema migrans (EM). The telltale rash starts as a small red spot at the site of the tick bite. The spot expands over a period of days or weeks, forming a circular or oval-shaped rash. Sometimes the rash resembles 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 dime to the width of a person's back, appears within a few weeks of a tick bite and usually at the site of the bite. As infection spreads, rashes can appear at different sites on the body.



Erythema migrans is often accompanied by symptoms such as fever, headache, stiff neck, body aches, and fatigue. Although these flu-like symptoms may resemble those of common viral infections, Lyme disease symptoms tend to persist or may come and go.



Arthritis

After several months of *B. burgdorferi* infection, slightly more than half of people not treated with antibiotics develop recurrent attacks of painful and swollen joints that last a few days to a few months. The arthritis can shift from one joint to

another. The knee is most commonly affected. About 10 to 20 percent of untreated people will go on to develop chronic (long-lasting) arthritis.

Neurological Symptoms

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

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

More subtle changes such as memory loss, difficulty concentrating, and a change in mood or sleeping habits have also been associated with Lyme disease.

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

Less commonly, untreated people may develop other problems weeks, months, or even years after infection. These include

Heart Problems

Fewer than 1 out of 10 people with Lyme disease develop heart problems, such as an 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 infection.

Other Symptoms

Less commonly, Lyme disease can result in eye inflammation, hepatitis (liver disease), and severe fatigue, although none of these problems is likely to appear without other Lyme disease symptoms being present.

How Lyme Disease is Diagnosed

Doctors or other health care workers may have difficulty diagnosing Lyme disease because many of its symptoms are similar to those of other disorders. In addition, the only distinctive sign unique to Lyme disease—the erythema migrans 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 a person's 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.

When a person with possible Lyme disease symptoms does not develop the distinctive rash, a doctor will rely on a detailed medical history and a careful physical examination for clues to diagnose it, with laboratory tests to support the diagnosis.

Blood Tests

The Lyme disease bacterium is difficult to find in laboratory tests of body tissues or fluids. Therefore, most health care providers look for evidence of **antibodies** against *B. burgdorferi* in the blood to confirm the bacterium's role as the cause of symptoms.



Some people with nervous system symptoms may also get a spinal tap. Using this procedure, doctors can detect brain and spinal cord inflammation and can look for antibodies or genetic material of *B. burgdorferi* in the spinal fluid.

Doctors cannot always firmly establish whether Lyme disease bacteria are causing symptoms. In the first few weeks following infection, antibody tests are not reliable because a person's immune system has not produced enough antibodies to be detected. Antibiotics given early during infection may also prevent antibodies from reaching detectable levels, even though the Lyme disease bacterium is the cause of symptoms.

The antibody test most often used is called an ELISA (enzyme-linked immunosorbent assay) test. The U.S. Food and Drug Administration 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.

When an ELISA is positive, it should be confirmed with a second, more specific test called a Western blot.

Doctors must rely on their clinical judgment in diagnosing someone with Lyme disease when the person does not have the distinctive EM rash. Such a diagnosis would be based on

- Time of year
- History of a tick bite
- Symptoms
- Thorough ruling out of other diseases that might cause those symptoms

Doctors may consider such factors as the first appearance of symptoms during the summer months when tick bites are most likely to occur and outdoor exposure in an area where Lyme disease is common.

New Tests Under Development

Health care providers need tests to distinguish between people who have recovered from previous infection and those who continue to suffer from active infection. To improve the accuracy of Lyme disease diagnosis, National Institutes of Health (NIH)-supported researchers are re-evaluating existing tests and developing a number of new tests that promise to be more reliable than currently available ones.

NIH scientists are developing tests that use the highly sensitive genetic engineering technique known as PCR (polymerase chain reaction) as well as microarray 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 the early detection of specific antibodies in people with Lyme disease. Since the **genome** of *B. burgdorferi* has been **sequenced**, new avenues are available for improving understanding of the disease and its diagnosis.

How Lyme Disease is Treated

Using antibiotics appropriately, health care workers can effectively treat nearly anyone with Lyme disease. In general, the sooner treatment is begun following infection, the quicker and more complete the 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 subsequent symptoms such as arthritis or neurological problems. Doxycycline will also effectively treat most other tickborne diseases.

When Lyme disease occurs in children younger than 9 years, or in pregnant or breast-feeding women, they are usually treated with amoxicillin, cefuroxime axetil, or penicillin because doxycycline can stain the permanent teeth developing in young children or unborn babies. People allergic to penicillin are given erythromycin or related drugs.

Arthritis

People with Lyme arthritis may be treated with oral antibiotics. People with severe arthritis may be treated with ceftriaxone or penicillin given intravenously. To ease discomfort and to further healing, the doctor might also give anti-inflammatory drugs, draw fluid from affected joints, or surgically remove the inflamed lining of the joints.

Lyme arthritis goes away in most people 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. If the disease has persisted long enough, however, it may permanently damage the structure of the joints.

Neurological Problems

Doctors usually treat people who have neurological symptoms with the antibiotic ceftriaxone given intravenously once a day for a month or less. Most people recover completely.

Heart Problems

Doctors prefer to treat people with Lyme disease who have heart symptoms with antibiotics such as ceftriaxone or penicillin given intravenously for about 2 weeks. If these symptoms persist or are severe enough, they may also be treated with corticosteroids or given a temporary internal cardiac pacemaker. People with Lyme disease rarely have long-term heart damage.

Following treatment for Lyme disease, some people still have muscle achiness, neurological symptoms such as problems with memory and concentration, and fatigue. NIH-sponsored researchers are conducting studies to determine the cause of these symptoms and how to best treat them. Studies suggest that people who suffer from chronic Lyme disease may be **genetically predisposed** to develop an **autoimmune** response that contributes to their symptoms. Researchers are now examining the significance of this finding in great detail.

Researchers are also currently conducting studies to find out the best length of time to give antibiotics for the various signs and symptoms of Lyme disease.

Unfortunately, a bout with Lyme disease is no guarantee that the illness will not return. The disease can strike more than once in the same person if he or she is reinfected with Lyme disease bacteria.

Lyme Disease Prevention

Avoid Ticks

At present, the best way to 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 them harbor the germs.

Most people with Lyme disease become infected during the summer, when immature ticks are most prevalent. In warm climates, deer ticks thrive and bite during the winter months.

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

Pregnant women should be especially careful to avoid ticks in Lyme disease areas because infection can be transferred to an unborn child. Although rare, such a prenatal infection may make the woman more likely to miscarry or deliver a stillborn baby.

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- To help prevent contact with ticks, walk in the center of trails to avoid picking up ticks from overhanging grass and brush.
 - To minimize skin exposure to ticks, wear long pants and long-sleeved shirts that fit tightly at the ankles and wrists. As a further safeguard wear a hat, tuck pant legs into socks, and wear shoes that leave no part of the feet exposed.
 - To make it easy to find ticks on clothes, wear light-colored clothing.
 - To keep ticks away, spray clothing with the insecticide permethrin, commonly found in lawn and garden stores.
 - To repel ticks, spray clothing or the skin with insect repellents that contain a chemical called DEET (N, N-diethyl-M-toluamide).

Although highly effective, these repellents can cause some serious side effects, particularly when high concentrations are used repeatedly on the skin. Infants and children especially may suffer from bad reactions to DEET. If you repeatedly apply insect repellants with concentrations of DEET higher than 15 percent, you should wash your skin with soap and water as well as any clothing.

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 the body.
- Wash all clothing.
- Check pets for ticks before letting them in the house.

A pet 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.

If a tick is attached to the skin

- Pull it out gently with tweezers, taking care not to squeeze the tick's body.
- Apply an antiseptic to the bite.

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

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



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.

Research: The Key to Progress

The National Institutes of Health (NIH), a part of the U.S. Department of Health and Human Services (DHHS), conducts and supports biomedical research aimed at meeting the challenges of Lyme disease.

Vaccine Development

Because Lyme disease is difficult to diagnose and sometimes does 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 defenses** are called upon to destroy it.

Researchers are having difficulty developing an effective vaccine for Lyme disease for several reasons. Scientists need to find out how the immune system protects against the bacteria. The first vaccine based on the OspA of the Lyme bacterium is no longer in use. Scientists, however, are evaluating other vaccine candidates. Two of these, also based on OspA, show promise in clinical trials, to date.

Scientists are gaining a better understanding of the human **immune response** that leads to Lyme disease. For example, researchers are uncovering the mechanisms responsible for 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 under development, indicates active Lyme disease infection earlier than antibody tests now in use.

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

antibodies—molecules 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.

genes—units of genetic material that carry the directions a cell uses to perform a specific function.

genetic predisposition—when a person has alterations in the genes of their cells that increase his/her risk of developing the disease.

genome—the sum of all the genetic material in any organism.

immune defenses—a bodywide network of cells and organs that has evolved to defend the body against attacks by disease-causing germs.

immune response—the reaction of the immune system to foreign substances.

immune system—a complex network of specialized cells, tissues, and organs that defends the body against attacks by disease-causing germs.

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

molecules—the building blocks of a cell. Some examples are proteins, fats, and carbohydrates.

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

sequence—to determine the precise order of the four chemical parts of a gene—adenine, cytosine, guanine, and thymine.

tissues—groups 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 health care provider. Other sources of information include

**National Institute of Allergy and
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National Institutes of Health

31 Center Drive, MSC 2520

Bethesda, Maryland 20892-2520

301-496-5717

<http://www.niaid.nih.gov>

**National Institute of Arthritis and
Musculoskeletal and Skin Diseases
Information Clearinghouse**

National Institutes of Health

1 AMS Circle

Bethesda, Maryland 20892-3675

1-877-22-NIAMS (1-877-226-4267)

301-495-4484

<http://www.niams.nih.gov>

National Institute of Neurological Disorders and Stroke
National Institutes of Health

P.O. Box 5801

Bethesda, Maryland 20892

1-800-352-9424

301-496-5751

<http://www.ninds.nih.gov>

National Library of Medicine

Medlineplus

8600 Rockville Pike

Bethesda, Maryland 20894

301-496-6308

<http://medlineplus.gov>

U.S. Centers for Disease Control and Prevention

1600 Clifton Road

Atlanta, Georgia 30333

1-800-311-3435

<http://www.cdc.gov>

U.S. Food and Drug Administration

1-888-INFO FDA (1-888-463-6332)

<http://www.fda.gov>

Photo Descriptions & Credits

Front cover—Old growth cedar and ferns.

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

P. 3—*Ixodes scapularis* (enlarged), most common tick vector in the Northeastern and Midwestern United States. *Dr. Willy Burgdorfer, National Institute of Allergy and Infectious Diseases*

P. 4—Scientist holding mouse. *Stockphoto:*

Photodisc/Getty Images

P. 6 (Top)—Erythema migrans rash on an arm.

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P. 6 (Bottom)—Swollen knees due to Lyme arthritis.

Courtesy of Dr. Alan Steere, Massachusetts General Hospital, Boston

P. 10—Chemist performing a scientific experiment.

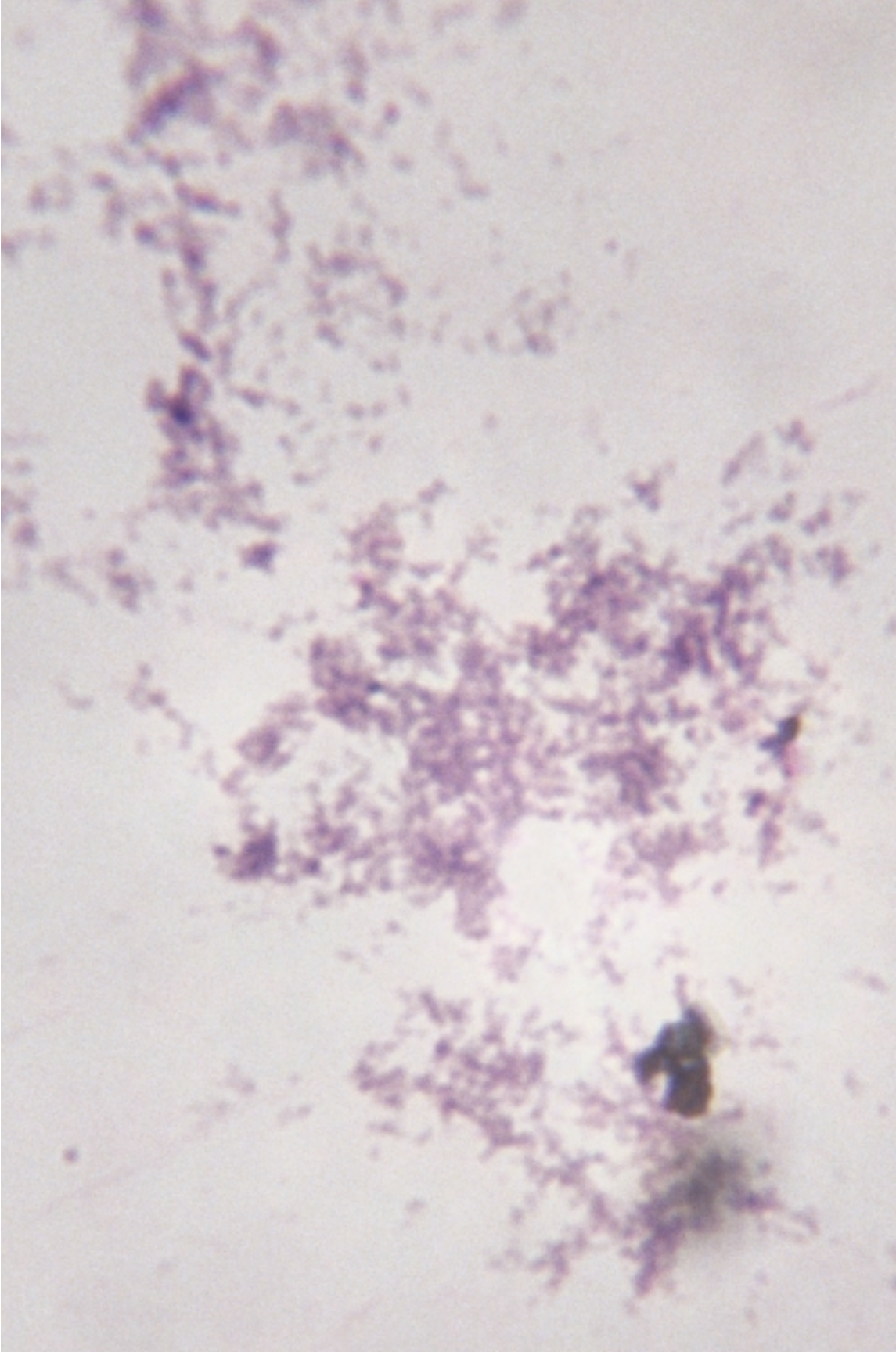
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P. 19—Deer are common carriers of ticks which can transmit Lyme disease to humans and animals.

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Inside back cover—Microscopic image of *Borrelia burgdorferi*. *Stock photo: Photodisc/Getty Images*

Notes



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