Downstream

with Benjamin Bender

EDITOR'S NOTE: *Downstream is an occasional column in this publication. It features articles about environmental awareness and action that can help us be better stewards of our natural heritage. Articles about other important aspects of the natural world also appear here.*

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INTERN REPORT: The Storied Past of a Dangerous Disease

Lyme disease seems to be a household name these days. The dangers of the disease are on the lips of every outdoors person warning others of the deer tick (*Ixodes scapularis*).

Most have heard of the bulls-eye rash and the joint pain and other telltale signs and symptoms.

But where and when did it start? Who first described it? How did we get where we are with the disease today?

Dr. Rudolph J. Scrimenti published the first occurrence of a sign of Lyme disease in 1970:

"To my knowledge, this is the first case of *erythema chronicum migrans* in the United States. Eruption and radicular pain followed a wood tick bite. Treatment with benzathine penicillin G (Bicillin) was curative." [1]

Erythema chronicum migrans, the "bull's eye rash" commonly associated with the bite of a deer tick and subsequent onset of Lyme's Disease. Image source: www.enacademic.com

Erythema chronicum migrans is a sign of Lyme that refers to the expanding "bulls-eye" shaped rash that is often seen as an early sign of infection. Note that this is not a skin reaction but rather a manifestation of the bacteria under the skin.

Doctors had seen erythema migrans in Europe but this case in Wisconsin was the first case seen in the United States. The bulls-eye rash is also a sign of southern tick-associated rash illness (STARI), which is not related to the Lyme disease bacteria.

Mysterious Disease in Lyme, Connecticut

In 1976 the Connecticut State Department of Health released Circular Letter #12-32. This letter to Directors of Health detailed 51 cases of mysterious symptoms in residents of Lyme, Connecticut and its surrounding communities. The letter states that there were 4.3 cases per 1,000 residents. Thirty-nine of the original 51 were children.

The symptoms varied between individuals: "It has been characterized by usually short and mild but often recurrent attacks of pain and swelling in a few large joints, especially knees, with longer intervening periods of no symptoms at all. No patients have had permanent injury to joints. Although almost half the patients had only joint symptoms, others had fever, headaches, weakness and a skin rash as well. One quarter of the patients had an unusual skin lesion before the onset of joint symptoms." [2]

Medical professionals considered arthritis to be the cause of the symptoms. They speculated that the arthritis was being transmitted by biting insects because of the presence of a skin lesion. Blood studies conducted at the time were unable to find any definite causal agent.

Dr. Douglas S. Lloyd, Commissioner of the Connecticut State Department of Health, pressed in this letter that they should find the cause of the disease before they took measures to "prevent contact with an unknown virus carried by an unknown insect..."[2] as it might cause panic.

Identifying the Cause

The first person to isolate the bacteria that causes Lyme disease was Dr. Wilhelm "Willy" Burgdorfer. He was a medical entomologist from Switzerland who studied at the Swiss Tropical Institute.

His studies there focused on the *Borrelia* bacteria that were causing relapsing fever in Africa.

Borrelia duttoni bacteria are found in the soft-bodied tick *Ornithodoros moubata*. B. duttoni is a *spirochete*. It is important to note that a spirochete is a spiral-shaped bacteria that causes these

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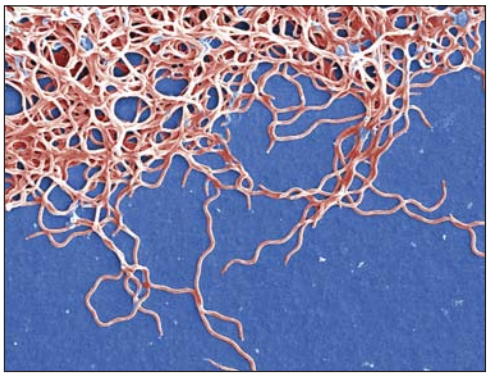
diseases. Spirochetes have tiny flagella that move, allowing the bacteria to "swim" and travel throughout the host.

All forms of Borrelia are spirochetes, though not all tick-borne illnesses are caused by spirochetes. *Rickettsial* bacteria, such as the ones that cause Rocky Mountain spotted fever, are more likely to be shaped like small rods and are easily discernible from spirochetes by a trained eye.



Borrelia burgdorferi bacteria as seen through a microscope. Photo credit: CDC/Photo: Janice Haney Carr

To detect bacteria in a tick, it is dissected. The hemolymph, roughly the blood of the tick, is collected, usually by removing a leg. The hemolymph is smeared on a microscope slide and chemically stained. The stain highlights the cells being viewed in the sample, allowing the viewer to see them more clearly. Dr. Burgdorfer used this method to find the spirochetes in ticks that were causing the relapsing fever in Africa.

Dr. Burgdorfer's Breakthrough Discovery

Dr. Burgdorfer came to the United States in 1951 to work at the Rocky Mountain Laboratory in Hamilton, Montana as a Research Fellow. His research focused on ticks and tick-borne pathogens.

He extended his fellowship to continue his research and became a United States Citizen in 1953. In 1954 he began doing national defense-related work that focused on the "rapid identification of pathogens that may be used against the United States."

After the germ warfare work, Dr. Burgdorfer continued research on various tick-borne pathogens, including Colorado tick fever virus, rickettsiae, tularemia, and spirochetes that caused relapsing fever. He also worked with fleas and the black plague, and with mosquitoes and yellow fever.

From 1971 to 1976 there was a spike in cases of Rocky Mountain spotted fever (*Rickettsia rickettsii*) in New York State. There were 124 cases reported, eight of which resulted in death. Officials suspected the dog tick, *Dermacentor variabilis* as the main vector. Sampling of the local tick populations did not yield conclusive results. The percentage of the infected dog tick population seemed insignificant.

These tests led to a search for another culprit. The other tick species with a large presence in the areas of infection was the deer tick. The Rocky Mountain Lab received the first deer ticks for dissection in 1979. This was the first time Dr. Burgdorfer had worked with *Ixodies scapularis*. Dr. Burgdorfer found *R. montana* in these ticks, but this form of Rickettsia does not affect humans.

By 1981 Dr. Burgdorfer was still looking for harmful strains of Rickettsia in the deer ticks. There were spiral-shaped bacteria in the digestive system, or midgut of an eastern deer tick from Shelter Island, New York, on the Long Island Sound.

He realized almost immediately that these were spirochetes. He examined them under a dark field microscope and watched them move. He knew that they were indeed spirochetes because of the way the bacteria moved translationally (the motion by which a body shifts from one point in space to another) and rotationally.

Dr. Burgdorfer and his colleagues ordered blood samples from patients showing Lyme arthritis to be tested. He used direct fluorescent antibody testing to identify the presence of the bacteria in the patient's blood. Genetic testing of the bacteria determined the spirochetes were Borrelia. They named the new species *B. burgdorferi* after the man who discovered it.

The Spread of an Ancient Bacteria

Despite the only recent discovery, studies have shown that the B. burgdorferi is prehistoric. The Yale School of Medicine examined the genetic makeup of the bacteria to see how the disease could have distributed itself around the country. They believe that the bacteria has existed for thousands of years and spread from the East Coast westward to Wisconsin.

The range became fragmented at some point, most likely due to deforestation, leading to the independent emergences of Lyme disease in multiple places.

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Dr. Wilhelm "Willy" Burgdorfer, inoculating ticks in his laboratory in 1954. Image source: nih.gov

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Prevalence of blacklegged ticks that cause Lyme Disease. Image source: www.health.pa.gov

There is also evidence that Borrelia burgdorferi exists in Europe.

Range expansion of the deer tick is a major reason why Lyme cases are on the rise. White-tailed deer *(Odocoileus virginianus*) populations provide blood meals and mating areas for the ticks, but are not good reservoirs for the bacteria.

The name 'deer tick' almost draws our attention away from a more important reservoir of the disease. The deer mouse (*Peromyscus maniculatus*) and the white-footed mouse (*P. leucopus*) are major vectors of B. burdorferi. The ticks pick up the disease from the mice and become infected, carrying the bacteria in their digestive system.

Some researchers view acorn crops as a major factor in Lyme disease occurrence. The acorns provide food for both the deer and the mice and can bring them all together, which spreads the ticks and the bacteria.

Climate change is also a factor in the spread of Lyme disease. Warmer temperatures and mild winters allow more ticks to survive throughout the year.

There are more hospitable places for the mice and ticks to live. Exotic invasive species such as Japanese barberry (*Berberis thunbergii*) also play a major role in tick survival. Underneath a Japanese barberry is a microclimate with elevated relative humidity. The humid microclimate provides a nice habitat for mice and ticks. Ticks can dry out, which causes them to die, but the humidity allows them to stay hydrated over the winter or during hot, dry periods.

Even the tiniest of deer ticks can bite and infect humans with dangerous bacteria.

Protect Yourself from Ticks

Lyme disease and deer ticks are a growing problem but there are measures you can take to defend yourself from them. According to the Center for Disease Control and Prevention (CDC), treating your clothing with permethrin spray and using insect repellant containing 20% DEET is a good way to protect yourself from a tick bite.

Always check your body for ticks and check your clothing too. Wearing light-colored clothing can aid in seeing any ticks that may be walking on you. Placing your clothes in the dryer and tumbling them on high heat for 10 minutes will kill any ticks still on them.

At your home you can mow your lawn and trim weeds, especially next to walkways, to reduce contact with ticks.

If a tick does become embedded in your skin you remove it with tweezers. Do not rely on the notion that household products such as soap, petroleum jelly, peanut butter or anything of the sort will make the tick retreat. Methods like these only kill the tick while it is embedded and make it harder to remove with tweezers. Burning the tick can make the tick expel its gut contents back into the wound, increasing risk of infection.

In Conclusion

It is good to know the history of the dangerous disease that affects Pennsylvania and is still a real threat to our health. The discovery of the disease and studies of its spread are only parts of solving the overall problem.

Diagnosis and treatment are still difficult. There were 7,400 reported cases of Lyme disease in Pennsylvania in 2014, 84 of which were reported in Franklin County. [3]

It is important to consult your physician if you suspect you have Lyme disease. You can find a list of signs and symptoms on the CDC website: www.cdc.gov

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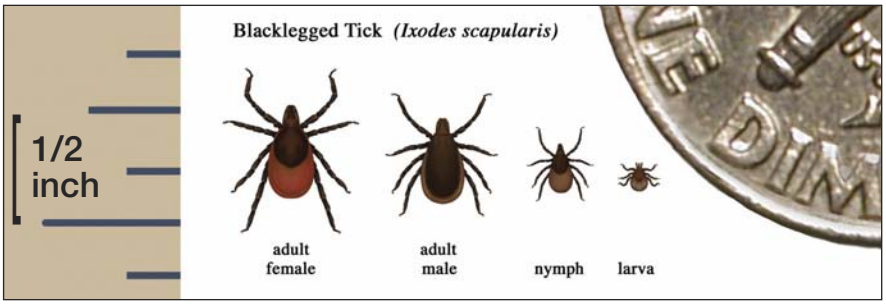

Life stages of the blacklegged deer tick. Most humans are infected with bites from ticks in the immature nymph stage. Image source: www.cdc.gov

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Renfrew Institute intern, Ben Bender, collects water samples for analysis. Bender is the author of this article on ticks and Lyme Disease. Photo by Melodie Anderson-Smith.

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