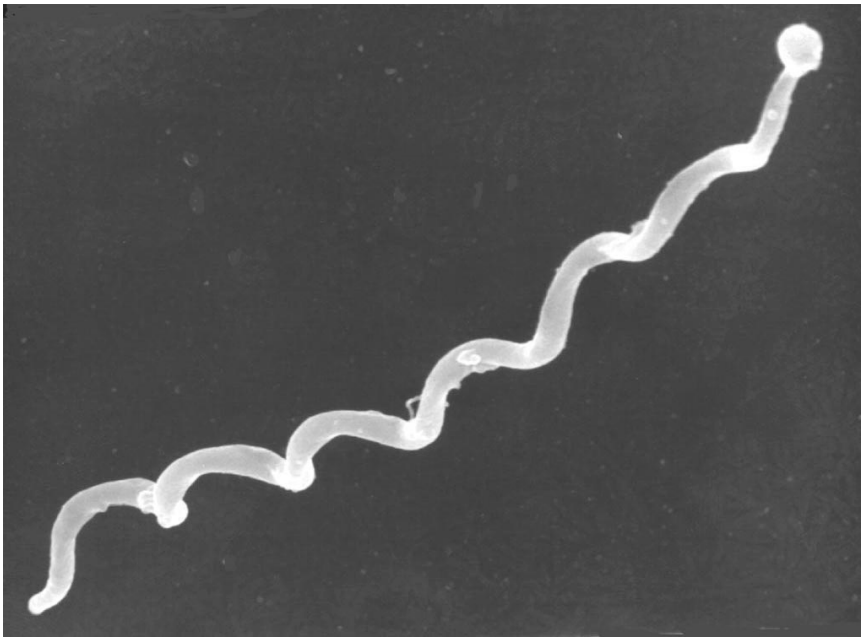
MicroRogue: Borbu (*Borrelia burgdorferi*)

(Brian Stevenson)



Scanning electron micrograph image of *Borrelia burgdorferi*. Brian Stevenson.

Claim to Fame: Lyme disease.

Lyme disease is the most common vector-borne bacterial disease in North America, Europe, and other parts of the world. "Vector-borne" means that the bacteria are transmitted to humans and other vertebrates through the bites of blood-feeding arthropods. In the case of Borbu and Lyme disease, the vectors are ticks of the genus *Ixodes*.

Other types of ticks cannot transmit Borbu, although they might carry other bacteria, viruses, or protozoans that can make people sick. It is important to remove ticks as soon as possible, because the longer they feed on a person, the greater the possibility that they will transmit infectious microbes.

An unusual bacterium with unusual movement. There are many kinds of microbes: some say millions of species but perhaps there are many more (we are one species, *Homo sapiens*). How to organise this impossibly large number of species in groups and name them? An entire branch of microbiology is devoted to this question and most microbiologists tend to try an organize according to phylogeny, the evolutionary history of microbes, i.e. closely related phyla are closely related evolutionarily.

Borbu belongs to the spirochete phylum, which is a branch of bacteria that look different from most other bacteria that we know. One major difference is their flagella, which are long, helix-shaped rods that are used for movement. The helical flagella of most bacteria point away from the cell and propel the bacteria through fluids by spinning, much like a boat propeller spins in water to make the boat move.

Spirochetes, on the other hand, wrap their helical flagella around their long cell bodies, giving the cell a helical shape (see above). When the flagella rotates, the entire bacterial cell rotates

like a corkscrew. This is a very efficient way to move through dense environments, which helps Borbu move through relatively solid tissues in the bodies of humans and other vertebrates. Borbu and its relatives are some of the most invasive bacteria that we know.

An unusual symptom of Lyme disease: the bull's eye rash. The ability of Borbu to move through solid tissue in human bodies results in one of the most distinctive symptoms of Lyme disease: the bull's eye rash (technically, "erythema migrans", which means "moving redness"). This red rash spreads across the skin from the site where the tick fed. It is caused by Borbu cells moving through skin tissue, away from the site of inoculation, and creating inflammation as they move.

This 2007 photograph depicts the pathognomonic erythematous rash in the pattern of a bull's-eye, referred to as erythema migrans. The rash manifested at the site of a tick bite, on this Maryland woman's upper arm, signifying a case of Lyme disease, caused by the bacterium *Borrelia burgdorferi*, and transmitted to humans, by the bite of infected blacklegged ticks. CDC/ James Gathany.

Lyme disease is a zoonosis. A zoonotic infection means that the causative agent exists in nature by infecting other animals, but occasionally gets into a human. Most human infections originated in wild animals and are thus zoonotic. Borbu exists in nature by cycling between *Ixodes* ticks and mice or other wild vertebrates.

Humans are "dead-end" hosts. Occasionally, an infected tick will feed on a human and cause Lyme disease, but we are "dead-end" hosts and Borbu usually does not spread from human-to-human. In other words, humans with Lyme disease do not transmit the infection to others,

Learning about zoonoses. We can learn a lot about zoonoses by studying interactions between Borbu and the wild animals that it specializes in infecting. As far as know, Borbu does not cause any harm to the mice or other wild animals that it normally infects. This makes sense, since the life of Borbu depends upon the life of the mouse it is infecting, and if the bacteria made the mouse sick, then the mouse would probably be quickly eaten by a predator. And if the predator

were not susceptible to Borbu, then it would also be a dead-end host and Borbu's life would be short.

Lyme Disease pathology is caused by our own defenses. Borbu cells have features that prevent the immune system of host mice from seeing the bacteria as an enemy, and so the bacteria are ignored. So why do people get sick from Borbu?

The problem for us is that Borbu does things that are ideal for infecting a mouse, but we aren't mice. Our bodies are different enough that our immune systems detect when Borbu does things that mice would not notice. Human immune systems then respond to Borbu by triggering inflammation. All of the symptoms of Lyme disease appear to be caused by the person's immune system, and not by the bacteria directly causing injury themselves.

Sometimes, the immune system responses of a Lyme disease patient cause damage to their bodies that lasts long after the bacteria have been killed by antibiotics. The possibility of long-term physical damage is thus an important reason to watch out for ticks.

Borbu is nasty pathogen delivered by a nasty blood-sucking tick that we should try and avoid.