**FACTS ABOUT LYME DISEASE**

**Lyme disease** (Ld) is caused by the bacterium, *Borrelia burgdorferi* (Bb), called a spirochete [spy’-ro-keet] that is typically transmitted by certain ticks to a wide range of birds, reptiles, and mammals, including humans. Ld can cause a number of symptoms ranging from a relatively benign skin rash to severe, debilitating physical manifestations. Cognitive and psychiatric features may also develop. In North America, Ld was first described clinically when a Wisconsin physician was bitten by a tick while hunting locally in October 1969. Since November 1988, Ld has been a reportable disease in Ontario.

**CAUSAL ORGANISM**

Bb has diverse forms: 1) *spirochetes* (bioactive, elongated, helical-shaped); 2) atypical: a) ring-shaped, looped, rolled; b) blebs (budding vesicles); and 3) *alternate*: a) round bodies; and b) granular (ultra-microscopic, dot-like grains).

Bb develops gelatinous masses, called *biofilms*, for increased survival. These persister biofilm colonies consist of spirochetes, cell wall deficient forms consisting of cysts (round bodies), and reside in a dormant, non-dividing state. These polysaccharide-based matrices protect Bb against the host's immune system and antibiotic therapy. Biofilms always indicate chronicity of infection; these colonies can perpetuate Bb by resisting anti-Lyme herbs and innate immune response. Since Bb shifts from one physical form to another, knowledge of diverse forms is vital for planning treatment strategy.

When an infected tick feeds, it regurgitates spirochete-laden fluids into the host. Not only does Bb move via blood, it migrates through skin and connective tissue. Bb has different physical and biochemical characteristics depending on whether it is residing in a vector tick, or present in a suitable, warm-blooded host.

**VECTORS**

Ticks are neither “insects” nor “bugs;” they are arachnids (spider-like creatures). Ticks do not jump, fly, or drop out of trees. They wait on low vegetation to attach to suitable hosts.

The primary vector of Ld in Ontario is the blacklegged tick, *Ixodes scapularis*. This tick was first studied in 1972 in a breeding colony at Long Point on the north shore of Lake Erie and, in 1987, Bb was isolated from ticks and mice collected there. More recently, established populations of blacklegged ticks have been found at Point Pelee National Park*, Rondeau Prov. Park*, Long Point (2 areas)*, Turkey Point Prov. Park*, Turkey Point lowland*, Wainfleet Bog Conservation Area*, Presqu’ile Provincial Park, Prince Edward Point National Area*, Verona*, and St. Lawrence Islands National Park (3 areas)*, Murphys Point Prov. Park*, and Charleston Lake Prov. Park. [Key: *Bb confirmed in ticks.*]

The life cycle of *I. scapularis* is 2-5 years, and consists of 4 life stages: egg, larva, nymph, and adult (male, female) (Fig.1). The immature (larva, nymph) stages require a blood meal to molt to the next stage, and the female needs blood as nourishment to produce eggs. When the larva attaches, and becomes fully engorged in 3-5 days, it drops off and molts to a nymph. As a nymph, it again quests for a host (i.e., mouse, chipmunk, songbird), and feeds for 3-5 days, drops off, and molts to an adult (male, female). In late spring, a fertile female lays 1000-3000 eggs in moist leaf litter. After 35 days, the eggs hatch into larvae, which promptly seek a host (i.e., mouse, chipmunk, songbird). While feeding on a Bb-infected host, the ticks can acquire spirochetes. Whenever the blacklegged tick becomes infected with Bb, it is infected for life. However, a gravid *I. scapularis* female does not pass Bb to her eggs.

Our 10-year tick-host study of blacklegged ticks in Ontario pinpoints this tick species as far north as the 50th parallel, which transects Minaki in northwestern Ontario (Fig. 2). All of the blacklegged ticks submitted by veterinarians and people were adults, and had a 12.9% Bb infection rate. These ticks had a wide geographic distribution province-wide, and were collected from people, domestic and wildlife hosts, which had no out-of-province travel. Not only do females play a major role in Bb transmission in Ontario, songbird-transported, larval and nymphal ticks, after molt, are potential vectors (Scott et al. 2012).

**HOSTS**

Both mammals and birds play a vital role in the maintenance and dispersal of Lyme vector ticks. In North America, blacklegged ticks have been reported on at least 54 mammalian hosts and 79 avian species. Rodents (e.g., mice, chipmunks) and shrews are primary reservoirs of Bb. Adult blacklegged ticks seek large hosts, including people, and conduct host-seeking activity when the temperature is above 0°C, peaking in May and, later, in October (Fig. 2). Blacklegged ticks have antifreeze-like compounds in their bodies, and overwinter successfully in the humus layer under an insulating blanket of snow. White-tailed deer, which act as amplifying hosts of all 3 motile stages of the blacklegged tick, play an important role in sustaining established tick populations. However, deer are refractory to Bb and, because deer do not transmit Bb to ticks, they break the Ld cycle.

Songbirds act as short- and long-range dispersing hosts of larval and nymphal black-legged ticks. During northward spring migration, songbirds make landfall at stopovers to refuel and replenish food reserves in Ld endemic areas and, while meandering through low-vegetation areas, they become parasitized by Bb-infected ticks. Subsequently, these engorged ticks are carried hundreds of kilometres, and released across Canada. Our studies confirmed that songbirds carry Bb-infected ticks northward across the Canada-

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*Fig. 1. In Lyme disease endemic areas, Bb cycles enzootically between vector ticks and reservoir hosts on a continuous basis.*

*Fig. 2. Blacklegged ticks and their hosts.*
U.S. border and, likewise, from at least 43 established *I. scapularis* Canadian populations (ON, 23; QC, 5; MB, 6; NB, 3; NS, 6) during spring migration. We have documented immature *I. scapularis* on songbirds from northern Alberta to Nova Scotia, some of which are infected with Bb. Some songbirds (i.e., American Robin, Song Sparrow) can harbour Bb, and act as reservoir hosts. Blacklegged ticks can be coinfected with several pathogens including: *Anaplasma phagocytophilum* (human granulocytic anaplasmosis [HGA]), *Babesia* spp. (i.e., *Babesia microti* [human babesiosis]), *Bartonella* spp. (i.e., *Bartonella henselae* [cat scratch disease]). *Mycoplasma fermentans* (Chronic Fatigue), Protomyxzoa rheumatis, relapsing fever group spirochetes, deer tick virus, and multiple other viruses (i.e., HH-6, EBV, CMV). Recently, *A. phagocytophilum* was detected in ticks collected from songbirds in southern Canada. Because songbirds disperse ticks widely across Ontario, one does not have to go to an endemic area to contract Lyme disease.

### TICK BITE

Ticks do not “burrow” in or under the skin. Instead, the tick attaches itself to the host with its hypostome (piercing mouthpart), and draws a blood meal (see front cover). This feeding structure has backward-pointing barbs, which provides a temporary steadfast attachment. Before entry, the hypostome injects a painkiller, an antihistamine to anaesthetize the tissue, and anti-clotting chemicals to desensitize the bite site. After entry, the hypostome produces a cement-like compound, which holds the tick firmly attached. When engorgement is finished, the tick softens this substance, and releases itself from the host. Ticks often bite in non-conspicuous areas of the body. 85% do not remember a tick bite. Although Bb transmission normally takes 24-48 hours, anecdotal experience provides instances of spirochetal transfer by *I. scapularis* adults in less time. Notably, other pathogens (i.e., HGA), which often are harboured by this tick species, can be transmitted in less than 24 hours. Powassan virus can be transmitted within 15 minutes.

### TICK REMOVAL

Various “home remedies” for tick removal have not been proven effective. Under no circumstance should a flame, ointment, flammable liquid (gasoline, lighter fluid, acetone, nail polish, etc.) or caustic material be used in removal attempts. Using **superfine-pointed** stainless steel tweezers, a health-care practitioner (HCP), can careful remove an attached tick. Most tweezers are too blunt, and will cause an embedded tick to regurgitate body fluids.

For removal yourself, place the tweezers snugly against the skin and, with a firm grip of the tick’s capitulum (head), gently pull the tick straight out with steady pressure. Do not twist the tick. A sterilized needle also works well for removal. It is important to remove the tick’s hypostome from the skin to reduce the chance of infection. Apply an antiseptic to the bite area, and wash your hands. Note in your medical records: date of removal, location on the body, and geographic area. Try to keep the tick live by placing it in a vial with a piece of moisten paper towel, and put vial in a ziplock bag with slightly moisten paper towel; keep at 10-20°C. A dead tick can be PCR tested if it is not spoiled; put dead tick in tightly sealed vial of rubbing alcohol. Have the tick identified/tested by a lab, health department, or veterinarian. Ticks off people can be sent by your HCP to the Parasitologist, Central Laboratory, 81 Resources Rd., Etobicoke, ON M9P 3T1, or directly to the federal Public Health Agency of Canada via: http://www.phac-aspc.gc.ca/id-mi/tickinfo-eng.php#psu. **Instruction:** Request identification, and if it is a blacklegged tick test for Bb and tick-associated pathogens.

### PICTURE OF RASH

If a rash develops at the bite site, take a close-up colour picture of the rash in bright light. See Rashes section. Place a ruler beside the rash to show the actual size. Record the measurements (length and width) of the rash. Also, include a card in the photo with the date.

### ALTERNATE TRANSMISSION

During pregnancy, Bb can cross the placenta to the unborn child. Bb may also be transmitted during breastfeeding via the mother’s milk to the infant. Likewise, spirochetes can be transmitted to a person by drinking unpasteurized, Bb-infected milk. Bb can be transmitted to the recipient during a blood transfusion. Sexual transmission in humans may occur; Bb has been noted in canine and human semen and vaginal secretions. Safe sex is advised.

### LYME DISEASE TESTING

Routine Ld testing lacks complete reliability. Since it takes 4–6 weeks for Ld antibodies to show positivity, serological (blood) testing needs be delayed after the tick bite. Antibodies peak at 6–8 weeks after initial infection, and then subside to a lower level. By year 2, less than 50% of patients still have a strong antibody response. Serological tests (i.e., ELISA and Western blot) are commonly employed; however, other screening tests are available. PCR testing may be used for tissue and certain body fluids (i.e., whole blood, synovial fluid, urine). Western blot, a qualitative test, is suggested initially because it is more specific in detecting IgM and IgG antibodies produced by the body in response to Bb infection. Culturing of blood and semen/vaginal secretions can be done.

Preliminary serological screening tests (e.g., ELISA) measure the quantity of antibodies, and often show negative results; 4-65% accuracy has been reported. If the sample is obtained too early (e.g., within 4 weeks after tick bite), or the patient does not have a strong enough immune response, a false negative test can result. Since commonly-used antibody testing (i.e., ELISA. Immunoblot) has low sensitivity, Ld remains a clinical diagnosis.

**Note:** Ld is a “great masquerader.” Physicians have been known to label Ld as other diseases/disorders like chronic fatigue, fibromyalgia, stress, depression, mononucleosis, ADHD, autism, Q-fever, tularemia, scleroderma, Crohn’s disease, sarcoidosis, multiple chemical sensitivities, and psychiatric disorders. Ld mimics an array of neurological diseases (i.e., Alzheimer’s disease, Parkinson’s disease, Lou Gehrig’s [ALS], multiple sclerosis, Rasmussens encephalitis, brain tumour), and connective-tissue diseases (i.e., systemic lupus erythematosus, rheumatoid arthritis, nodular fasciitis, Parsonage-Turner syndrome). Using DNA from brains of Alzheimers’ patients from the Harvard brain bank, 7 of 22 in the New England states were positive for Bb. Similar results have been noted elsewhere.

Testing for other diseases is very important in determining the diagnosis. Bb is a “stealth pathogen,” that slips by the immune system, and sequesters and hides in the eye, bone, brain, ligaments, tendons, nerve cells, lymph nodes, and scar tissue; Bb is hard to detect and difficult to treat, especially when established. If left undiagnosed and untreated, Ld can spread throughout the body and become a persistent, bacterial infection. Since Bb has pleomorphic forms (i.e., spirochetes, round bodies), plus biofilms, different therapeutics are often needed for an extended period of time. Post-treatment, patients may have recurring symptoms. Ld may be acute, recurrent, or persistent; it can be fatal.

Early treatment of Lyme disease is paramount. Treatment delay can result in treatment failure, worse patient outcomes, unnecessary suffering, and increased medical expenses.

### PREVENTATIVE MEASURES

In order to see ticks on outdoor clothing, wear light-coloured long pants, long-sleeve shirt, closely knitted socks, and fully closed shoes or boots. Tuck shirt into pants and pants into socks to help prevent upward crawling ticks from getting under clothing. After outings, do a full-body tick check. Wash clothes promptly, & put in dryer for 10 minutes to kill ticks. Tick repellants, containing DEET, act as a deterrent. Effective, bio-friendly, non-DEET repellents, include: picaridin (Natarepell, [www.rei.com]), or BioUD™ (<https://www.homs.com/bioaud/>) . Avoid getting repellents in eyes, mouth, or on hands of children. Plant oils, such as lemon eucalyptus extract, are less efficacious than repellents listed.
**SYMPTOMS OF LYME DISEASE**

The following symptoms are associated with Ld:

**RASHES** (less than 50% have rash; 30-50% in adults; less than 10% in children)

**Typical**

i) bull’s-eye rash (erythema migrans [EM]); has red circumference with central clearing (5-70 cm in diameter) - often starts in 3-30 days; may start weeks or months later - gradually expands, and eventually disappears (a) - duration: average 27 days (4-100 days) - sometimes warm to touch

ii) homogeneous (a type of EM rash, which has uniform reddish colour) - expands as Bb infection spreads - more people have this type (b) than those with the bull’s-eye rash (a)

iii) rash on dark skin (c)

**Atypical**

i) multiple blotchy/erythema multiforme rashes (Slides d, e) - occur later as secondary rashes - indicates dissemination of Bb
d) reddish rash, darker in centre - the darker central area hints of secondary infection from tick feeding (not shown)

iii) painless, bluish-red swelling or nodule on ear lobe of children (Slide f), or on nipple/areola of breast (more common in Europe)

iv) combination: multiple, homogeneous rash on dark skin (g)

iv) Acrodermatitis chronica atrophicans (ACA) - bluish-red inflammatory lesions on extremities: buttocks, limbs, legs, hands (h) - develops slowly; atrophy (wasting away) of skin; becomes grayish-tan; patchy (i) - rash duration of 1-17 yr; common over age 40 - common in Europe, infrequent in N. America

v) a rash like “hives” (not shown)

vi) measles-like rash (see Slide d & e: interspersed between large blotchy EM rashes)

In total, there are at least 18 forms of Ld rashes.

**LATE SYMPTOMS**

Any of the following symptoms can occur with Ld; patients may have any combination of them, and onset occurs in any month. They may occur months/years after initial infection.

**ENDOCRINE**

- Loss of sustained energy, profound fatigue
- Re-occurring “flu-like” symptoms; weakness
- Constant low body temperature, cold hands
- Constant thirst, frequent urination

**MUSCULOSKELETAL**

- Muscle ache (myalgia), backache
- Muscle spasms, twitching (paresthesias)
- Migratory joint/muscle & pain
- Ongoing muscle weakness
- Temporal-mandibular joint (TMJ) pain

**EARS**

- Hearing loss
- Ear pain; ringing in ears (Tinnitus), buzzing
- Rapid respiration

**EYES**

- Conjunctivitis; swelling around eyes
- Blurred vision, double vision, difficulty focusing
- Change in colour vision; blindness
- Sensitivity to bright &/or fluorescent light
- Dry eyes: inflammation (i.e., uveitis, retinitis)
- Prickly or itchy sensations, optic neuritis
- Difficulty with night vision; “Lazy eye”

**NEUROLOGICAL**

- Headaches, head pressure
- Lightheadness, dizziness, “space-out” feeling
- Loss of balance (ataxia), “tipsy” feeling
- Loss of reflexes, sensory loss, numbness
- Tremors, seizures, “insides” shake
- Peripheral neuropathy (nerve damage)
- Tingling, prickly, or burning sensations
- Twitch of face or other muscles
- Increased motion sickness; clumsiness
- Fasciculations (small muscle contractions)
- Unilateral or bilateral facial nerve palsy

**NEUROPSYCHIATRIC MANIFESTATIONS**

- Moody and irritable; less able to cope
- Unusual depression, suicidal thoughts
- Feeling I’m going “crazy,” hallucinations
- Anxiety, panic attacks, anger, rage

**COGNITIVE FUNCTION PROBLEMS**

- Loss or inability to concentrate or comprehend
- Short-term memory loss, short attention span
- Difficulty with synthesis of new information
- Letter/word reversal, speech difficulty, name block

**SKIN**

- Formications (“crawling” on skin)
- Numbness/tingling in hands/feet (paresthesias)
- Itching
- Bb infection may trigger acne
- Sore soles, esp. in A.M.

**RESPIRATORY**

- Persistent cough; non-productive cough
- Hypersensitivity to loud noise

**COGNITIVE FUNCTION PROBLEMS**

- Calculation difficulties
- Disorientation, forgetful, lose patience, confusion
- Getting lost, lose track
LYME DISEASE IN ONTARIO

Motile Stages of Blacklegged Tick

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