Alpha-gal/Meat Allergy

Meat allergy caused by the bite of the deer tick, *Amblyomma americanum*.

The tick’s saliva triggers immune response to a carbohydrate, alpha-gal, found in red meat. Although eating red meat is the most common allergic trigger to alpha-gal, ingredients found in everyday products such as dairy, gelatin, soap, cosmetics, lotions, household products, and medications can also cause an allergic reaction.*

Symptoms: Can develop 3-4 hours after exposure and include upset stomach, headaches, hives, rashes, swelling, shortness of breath, anaphylaxis.

* The Tick-Borne Conditions United, [www.tbcunited.org](http://www.tbcunited.org) website can provide additional information for you about alpha-gal. NOTE: If you click on the link, you will have left the [www.LymeDiseaseAssociation.org](http://www.LymeDiseaseAssociation.org) website. The information presented there is that of the Tick-Borne Conditions United.

©LDA. 2015. This web site provides practical and useful information on the subject matters covered. It is distributed with the understanding that LDA is not engaged in rendering medical or other professional services. Seek professional services if necessary.
53 Publications for LDA-Funded Research

The LDA has a long history of funding/supporting research projects that lead to real results. Below is the list of links to peer-reviewed articles that acknowledge LDA’s funding/support. Click on the publication link (or just scroll down to it) to see the authors, which authors LDA provided the funding for (green), and the abstract and a link to the publication itself when possible. When a journal has multiple publications, click on the year in which you are interested.

Brain, Behavior, & Immunity – Health 2020
Frontiers in Medicine 2019
Meta Gene 2019
Ticks and Tick-Borne Diseases 2018
Archives of Clinical Neuropsychology 2018
(2) Psychosomatics 2018, 2013
Healthcare (Basel) 2018
Bio-Protocol 2017
(6) PLOS One 2017, 2012 (2), 2011, 2010
The FEBS Journal 2017
ACS Chemical Biology 2017
Biochemistry 2017
Antibiotics March 2017
(2) Frontiers in Microbiology October 2016, May 2016
Park Science (NPS, Department of Interior) 2016
FEBS Microbiology Letters 2015
Clinical Infectious Disease 2014
Veterinary Sciences 2014
International Journal of Medical Sciences 2013
Northeastern Naturalist, 2013
Open Neurology Journal 2012
Journal of Bacteriology 2011
Genetics 2011
Journal of Medical Entomology 2010
Neurobiology of Disease 2010
Archives General Psychiatry 2009
Gene 2009
(2) Neurology 2008, 1999
Emerging Infectious Diseases July 2008
Minerva Medica October 2008
Click here to see a sample of conference presentations from researchers who have received LDA funding for their work.

Conference Presentations Resulting from LDA-Funding

**Journal Articles Below**


Anti-lysoganglioside and other anti-neuronal autoantibodies in post-treatment Lyme Disease and Erythema Migrans after repeat infection

**Brian A. Fallon** a,b,* Barbara Strobino, a,b, Sean Reim c, Julie Stoner d, Madeleine W. Cunningham c

a Columbia Psychiatry, Columbia University Irving Medical Center, New York, USA
b New York State Psychiatric Institute, 1051 Riverside Drive, New York, USA
c Department of Microbiology and Immunology, University of Oklahoma Health Sciences Center, Oklahoma City, USA
d Department of Biostatistics, University of Oklahoma Health Sciences Center, Oklahoma City, USA

*Corresponding author: Brian A. Fallon, Columbia University, 1051 Riverside Drive, Unit 69, New York, NY, 10032, USA.
Abstract: **Background:** Molecular mimicry targeting neural tissue has been reported after Borrelia burgdorferi (Bb) infection. Herein, we investigate whether antineuronal autoantibodies are increased and whether antibody-mediated signaling of neuronal cells is elevated in a cohort of symptomatic adults with a history of Lyme Disease (LD).

**Methods:** Participants (n = 179) included 24 with recent Erythema Migrans (EM) without prior LD, 8 with recent EM and prior LD (EM + prior LD), 119 with persistent post-treatment LD symptoms (PTLS), and 28 seronegative endemic controls with no prior LD history. Antineuronal immunoglobulin G (IgG) titers were measured by standard ELISA and compared with mean titers of normal age-matched sera against lysoganglioside, tubulin, and dopamine receptors (D1R and D2R). Antibody-mediated signaling of calcium calmodulin dependent protein kinase II (CaMKII) activity in a human neuronal cell line (SK-N-SH) was identified in serum. **Results:** EM + prior LD cases had higher antibody titers than controls for anti-lysoganglioside GM1 (p = 0.002), anti-tubulin (p = 0.03), and anti-D1R (p = 0.02), as well as higher expression in the functional antibody-mediated CaMKII Assay (p = 0.03). The EM cases with no prior history showed no significant differences on any measures. The PTLS cases demonstrated significantly higher titers (p = 0.01) than controls on anti-lysoganglioside GM1, but not for the other measures.

**Conclusion:** The finding of elevated anti-neuronal autoantibodies in our small sample of those with a prior history of Lyme disease but not in those without prior Lyme disease, if replicated in a larger sample, suggests an immune priming effect of repeated infection; the CaMKII activation suggests that antineuronal antibodies have functional significance. The elevation of anti-lysoganglioside antibodies among those with PTLS is of particular interest given the established role of anti-ganglioside antibodies in peripheral and central neurologic diseases. Future prospective studies can determine whether these autoantibodies emerge after Bb infection and whether their emergence coincides with...
persistent neurologic or neuropsychiatric symptoms.

52. Frontiers in Medicine, December 6, 2019

The General Symptom Questionnaire-30 (GSQ-30): A Brief Measure of Multi-System Symptom Burden in Lyme Disease

Brian A. Fallon 1,2*, Nevena Zubcevik 3,4, Clair Bennett 1,2, Shreya Doshi 1,2, Alison W. Rebman 5, Ronit Kishon 1,2, James R. Moeller 1,2, Nadlyne R. Octavien 3 and John N. Aucott 5

1 Department of Psychiatry, Lyme and Tick-Borne Diseases Research Center, Columbia University Irving Medical Center, New York, NY, United States
2 Department of Psychiatry, New York State Psychiatric Institute, New York, NY, United States
3 Department of Physical Medicine and Rehabilitation, Dean Center for Tick borne Illness, Harvard Medical School, Spaulding Rehabilitation Hospital, Boston, MA, United States
4 Department of Physical Medicine and Rehabilitation, Massachusetts General Hospital, Boston, MA, United States
5 Division of Rheumatology, Department of Medicine, Lyme Disease Research Center, Johns Hopkins School of Medicine, Baltimore, MD, United States
*Correspondence: Brian A. Fallon, baf1@cumc.columbia.edu

Abstract: Introduction: The multi-system symptoms accompanying acute and post-treatment Lyme disease syndrome pose a challenge for time-limited assessment. The General Symptom Questionnaire (GSQ-30) was developed to fill the need for a brief patient-reported measure of multi-system symptom burden. In this study we assess the psychometric properties and sensitivity to change of the GSQ-30. Materials and Methods: 342 adult participants comprised 4 diagnostic groups: Lyme disease (post-treatment Lyme disease syndrome, n = 124; erythema migrans, n = 94); depression, n = 36; traumatic brain injury, n = 51; healthy, n = 37. Participants were recruited from clinical research facilities in Massachusetts, Maryland,
and New York. Validation measures for the GSQ-30 included the Patient Health Questionnaire-4 for depression and anxiety, visual analog scales for fatigue and pain, the Sheehan Disability Scale for functional impairment, and one global health question. To assess sensitivity to change, 53 patients with erythema migrans completed the GSQ-30 before treatment and 6 months after 3 weeks of treatment with doxycycline.

**Results:** The GSQ-30 demonstrated excellent internal consistency (Cronbach $\alpha = 0.95$). The factor structure reflects four core domains: pain/fatigue, neuropsychiatric, neurologic, and viral-like symptoms. Symptom burden was significantly associated with depression ($rs = 0.60$), anxiety ($rs = 0.55$), pain ($rs = 0.75$), fatigue ($rs = 0.77$), functional impairment ($rs = 0.79$), and general health ($rs = -0.58$). The GSQ-30 detected significant change in symptom burden before and after antibiotic therapy; this change correlated with change in functional impairment. The GSQ-30 total score significantly differed for erythema migrans vs. three other groups (post-treatment Lyme disease syndrome, depression, healthy controls). The GSQ-30 total scores for traumatic brain injury and depression were not significantly different from post-treatment Lyme disease syndrome. **Conclusions and Relevance:** The GSQ-30 is a valid and reliable instrument to assess symptom burden among patients with acute and post-treatment Lyme disease syndrome and is sensitive in the detection of change after treatment among patients with erythema migrans. The GSQ-30 should prove useful in clinical and research settings to assess multi-system symptom burden and to monitor change over time. The GSQ-30 may also prove useful in future precision medicine studies as a clinical measure to correlate with disease-relevant biomarkers.


Genetic Variation in the ABCB1 Gene Associated with Post Treatment Lyme Disease Syndrome Status
Joanna Lyon 1, Hyunuk Seung 2

1 Advanced Clinical Pharmacist, University of Maryland School of Pharmacy, United States of America jlyon@rx.umaryland.edu
2 Department of Pharmacy Practice and Science, University of Maryland School of Pharmacy, United States of America hseung@rx.umaryland.edu

Abstract: Post Treatment Lyme Disease Syndrome (PTLDS) poses a difficult to understand health issue. This multi-centered, randomized control trial studied the possible correlation between ABCB1 (MDR1) gene variants and the incidence of PTLDS in affected patients. Genomic DNA was isolated and analyzed for four ABCB1 gene SNPs (rs1128503, rs1045642, rs2235067, and rs4148740). Significant findings include the association of rs1128503 TC variant with PTLDS status. Additionally, the rs1128503+ rs1045642+ rs2235067 SNP combination increased rs1128503 genotype TC significance to 3.83 times the rs1128503 genotype CC. The TT variant of rs4148740 in conjunction with rs1128503 reduced the odds ratio and appeared to convey a PTLDS protective status to the rs1128503 TC variant.


Regional prevalences of Borrelia burgdorferi, Borrelia bissettiae, and Bartonella henselae in Ixodes affinis, Ixodes pacificus and Ixodes scapularis in the USA.
Maggi RG 1, Toliver M 2, Richardson T 3, Mather T 4, Breitschwerdt EB 5

1 Intracellular Pathogens Research Laboratory, Comparative Medicine Institute, College of Veterinary Medicine, North Carolina State University (NCSU), 1060 William Moore Drive, Raleigh, NC 27607. rgmaggi@ncsu.edu
2 Public Health Pest Management Section, NC Department of Environment and Natural Resources, 10005 Waterford Court,
ABSTRACT: The objective of this work was to determine the prevalence of Borrelia and Bartonella species in Ixodes spp. ticks collected from 16 USA states. Genus PCR amplification and sequence analysis of Bartonella and Borrelia 16SsRNA-23SsRNA intergenic regions were performed on DNA extracted from 929 questing adult ticks (671 Ixodes scapularis, 155 Ixodes affinis, and 103 Ixodes pacificus). Overall, 129/929 (13.9%) Ixodes ticks were PCR positive for Borrelia burgdorferi sensu stricto, 48/929 for B. bissettiae whereas 23/929 (2.5%) were PCR positive for a Bartonella henselae. Borrelia bissettiae or B. burgdorferi s.s. and B. henselae co-infections were found in I. affinis from North Carolina at a rate of 4.5%; in a single I. scapularis from Minnesota, but not in I. pacificus. For both bacterial genera, PCR positive rates were highly variable depending on geographic location and tick species, with Ixodes affinis (n = 155) collected from North Carolina, being the tick species with the highest prevalence’s for both Borrelia spp. (63.2%) and B. henselae (10.3%). Based on the results of this and other published studies, improved understanding of the enzootic cycle, transmission dynamics, and vector competence of Ixodes species (especially I. affinis) for transmission of Borrelia spp. and B. henselae should be a public health
Neurocognition in Post-Treatment Lyme Disease and Major Depressive Disorder

Keilp JG 1,2,3*, Corbera K 1, Gorlyn M 2, Oquendo MA 2,3,4, Mann JJ 2,3 Fallon BA 1,2,3

*Corresponding author at: New York State Psychiatric Institute and Department of Psychiatry, Columbia University College of Physicians and Surgeons, Box 42, NYSPI, 1051 Riverside Drive, New York, NY 10032, USA. Tel.: 1-646-774-7509. E-mail: jgk13@cump.columbia.edu (J.G. Keilp)

1 Lyme Disease Research Center, Columbia University College of Physicians and Surgeons, New York, NY
2 Department of Psychiatry, Columbia University College of Physicians and Surgeons, New York, NY
3 Department of Molecular Imaging and Neuropathology, New York State Psychiatric Institute, New York, NY
4 Department of Psychiatry, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

Dr. John Keilp, senior neuropsychologist for the Columbia Lyme & Tick-borne Diseases Research Center’, reports that the cognitive profile of patients with post treatment Lyme disease is meaningfully different from the profile of patients with major depression. This is a neurocognitive biomarker or fingerprint of post-treatment Lyme disease. Although both groups might have fatigue and mental fogginess, the Lyme group more often reports problems with verbal memory and verbal fluency while the depressed (non-Lyme) group more often reports slower processing speed and poor attention. These results highlight the value of neurocognitive testing in helping to tease out the potential causes of cognitive problems in patients with post-treatment Lyme disease.
Depressive Symptoms and Suicidal Ideation Among Symptomatic Patients with a History of Lyme Disease Versus Two Comparison Groups

Shreya Doshi M.A 1*, John G. Keilp Ph.D 2., Barbara Strobino Ph.D. 1, Martin McElhinney Ph.D. 1, Judith Rabkin Ph.D. 1, Brian A. Fallon M.D. 1

1 Division of Clinical Therapeutics, Department of Psychiatry, New York State Psychiatric Institute, New York, NY
2 Division of Molecular Imagining and Neuropathology, Department of Psychiatry, New York State Psychiatric Institute, New York, NY
*sd2698@tc.columbia.edu

ABSTRACT: Background: Depression has been reported in 8–45% of patients with posttreatment Lyme symptoms (PTLS), but little is known about suicidal ideation in these patients. Method: Depression and suicidal ideation were assessed using the Beck Depression Inventory (BDI-II). Scores from the PTLS group (n = 81) were compared to those from 2 other groups: HIV+ patients being treated for fatigue (n = 70), and a nonpatient comparison group (NPCG; n = 44). ANOVA and t-tests were used to compare groups; logistic regression was used to identify the strongest correlates of suicidal ideation. Results: Mean BDI-II scores fell in the mildly depressed range for PTLS and HIV+ patients, with both groups having higher depression scores than the NPCG. Suicidal ideation was reported by 19.8% of the PTLS patients and 27.1% of the HIV+ patients, a nonsignificant difference. Among those with mild or no depression, suicidal ideation was uncommon (6.5% PTLS and 11.9% HIV+). Among the patients with moderate-to-severe depression, suicidal ideation was more common (63.2% of 19 PTLS and 50% of 28 HIV+); among these, 2 with PTLS and 1 with HIV+ expressed suicidal intent. Further, 4.5% (n = 2) of the NPCG had suicidal ideation, each had scores in the moderate-
to-severe depression range. Higher scores on the cognitive symptoms subscale of the BDI-II predicted greater likelihood of suicidal ideation across patient groups. Conclusion: As expected, suicidal ideation is increased among patients who are depressed. The fact that 1 in 5 patients with PTLS reported suicidal ideation highlights the importance of screening for depression and suicidality to optimize patient care.

A Community Study of Borrelia burgdorferi Antibodies among Individuals with Prior Lyme Disease in Endemic Areas
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6023339/

Barbara Strobino 1,2,* Katja Steinhagen 3, Wolfgang Meyer 3, Thomas Scheper 3, Sandra Saschenbrecker 3, Wolfgang Schlumberger 3, Winfried Stöcker 3, Andrea Gaito 4 and Brian A. Fallon 1.1 Department of Psychiatry, Lyme and Tick-Borne Diseases Research Center, Columbia University Irving Medical Center, New York, NY 10032, USA; baf1@cumc.columbia.edu
2 Research Foundation for Mental Hygiene, Inc., New York, NY 10032, USA
3 Institute for Experimental Immunology, Euroimmun, 23560 Lübeck, Germany; k.steinhagen@euroimmun.de (K.S.); w.meyer@euroimmun.de (W.M.); t.scheper@euroimmun.de (T.S.); s.saschenbrecker@euroimmun.de (S.S.); w.schlumberger@euroimmun.de (Wo.S.); w.stoecker@euroimmun.de (Wi.S.)
4 Independent Researcher, Basking Ridge, NJ 07920, USA; adg0339@gmail.com
* Correspondence: barbara.strobino@nyspi.columbia.edu; Tel.: +1-646-774-8052

Abstract: The objective was to examine the prevalence of Borrelia antibodies among symptomatic individuals with recent and past Lyme disease in endemic communities using standard
assays and novel assays employing next-generation antigenic substrates. Single- and two-tiered algorithms included different anti-Borrelia ELISAs and immunoblots. Antibody prevalence was examined in sera from 32 individuals with recent erythema migrans (EM), 335 individuals with persistent symptoms following treatment for Lyme disease (PTLS), and 41 community controls without a history of Lyme disease. Among convalescent EM cases, sensitivity was highest using the C6 ELISA (93.8%) compared to other single assays; specificity was 92.7% for the C6 ELISA vs. 85.4–97.6% for other assays. The two-tiered ELISA-EUROLINE IgG immunoblot combinations enhanced case detection substantially compared to the respective ELISA-IgGWestern blot combinations (75.0% vs. 34.4%) despite similar specificity (95.1% vs. 97.6%, respectively). For PTLS cohorts, two-tier ELISA-IgG-blot positivity ranged from 10.1% to 47.4%, depending upon assay combination, time from initial infection, and clinical history. For controls, the two-tier positivity rate was 0–14.6% across assays. A two-tier algorithm of two-ELISA assays yielded a high positivity rate of 87.5% among convalescent EM cases with specificity of 92.7%. For convalescent EM, combinations of the C6 ELISA with a second-tier ELISA or line blot may provide useful alternatives to WB-based testing algorithms.


Lentiviral Knockdown of Transcription Factor STAT1 in Peromyscus leucopus to Assess Its Role in the Restriction of Tick-borne Flaviviruses
Adaeze O. Izuogu,1 and R. Travis Taylor1,*
*travis.taylor@utoledo.edu

1 Department of Medical Microbiology and Immunology, University of Toledo College of Medicine and Life Sciences, Toledo, Ohio, USA
ABSTRACT: Cellular infection with tick-borne flaviviruses (TBFVs) results in activation of the interferon (IFN) signaling pathway and subsequent upregulation of numerous genes termed IFN stimulated genes (ISGs) (Schoggins et al., 2011). Many ISGs function to prevent virus pathogenesis by acting in a broad or specific manner through protein-protein interactions (Duggal and Emerman, 2012). The potency of the IFN signaling response determines the outcome of TBFV infection (Best, 2017; Carletti et al., 2017). Interestingly, data from our lab show that TBFV replication is significantly restricted in cells of the reservoir species Peromyscus leucopus thereby suggesting a potent antiviral response (Izuogu et al., 2017). We assessed the relative contribution of IFN signaling to resistance in P. leucopus by knocking down a major transcription factor in the IFN response pathway. Signal transducer and activator of transcription 1 (STAT1) was specifically targeted in P. leucopus cells by shRNA technology. We further tested the impact of gene knockdown on the ability of cells to respond to IFN and restrict virus replication; the results indicate that when STAT1 expression is altered, P. leucopus cells have a decreased response to IFN stimulation and are significantly more susceptible to TBFV replication.


Nuclease activity gives an edge to host-defense peptide piscidin 3 over piscidin 1, rendering it more effective against persisters and biofilms.
Libardo MDJ1, Bahar AA2, Ma B3, Fu R4, McCormick LE5, Zhao J6, McCallum SA7, Nussinov R3,8, Ren D2,9,10,11, Angeles-Boza* AM1, Cotten* ML12.
*alfredo.angeles-boza@uconn.edu, *mcotten@wm.edu

1 Department of Chemistry, University of Connecticut, Storrs, CT, USA.
2 Department of Biomedical and Chemical Engineering, Syracuse
ABSTRACT: Host-defense peptides (HDPs) feature evolution-tested potency against life-threatening pathogens. While piscidin 1 (p1) and piscidin 3 (p3) are homologous and potent fish HDPs, only p1 is strongly membranolytic. Here, we hypothesize that another mechanism imparts p3 strong potency. We demonstrate that the N-termini of both peptides coordinate Cu2+ and p3-Cu cleaves isolated DNA at a rate on par with free Cu2+ but significantly faster than p1-Cu. On planktonic bacteria, p1 is more antimicrobial but only p3 features copper-dependent DNA cleavage. On biofilms and persister cells, p3-Cu is more active than p1-Cu, commensurate with stronger peptide-induced DNA damage. Molecular dynamics and NMR show that more DNA-peptide interactions exist with p3 than p1, and the peptides adopt conformations simultaneously poised for metal- and DNA-binding. These results generate several
important conclusions. First, homologous HDPs cannot be assumed to have identical mechanisms since p1 and p3 eradicate bacteria through distinct relative contributions of membrane and DNA-disruptive effects. Second, the nuclease and membrane activities of p1 and p3 show that naturally occurring HDPs can inflict not only physicochemical but also covalent damage. Third, strong nuclease activity is essential for biofilm and persister cell eradication, as shown by p3, the homolog more specific toward bacteria and more expressed in vascularized tissues. Fourth, p3 combines several physicochemical properties (e.g., Amino Terminal Copper and Nickel binding motif; numerous arginines; moderate hydrophobicity) that confer low membranolytic effects, robust copper-scavenging capability, strong interactions with DNA, and fast nuclease activity. This new knowledge could help design novel therapeutics active against hard-to-treat persister cells and biofilms.

https://pubs.acs.org/doi/abs/10.1021/acschembio.7b00237
Membrane Oxidation in Cell Delivery and Cell Killing Applications
Ting-Yi Wang,†,⊥ M. Daben J. Libardo,‡,⊥ Alfredo M. Angeles-Boza,*,‡ and Jean-Philippe Pellois*,†,§
†Department of Biochemistry and Biophysics, Texas A&M University, College Station, Texas 77843, United States
‡Department of Chemistry, University of Connecticut, Storrs, Connecticut 06269, United States
§Department of Chemistry, Texas A&M University, College Station, Texas 77843, United States
*E-mail: pellois@tamu.edu., *E-mail: alfredo.angeles-boza@uconn.edu.

ABSTRACT: Cell delivery or cell killing processes often involve the crossing or disruption of cellular membranes. We
review how, by modifying the composition and properties of membranes, membrane oxidation can be exploited to enhance the delivery of macromolecular cargoes into live human cells. We also describe how membrane oxidation can be utilized to achieve efficient killing of bacteria by antimicrobial peptides. Finally, we present recent evidence highlighting how membrane oxidation is intimately engaged in natural biological processes such as antigen delivery in dendritic cells and in the killing of bacteria by antimicrobial peptides. Overall, the insights that have been recently gained in this area should facilitate the development of more effective delivery technologies and antimicrobial therapeutic approaches.

https://pubs.acs.org/doi/abs/10.1021/acs.biochem.6b01046

Exploration of the Innate Immune System of Styela clava: Zn2+ Binding Enhances the Antimicrobial Activity of the Tunicate Peptide Clavanin A
Samuel A. Juliano†, Scott Pierce†, James A. deMayo‡, Marcy J. Balunas‡, and Alfredo M. Angeles-Boza*†
† Department of Chemistry, University of Connecticut, Storrs, Connecticut 06269-3060, United States
‡ Division of Medicinal Chemistry, Department of Pharmaceutical Sciences, University of Connecticut, Storrs, Connecticut 06269, United States
*E-mail: alfredo.angeles-boza@uconn.edu.

ABSTRACT: Tunicates have been used as primitive models for understanding cell-mediated and humoral immunity. Clavanin A (ClavA) is one member of a family of antimicrobial peptides produced by the solitary tunicate Styela clava. In this work, we demonstrate that ClavA utilizes Zn2+ ions to potentiate its antimicrobial activity not only by reducing the concentration at which the peptide inhibits the growth of bacteria but also by increasing the rate of killing. Membrane depolarization, β-
galactosidase leakage, and potassium leakage assays indicate that ClavA is membrane active, forms small pores, but induces cell death by targeting an intracellular component. ClavA and ClavA-Zn2+ added to Escherichia coli and imaged by confocal microscopy translocate across the cell membrane. E. coli mutants lacking the functional Zn2+ import system are less susceptible to ClavA, suggesting that the synergistic activity between ClavA and Zn2+ has a cytoplasmic target, which is further supported by its nucleolytic activity. Overall, these studies identify a remarkable new mechanism by which zinc contributes to the immune response in the tunicate S. clava.


Interferon Signaling in Peromyscus Leucopus Confers a Potent and Specific Restriction to Vector-borne Flaviviruses
Adaeze O. Izuogu1, Kristin L. McNally2, Stephen E. Harris3, Brian H. Youseff1, John B. Presloid1, Christopher Burlak4, Jason Munshi-South5, Sonja M. Best2, R. Travis Taylor1*
1 Department of Medical Microbiology and Immunology, University of Toledo College of Medicine and Life Sciences, Toledo, Ohio, United States of America, 2 Innate Immunity and Pathogenesis Unit, Laboratory of Virology, Rocky Mountain Laboratories, DIR, NIAID, NIH, Hamilton, Montana, United States of America, 3 The Graduate Center, City University of New York, New York, New York, United States of America, 4 Department of Surgery, University of Minnesota, Minneapolis, Minnesota, United States of America, 5 Louis Calder Center-Biological Field Station, Fordham University, Armonk, New York, United States of America
* travis.taylor@utoledo.edu

Abstract: Tick-borne flaviviruses (TBFVs), including Powassan virus and tick-borne encephalitis virus cause encephalitis or hemorrhagic fevers in humans with case-fatality rates ranging from 1-30%. Despite severe disease in humans, TBFV infection
of natural rodent hosts has little noticeable effect. Currently, the basis for resistance to disease is not known. We hypothesize that the coevolution of flaviviruses with their respective hosts has shaped the evolution of potent antiviral factors that suppress virus replication and protect the host from lethal infection. In the current study, we compared virus infection between reservoir host cells and related susceptible species. Infection of primary fibroblasts from the white-footed mouse (Peromyscus leucopus, a representative host) with a panel of vector-borne flaviviruses showed up to a 10,000-fold reduction in virus titer compared to control Mus musculus cells. Replication of vesicular stomatitis virus was equivalent in P. leucopus and M. musculus cells suggesting that restriction was flavivirus-specific. Step-wise comparison of the virus infection cycle revealed a significant block to viral RNA replication, but not virus entry, in P. leucopus cells. To understand the role of the type I interferon (IFN) response in virus restriction, we knocked down signal transducer and activator of transcription 1 (STAT1) or the type I IFN receptor (IFNAR1) by RNA interference. Loss of IFNAR1 or STAT1 significantly relieved the block in virus replication in P. leucopus cells. The major IFN antagonist encoded by TBFV, nonstructural protein 5, was functional in P. leucopus cells, thus ruling out ineffective viral antagonism of the host IFN response. Collectively, this work demonstrates that the IFN response of P. leucopus imparts a strong and virus-specific barrier to flavivirus replication. Future identification of the IFN-stimulated genes responsible for virus restriction specifically in P. leucopus will yield mechanistic insight into efficient control of virus replication and may inform the development of antiviral therapeutics.

41. Antibiotics, March 22, 2017
http://www.mdpi.com/2079-6382/6/1/10/pdf
Activity of Sulfa Drugs and Their Combinations against Stationary Phase B. burgdorferi In Vitro
Jie Feng, Shuo Zhang, Wanliang Shi and Ying Zhang
Abstract: Lyme disease is a most common vector-borne disease in the US. Although the majority of Lyme patients can be cured with the standard two- to four-week antibiotic treatment, at least 10%–20% of patients continue to suffer from prolonged post-treatment Lyme disease syndrome (PTLDS). While the cause for this is unclear, one possibility is that persisting organisms are not killed by current Lyme antibiotics. In our previous studies, we screened an FDA drug library and an NCI compound library on B. burgdorferi and found some drug hits including sulfa drugs as having good activity against B. burgdorferi stationary phase cells. In this study, we evaluated the relative activity of three commonly used sulfa drugs, sulfamethoxazole (Smx), dapsone (Dps), sulfachlorpyridazine (Scp), and also trimethoprim (Tmp), and assessed their combinations with the commonly prescribed Lyme antibiotics for activities against B. burgdorferi stationary phase cells. Using the same molarity concentration, dapsone, sulfachlorpyridazine and trimethoprim showed very similar activity against stationary phase B. burgdorferi enriched in persisters; however, sulfamethoxazole was the least active drug among the three sulfa drugs tested. Interestingly, contrary to other bacterial systems, Tmp did not show synergy in drug combinations with the three sulfa drugs at their clinically relevant serum concentrations against B. burgdorferi. We found that sulfa drugs combined with other antibiotics were more active than their respective single drugs and that four-drug combinations were more active than three-drug combinations. Four-drug combinations dapsone + minocycline + cefuroxime + azithromycin and dapsone + minocycline + cefuroxime + rifampin showed the best activity against stationary phase B. burgdorferi in these sulfa drug combinations. However, these four-sulfa-drug-containing combinations still had considerably less activity against B. burgdorferi stationary phase cells than the Daptomycin + cefuroxime + doxycycline used as a positive control which completely eradicated B. burgdorferi stationary phase cells.
Future studies are needed to evaluate and optimize the sulfa drug combinations in vitro and also in animal models.

40. Frontiers in Microbiology, October 19, 2016
Ceftriaxone Pulse Dosing Fails to Eradicate Biofilm-like Microcolony B. burgdorferiPersisters Which Are Sterilized by Daptomycin/Doxycycline/Cefuroxime DrugCombination without Pulse Dosing
Jie Feng1, Shuo Zhang1, Wanliang Shi1, Ying Zhang1*
1Department of Molecular Microbiology and Immunology, Bloomberg School of Public Health, Johns Hopkins University, USA
*Corresponding author: Ying Zhang, MD, PhD
Department of Molecular Microbiology and Immunology, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD 21205, USA yzhang@jhsph.edu

Abstract: Although the majority of Lyme disease patients can be cured, at least 10-20% of the patients continue to suffer from persisting symptoms such as fatigue, muscular and joint pain, and neurologic impairment after standard 2-4 week antibiotic treatment. While the causes for this post-treatment Lyme disease symptoms are unclear, one possibility is due to B. burgdorferi persisters that are not effectively killed by current antibiotics such as doxycycline or amoxicillin used to treat Lyme disease. A previous study showed that four rounds of ceftriaxone pulse dosing treatment eradicated B. burgdorferi persisters in vitro using a relatively young late log phase culture (5 day old). In this study, we investigated if ceftriaxone pulse dosing could also eradicate B. burgdorferi persisters in older stationary phase cultures (10 day old) enriched with more resistant microcolony form of persisters. We found that ceftriaxone pulse dosing could only eradicate planktonic log phase B. burgdorferi spirochetal forms and round body forms but not more resistant aggregated biofilm-like microcolony persisters enriched in stationary phase cultures. Moreover, we found that not all drugs are suitable for pulse dosing, with bactericidal drugs ceftriaxone and cefuroxime being more appropriate for pulse dosing than bacteriostatic drug doxycycline and persister drug daptomycin. We also showed that drug combination pulse dosing treatment was more effective than single drug pulse dosing. Importantly, we demonstrate that pulse dosing treatment impaired the activity of the persister drug daptomycin and its drug combination against B. burgdorferi persisters and that the most effective way to kill the more resistant biofilm-like microcolonies is the daptomycin/doxycycline/ceftriaxone triple drug combination without pulse dosing. Our findings indicate pulse dosing may not always work as a general principle but rather depends on the specific drugs used, with cidal drugs being more appropriate for pulse dosing than static or persister drugs, and that drug combination approach with persister drugs is more effective at killing the more resistant microcolony form of persisters than pulse dosing. These observations may have implications for more effective treatment of Lyme disease. Future studies are required to validate these findings in animal models of B. burgdorferi persistence.

A Drug Combination Screen Identifies Drugs Active against Amoxicillin-Induced Round Bodies of In Vitro Borrelia burgdorferi Persisters from an FDA Drug Library
Ying Zhang, Jie Feng, Wanliang Shi, Shuo Zhang, David Sullivan, Paul G. Auwaerter, Johns Hopkins
Abstract: Although currently recommended antibiotics for Lyme disease such as doxycycline or amoxicillin cure the majority of the patients, about 10–20% of patients treated for Lyme disease may experience lingering symptoms including fatigue, pain, or joint and muscle aches. Under experimental stress conditions such as starvation or antibiotic exposure, Borrelia burgdorferi can develop round body forms, which are a type of persister bacteria that appear resistant in vitro to customary first-line antibiotics for Lyme disease. To identify more effective drugs with activity against the round body form of B. burgdorferi, we established a round body persister model induced by exposure to amoxicillin (50 μg/ml) and then screened the Food and Drug Administration drug library consisting of 1581 drug compounds and also 22 drug combinations using the SYBR Green I/propidium iodide viability assay. We identified 23 drug candidates that have higher activity against the round bodies of B. burgdorferi than either amoxicillin or doxycycline. Eleven individual drugs scored better than metronidazole and tinidazole which have been previously described to be active against round bodies. In this amoxicillin-induced round body model, some drug candidates such as daptomycin and clofazimine also displayed enhanced activity which was similar to a previous screen against stationary phase B. burgdorferi persisters not exposure to amoxicillin. Additional candidate drugs active against round bodies identified include artemisinin, ciprofloxacin, nifuroxime, fosfomycin, chlortetracycline, sulfacetamide, sulfamethoxypyridazine and sulfathiazole. Two triple drug combinations had the highest activity against amoxicillin-induced round bodies and stationary phase B. burgdorferi persisters: artemisinin/cefoperazone/doxycycline and sulfachlorpyridazine/daptomycin/doxycycline. These findings confirm and extend previous findings that certain drug combinations have superior activity against B. burgdorferi persisters in vitro, even when pre-treated with amoxicillin. These findings may have implications for improved treatment of Lyme disease.

38. Park Science (NPS, Department of Interior) March 2016
http://www.nature.nps.gov/ParkScience/Archive/PDF/Article_PDFs/ParkScience32(1)Summer2015_36-41_Ford_et_al_3819.pdf

Tick surveillance and disease prevention on the Appalachian Trail
(Also published in Appalachian Trail Journeys, The Magazine of the Appalachian Trail Conservancy, May/June 2014)

Karl Ford, Robyn Nadolny, Ellen Stromdahl, and Graham Hickling

Abstract: The Appalachian National Scenic Trail (AT) runs 3,520 km (2,187 mi) from northern Georgia to northern Maine, traversing 14 states where Lyme disease and other tickborne diseases are endemic or emerging. Approximately 2–3 million visitors hike the AT annually, including through-hikers who spend five to six months on the trail in spring through early fall, when common tick species are active. Disease vector tick surveillance was conducted from April through August 2013 at 42 randomly selected AT shelter areas along a south-to-north transect covering the full length of the AT. Tick abundance at
shelters and tenting areas was compared with tick abundance on the AT itself, and the collected ticks were tested for common bacterial pathogens. Human-biting tick species collected comprised *Ixodes scapularis*, *Amblyomma americanum*, *Amblyomma maculatum*, and *Dermacentor variabilis*. Human pathogens *Borrelia burgdorferi* and *Rickettsia montanensis* were detected in tested ticks. Tick abundance on the trail was low overall (2.8 ticks per 1,000 m² sampled), but exceeded tick abundance in shelters and tenting areas by 14.5 times. No ticks were collected south of Virginia or north of Massachusetts, or above 829 m (2,720 ft) in elevation, which suggests that season and elevation are significant determinants of the risk of hiker exposure to questing ticks on the AT. Such information should be included in future health messaging to hikers along with preventive measures. Management issues are discussed.

37. FEMS Microbiology Letters Advance Access, July 24, 2015
http://femsle.oxfordjournals.org/content/early/2015/07/23/femsle.fnv120

Biofilm formation by *1 Borrelia sensu lato*

Arun Timmaraju1,2,†, Priyanka A.S. Theophilus1,†, Kunthavai Balasubramanian1,3, Shafiq Shakhil1, David F. Leuckel and Eva Sapi,*

1 Lyme disease research group, Department of Biology and Environmental Science, University of New Haven, West Haven, CT, USA
2 Present address: Interpace Diagnostics, New Haven, CT, 06519
3 Present address: Department of Hematology, Yale School of Medicine, New Haven, CT, 06520
† Contributed equally
* Correspondence: Eva Sapi Ph.D., Department of Biology and Environmental Sciences, University of New Haven, 1211 Campbell Avenue, Charger Plaza LL16. West Haven, CT, 06516, USA. esapi@newhaven.edu

Abstract: Bacterial biofilms are microbial communities held together by an extracellular polymeric substance matrix predominantly composed of polysaccharides, proteins and nucleic acids. We had previously shown that *Borrelia burgdorferi* sensu
stricto, the causative organism of Lyme disease in the United States is capable of forming biofilms in vitro. Here, we investigated biofilm formation by Borrelia afzelii and Borrelia garinii, which cause Lyme disease in Europe. Using various histochemistry and microscopy techniques, we show that Borrelia afzelii and Borrelia garinii form biofilms, which resemble biofilms formed by Borrelia burgdorferi sensu stricto. High-resolution atomic force microscopy revealed similarities in the ultra-structural organization of the biofilms formed by three Borrelia species. Histochemical experiments revealed a heterogeneous organization of exopolysaccharides among the three Borrelia species. These results suggest that biofilm formation might be a common trait of Borrelia genera physiology.

36. Clinical Infectious Diseases Advance Access, September 2, 2014
A comparison of Lyme disease serologic test results from four laboratories in patients with persistent symptoms after antibiotic treatment
Brian A. Fallon1, Martina Pavlicova2, Samantha W. Coffino3, Carl Brenner4
1 Department of Psychiatry, Columbia University, New York NY
2 Department of Biostatistics, Mailman School of Public Health, Columbia University, New York, NY
3 Department of Neurology, Columbia University, New York, NY
4 Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY

Summary: In patients with post-treatment Lyme syndrome, rates of positive serologic test results were generally similar among a university laboratory, a commercial laboratory, and two Lyme specialty laboratories, although interlaboratory variability was high and the IgM Western Blot performed poorly.

Abstract: Background – As the incidence of Lyme disease (LD) has increased, a number of “Lyme specialty laboratories” have emerged, claiming singular expertise in LD testing. We investigated the degree of interlaboratory variability of several LD serologic tests—whole cell sonicate (WCS) enzyme-linked immunosorbent assay (ELISA), IgM and IgG Western blots (WB), and an ELISA based on the conserved sixth region of VlsE (C6)—performed at one university laboratory, one commercial laboratory and two laboratories that specialize in LD testing.

35. Veterinary Sciences, 2014 www.mdpi.com/2306-7381/1/1/5
Filarial Nematode Infection in Ixodes scapularis Ticks Collected from Southern Connecticut
Pabbati Namrata, Jamie M. Miller, Madari Shilpa, Patlolla Raghavender Reddy, Cheryl Bandoski, Michael J. Rossi and Eva Sapi*
Abstract: It was recently demonstrated that the lone star tick Amblyomma americanum could harbor filarial nematodes within the genus Acanthocheilonema. In this study, Ixodes scapularis (deer) ticks collected from Southern Connecticut were evaluated for their potential to harbor filarial nematodes. Non-engorged nymphal and adult stage Ixodes scapularis ticks were collected in Southern Connecticut using the standard drag method. In situ hybridization with filarial nematode specific sequences demonstrated the presence of filarial nematodes in Ixodes ticks. Filarial nematode specific DNA sequences were amplified and confirmed by direct sequencing in Ixodes nymphal and adult ticks using either general filarial nematode or Onchocercidae family specific PCR primers. Phylogenetic analysis of the 12S rDNA gene sequence indicated that the filarial nematode infecting Ixodes scapularis ticks is most closely related to the species found in Amblyomma americanum ticks and belongs to the genus of Acanthocheilonema. Our data also demonstrated that infection rate of these filarial nematode in Ixodes ticks is relatively high (about 22% and 30% in nymphal and adult Ixodes ticks, respectively). In summary, the results from our studies demonstrated that filarial nematode infection was found in Ixodes ticks similar to what has been found in Amblyomma americanum ticks.

34. Psychosomatics 2013
http://www.psychosomaticsjournal.com/article/S0033-3182%2813%2900078-9/fulltext
Correlates of Perceived Health-Related Quality of Life in Post-treatment Lyme Encephalopathy

1 Department of Psychiatry, Columbia University, New York, NY.
2 Division of Clinical Therapeutics of the New York State Psychiatric Institute, New York, NY
*Corresponding Author: Brian A. Fallon, M.D bafl@columbia.edu

ABSTRACT: Background – Marked functional impairment has been reported by patients with post-treatment Lyme disease syndrome (PTLDS). Objective: We sought to identify but the clinical features that contribute most strongly to the impaired health status associated with PTLDS. Methods: Enrolled patients had a well-documented history of Lyme disease, prior treatment with at least 3 weeks with intravenous ceftriaxone, a positive IgG Western blot, and objective problems with memory. An index score to capture aggregate cognitive functioning, Short-Form 36 physical and
mental component summer scores, and scores on other clinical and demographic measures were examined. Multiple linear regressions were performed to determine significant predictors of perceptions of impaired life functioning as delineated by the Short-Form 36. Results: Fatigue was the most important contributor to perceived impairments in overall physical functioning, and fatigue and depression significantly predicted perceived impairments in overall mental functioning. Conclusions: Because fatigue and depression contribute prominently to reports of impaired physical functioning and mental functioning among patients with PTLDs, clinicians should assess patients for these symptoms and consider targeting these symptoms in the selection of treatment interventions. Future controlled studies should examine the effectiveness of such agents for patients with PTLDs.

33. International Journal of Medical Sciences 2013
http://www.medsci.org/v10p0915.htm
Lyme Borreliosis in Human Patients in Florida and Georgia, USA
Kerry L. Clark-1, Brian Leydet-1,2, Shirley Hartman-3

1-University of North Florida, 2-Louisiana State University, 3-Mandarin Wellness Center, Florida
Corresponding author: Kerry L. Clark, M.P.H., Ph.D., Department of Public Health, University of North Florida,
1 UNF Drive, Jacksonville, FL 32224. Phone: (904) 620-1427. Fax: (904) 620-2848. E-mail: kclark@unf.edu.

ABSTRACT: The aim of this study was to determine the cause of illness in several human patients residing in Florida and Georgia, USA, with suspected Lyme disease based upon EM-like skin lesions and/or symptoms consistent with early localized or late disseminated Lyme borreliosis. Using polymerase chain reaction (PCR) assays developed specifically for Lyme group Borrelia spp., followed by DNA sequencing for confirmation, we identified Borrelia burgdorferi sensu lato DNA in samples of blood and skin and also in lone star ticks (Amblyomma americanum) removed from several patients who either live in or were exposed to ticks in Florida or Georgia. This is the first report to present combined PCR and DNA sequence evidence of infection with Lyme Borrelia spp. in human patients in the southern U.S., and to demonstrate that several B. burgdorferi sensu lato species may be associated with Lyme disease-like signs and symptoms in southern states. Based on the findings of this study, we suggest that human Lyme borreliosis occurs in Florida and Georgia, and that some cases of Lyme-like illness referred to as southern tick associated rash illness (STARI) in the southern U.S. may be attributable to previously undetected B. burgdorferi sensu lato infections.

Distribution of Ticks & Prevalence of Borrelia burgdorferi in the Upper Connecticut River Valley of Vermont
Abigail C. Serra-1, Paul S. Warden-2, Colin R. Fricker-2, and Alan R. Giese-1,*

1-Lyndon State College VT, 2-Analytical Services, Inc. VT
*Corresponding author – alan.giese@lyndonstate.edu.

ABSTRACT: Ixodes scapularis (Black-legged Tick) has expanded its range in recent
decades. To establish baseline data on the abundance of the Black-legged Tick and Borrelia burgdorferi (the causative agent of Lyme disease) at the edge of a putative range expansion, we collected 1398 ticks from five locations along the Connecticut River in Vermont. Collection locations were approximately evenly distributed between the villages of Ascutney and Guildhall. Relative abundance and distribution by species varied across sites. Black-legged Ticks dominated our collections (n = 1348, 96%), followed by Haemaphysalis leporispalustris (Rabbit Tick; n = 45, 3%), and Dermacentor variabilis (American Dog Tick; n = 5, <1%). Black-legged Tick abundance ranged from 6198 ticks per survey hectare (all life stages combined) at the Thetford site to zero at the Guildhall site. There was little to no overlap of tick species across sites. Phenology of Black-legged Ticks matched published information from other regions of the northeastern USA. Prevalence of B. burgdorferi in adult Black-legged Ticks was 8.9% (n = 112)


Post-Treatment Lyme Syndrome and Central Sensitization.
Batheja S, Nields JA, Landa A, Fallon BA*.

Department of Psychiatry, Columbia University, and The New York State Psychiatric Institute.
*Send correspondence to Dr. Fallon; e-mail: baf1@columbia.edu

ABSTRACT: Central sensitization is a process that links a variety of chronic pain disorders that are characterized by hypersensitivity to noxious stimuli and pain in response to non-noxious stimuli. Among these disorders, treatments that act centrally may have greater efficacy than treatments acting peripherally. Because many individuals with post-treatment Lyme syndrome (PTLS) have a similar symptom cluster, central sensitization may be a process mediating or exacerbating their sensory processing. This article reviews central sensitization, reports new data on sensory hyperarousal in PTLS, explores the potential role of central sensitization in symptom chronicity, and suggests new directions for neurophysiologic and treatment research.

30. The Open Neurology Journal 2012: 6, (Suppl 1-M2) 79-87
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3474942/

A Reappraisal of the U.S. Clinical Trials of Post-Treatment Lyme Disease Syndrome
Brian A. Fallon*,1, Eva Petkova2, John G. Keilp3 and Carolyn B. Britton4
ABSTRACT: Four federally funded randomized placebo-controlled treatment trials of post-treatment Lyme syndrome in the United States have been conducted. Most international treatment guidelines summarize these trials as having shown no acute or sustained benefit to repeated antibiotic therapy. The goal of this paper is to determine whether this summary conclusion is supported by the evidence.

Methods: The methods and results of the 4 U.S. treatment trials are described and their critiques evaluated.

Results: 2 of the 4 U.S. treatment trials demonstrated efficacy of IV ceftriaxone on primary and/or secondary outcome measures.

Conclusions: Future treatment guidelines should clarify that efficacy of IV ceftriaxone for post-treatment Lyme fatigue was demonstrated in one RCT and supported by a second RCT, but that its use was not recommended primarily due to adverse events stemming from the IV route of treatment. While repeated IV antibiotic therapy can be effective, safer modes of delivery are needed.

29. PLoS ONE 7(10) 2012: e48277. doi:10.1371/journal.pone.0048277
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0048277

Characterization of Biofilm Formation by Borrelia burgdorferi In Vitro

Eva Sapi*, Scott L. Bastian, Cedric M. Mpoy, Shernea Scott, Amy Rattelle, Namrata Pabbati, Akhila Poruri, Divya Burugu, Priyanka A. S. Theophilus, Truc V. Pham, Akshita Datar, Navroop K. Dhaliwal, Alan MacDonald, Michael J. Rossi, David F. Luecke (Lyme Disease Research Group, Department of Biology and Environmental Sciences, University of New Haven, West Haven, Connecticut, United States of America); Saion K. Sinha (Department of Physics, University of New Haven, West Haven, Connecticut, United States of America).

*Corresponding Author Email: Eva Sapi, esapi@newhaven.edu

ABSTRACT: Borrelia burgdorferi, the causative agent of Lyme disease, has long been known to be capable of forming aggregates and colonies. It was recently demonstrated that Borrelia burgdorferi aggregate formation dramatically changes the in vitro response to hostile environments by this pathogen. In this study, we investigated the hypothesis that these aggregates are indeed biofilms, structures whose resistance to unfavorable conditions are well documented. We studied Borrelia burgdorferi for several known hallmark features of biofilm, including structural rearrangements in the aggregates, variations in development on various substrate matrices and secretion of a protective extracellular polymeric substance (EPS) matrix using several modes of microscopic, cell and molecular biology techniques. The atomic force microscopic results provided evidence that multilevel
rearrangements take place at different stages of aggregate development, producing a complex, continuously rearranging structure. Our results also demonstrated that Borrelia burgdorferi is capable of developing aggregates on different abiotic and biotic substrates, and is also capable of forming floating aggregates. Analyzing the extracellular substance of the aggregates for potential exopolysaccharides revealed the existence of both sulfated and non-sulfated/carboxylated substrates, predominately composed of an alginate with calcium and extracellular DNA present. In summary, we have found substantial evidence that Borrelia burgdorferi is capable of forming biofilm in vitro. Biofilm formation by Borrelia species might play an important role in their survival in diverse environmental conditions by providing refuge to individual cells.

28. PLOS One 2012
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0033280

Genome Stability of Lyme Disease Spirochetes: Comparative Genomics of Borrelia burgdorferi Plasmids
Sherwood R. Casjens1*, Emmanuel F. Mongodin2, Wei-Gang Qiu3, Benjamin J. Luft4, Steven E. Schutzer5, Eddie B. Gilcrease1, Wai Mun Huang1, Marija Vujadinovic1, John K. Aron1, Levy C. Vargas3, Sam Freeman3, Diana Radune6, Janice F. Weidman6, George I. Dimitrov6, Hoda M. Khouri6, Julia E. Sosa6, Rebecca A. Halpin6, John J. Dunn7, Claire M. Fraser2

1-University of Utah School of Medicine, 2-University of Maryland School of Medicine, 3-Hunter College of the City University of New York, 4-Stony Brook University, NY, 5- New Jersey Medical School, 6-J. Craig Venter Institute, MD, 7- Brookhaven National Laboratory, NY
*Corresponding Author Email: sherwood.casjens@path.utah.edu

ABSTRACT: Lyme disease is the most common tick-borne human illness in North America. In order to understand the molecular pathogenesis, natural diversity, population structure and epizootic spread of the North American Lyme agent, Borrelia burgdorferi sensu stricto, a much better understanding of the natural diversity of its genome will be required. Towards this end we present a comparative analysis of the nucleotide sequences of the numerous plasmids of B. burgdorferi isolates B31, N40, JD1 and 297. These strains were chosen because they include the three most commonly studied laboratory strains, and because they represent different major genetic lineages and so are informative regarding the genetic diversity and evolution of this organism. A unique feature of Borrelia genomes is that they carry a large number of linear and circular plasmids, and this work shows that strains N40, JD1, 297 and B31 carry related but non-identical sets of 16, 20, 19 and 21 plasmids, respectively, that comprise 33–40% of their genomes. We deduce that there are at least 28 plasmid compatibility types among the four strains. The B. burgdorferi ~900 Kbp linear chromosomes are evolutionarily exceptionally stable, except for a short ≤20 Kbp plasmid-like section at the right end. A few of the plasmids, including the linear lp54 and circular cp26, are also very stable. We show here that the other plasmids, especially the linear ones, are considerably more variable. Nearly all of the linear plasmids have undergone one or more substantial inter-plasmid rearrangements since their last common ancestor. In spite of these rearrangements and differences in plasmid contents, the overall gene complement of the different isolates has remained relatively constant.
Whole-Genome Sequences of Thirteen Isolates of Borrelia burgdorferi

Steven E. Schutzer1,* , Claire M. Fraser-Liggett2, Sherwood R. Casjens3,* , Wei-Gang Qiu4, John J. Dunn5, Emmanuel F. Mongodin2, and Benjamin J. Luft6

1-University of Medicine and Dentistry of New Jersey—New Jersey Medical School, 2-Institute for Genome Sciences, University of Maryland, School of Medicine, 3-University of Utah Medical School, 4- Hunter College of the City University of New York, 5-Brookhaven National Laboratory, Upton, New York 6-Stony Brook University

*Corresponding author. Mailing address for Steven E. Schutzer: Department of Medicine, University of Medicine and Dentistry of New Jersey—New Jersey Medical School, Newark, NJ 07103. E-mail: schutzer@umdnj.edu. Mailing address for Sherwood R. Casjens: Department of Pathology, University of Utah Medical School, Room 2200 EEJMRB, 15 North Medical Dr. East, Salt Lake City, UT 84112. E-mail: sherwood.casjens@path.utah.edu

ABSTRACT: Borrelia burgdorferi is a causative agent of Lyme disease in North America and Eurasia. The first complete genome sequence of B. burgdorferi strain 31, available for more than a decade, has assisted research on the pathogenesis of Lyme disease. Because a single genome sequence is not sufficient to understand the relationship between genotypic and geographic variation and disease phenotype, we determined the whole-genome sequences of 13 additional B. burgdorferi isolates that span the range of natural variation. These sequences should allow improved understanding of pathogenesis and provide a foundation for novel detection, diagnosis, and prevention strategies.

Distinct Cerebrospinal Fluid Proteomes Differentiate Post-Treatment Lyme Disease from Chronic Fatigue Syndrome


1-Department of Medicine, University of Medicine and Dentistry of New Jersey-New Jersey Medical School, Newark, New Jersey, United States of America, 2 Department of Neurology, University of Medicine and Dentistry of New Jersey-New Jersey Medical School, Newark, New Jersey, United States of America, 3 Division of Biostatistics and Epidemiology, University of Medicine and Dentistry of New Jersey-New Jersey Medical School, Newark, New Jersey, United States of America, 4 Biological Sciences Division, Pacific Northwest National Laboratory, Richland, Washington, United States of America, 5 Department of Physical and Analytical Chemistry, Uppsala University, Uppsala, Sweden, 6 Department of Neurology, State University of New York-Stony Brook, Stony Brook, New York, United States of America, 7 Department of Psychiatry, Columbia University Medical Center, New York, New York, United States of America, 8 Department of Pain Medicine and Palliative Care and Beth Israel Medical Center, Albert Einstein School of Medicine, Bronx, New York, United States of America

*Corresponding Author Email: schutzer@umdnj.edu
# These authors contributed equally to this work

ABSTRACT: Neurologic Post Treatment Lyme disease (nPTLS) and Chronic Fatigue (CFS) are syndromes of unknown etiology. They share features of fatigue and cognitive dysfunction, making it difficult to differentiate them. Unresolved is whether nPTLS is a subset of CFS.

Pooled cerebrospinal fluid (CSF) samples from nPTLS patients, CFS patients, and healthy volunteers were comprehensively analyzed using high-resolution mass spectrometry (MS), coupled with immunoaffinity depletion methods to reduce protein-masking by abundant proteins. Individual patient and healthy control CSF samples were analyzed directly employing a MS-based label-free quantitative proteomics approach. We found that both groups, and individuals within the groups, could be distinguished from each other and normals based on their specific CSF proteins (p<0.01). CFS (n = 43) had 2,783 non-redundant proteins, nPTLS (n = 25) contained 2,768 proteins, and healthy normals had 2,630 proteins. Preliminary pathway analysis demonstrated that the data could be useful for hypothesis generation on the pathogenetic mechanisms underlying these two related syndromes. nPTLS and CFS have distinguishing CSF protein complements. Each condition has a number of CSF proteins that can be useful in providing candidates for future validation studies and insights on the respective mechanisms of pathogenesis. Distinguishing nPTLS and CFS permits more focused study of each condition, and can lead to novel diagnostics and therapeutic interventions.

25. Genetics: Published Articles Ahead of Print, published on September 2, 2011 as 0.1534/genetics.111.130773 Copyright 2011
http://www.genetics.org/content/189/3/951.long

Pervasive Recombination and Sympatric Genome Diversification Driven by Frequency-Dependent Selection in Borrelia burgdorferi, the Lyme disease Bacterium
James Haven*,†, Levy C. Vargas‡, Emmanuel F. Mongodin§, Vincent Xue§, Yozen Hernandez†, Pedro Pagan†, Claire M. Fraser-Liggett‡, Steven E. Schutzer**, Benjamin J. Luft††, Sherwood R. Casjens‡‡, and Wei-Gang Qiu†*, §§, 2

*Department of Biology, The Graduate Center, City University of New York, New York, New York 10016
†Department of Biological Sciences and The Center for Gene Structure and Function and
§Department of Computer Science, Hunter College, City University of New York, New York, New York 10065
‡Institute for Genome Sciences, University of Maryland BioPark, Baltimore, Maryland 21201
**Department of Medicine, University of Medicine and Dentistry of New Jersey–New Jersey Medical School, Newark, New Jersey 07103
††Department of Medicine, Health Science Center, Stony Brook University, Stony Brook, New York 11794
‡‡Department of Pathology, Division of Molecular Cell Biology and Immunology,
ABSTRACT: How genomic diversity within bacterial populations originates and is maintained in the presence of frequent recombination is a central problem in understanding bacterial evolution. Natural populations of Borrelia burgdorferi, the bacterial agent of Lyme disease, consist of diverse genomic groups co-infecting single individual vertebrate hosts and tick vectors. To understand mechanisms of sympatric genome differentiation in B. burgdorferi, we sequenced and compared 23 genomes representing major genomic groups in North America and Europe. Linkage analysis of over 13,500 single nucleotide polymorphisms revealed pervasive horizontal DNA exchanges. Although three times more frequent than point mutation, recombination is localized and weakly affects genome-wide linkage disequilibrium. We show by computer simulations that, while enhancing population fitness, recombination constrains neutral and adaptive divergence among sympatric genomes through periodic selective sweeps. In contrast, simulations of frequency-dependent selection with recombination produced the observed pattern of a large number of sympatric genomic groups associated with major sequence variations at the selected locus. We conclude that negative frequency-dependent selection targeting a small number of surface-antigen loci (ospC in particular) sufficiently explains the maintenance of sympatric genome diversity in B. burgdorferi without adaptive divergence. In fact, pervasive recombination makes it unlikely for local B. burgdorferi genomic groups to achieve host specialization. B. burgdorferi genomic groups in northeastern United States are thus best viewed as constituting a single bacterial species, whose generalist nature is a key to its rapid spread and human virulence.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2837073/

Extraction of Total Nucleic Acids from Ticks for the Detection of Bacterial & Viral Pathogens
Chris D. Crowder-1, Megan A. Rounds-1, Curtis A. Phillipson-1, John M. Picuri-1, Heather E. Matthews-1, Justina Halverson-1, Steven E. Schutzer-2, David J. Ecker-1, and Mark W. Eshoo-1

1-Ibis Biosciences, 1896 Rutherford Road, Carlsbad, CA 92008 (Mark W. Eshoo e-mail: meshoo@ibisbio.com), 2-University of Medicine and Dentistry of New Jersey, Dept. of Medicine, 185 South Orange Ave., Newark, NJ 07103.

ABSTRACT: Ticks harbor numerous bacterial, protozoal, and viral pathogens that can cause serious infections in humans and domestic animals. Active surveillance of the
tick vector can provide insight into the frequency and distribution of important pathogens in the environment. Nucleic-acid based detection of tick-borne bacterial, protozoan, and viral pathogens requires the extraction of both DNA and RNA (total nucleic acids) from ticks. Traditional methods for nucleic acid extraction are limited to extraction of either DNA or the RNA from a sample. Here we present a simple bead-beating based protocol for extraction of DNA and RNA from a single tick and show detection of Borrelia burgdorferi and Powassan virus from individual, infected Ixodes scapularis ticks. We determined expected yields for total nucleic acids by this protocol for a variety of adult tick species. The method is applicable to a variety of arthropod vectors, including fleas and mosquitoes, and was partially automated on a liquid handling robot.

Genotypic variation and Mixtures of Lyme Borrelia in Ixodes Ticks from North America and Europe

ABSTRACT: Lyme disease, caused by various species of Borrelia, is transmitted by Ixodes ticks in North America and Europe. Studies have shown the genotype of Borrelia burgdorferi sensu stricto (s.s.) or the species of B. burgdorferi sensu lato (s.l.) affects the ability of the bacteria to cause local or disseminated infection in humans.

Methodology/Principal Findings: We used a multilocus PCR electrospray mass spectrometry assay to determine the species and genotype Borrelia from ticks collected in New York, Connecticut, Indiana, Southern Germany, and California and characterized isolates from parts of the United States and Europe. These analyses identified 53 distinct genotypes of B. burgdorferi sensu stricto with higher resolution than ospC typing. Genotypes of other members of the B. burgdorferi sensu lato complex were also identified and genotyped including B. afzelii, B. garinii, B. lusitaniae, B. spielmanii, and B. valaisiana. While each site in North America had genotypes unique to that location, we found genotypes shared between individual regions and two genotypes found across the United States. Significant B. burgdorferi s.s. genotypic diversity was observed between North America and Europe: only 6.6% of US genotypes (3 of 45) were found in Europe and 27% of the European genotypes (3 of 11) were observed in the US. Interestingly, 39% of adult Ixodes scapularis ticks from North America were infected with more than one genotype of B. burgdorferi s.s. and 22.2% of Ixodes ricinus ticks from Germany were infected with more than one genotype of B. burgdorferi s.l.

Conclusions/Significance: The presence of multiple Borrelia genotypes in ticks increases the probability that a person will be infected with more than one genotype of B. burgdorferi, potentially increasing the risks of disseminated Lyme disease. Our study indicates that the genotypic diversity of Borrelia in ticks in both North America and Europe is higher then previously reported and can have potential clinical consequences.
Inflammation and central nervous system Lyme disease.

Brian A. Fallon* -a, d, Elizabeth S. Levin-b, Pernilla J. Schweitzer-b, David Hardesty-a-c

ABSTRACT: Lyme disease, caused by the bacterium Borrelia burgdorferi, can cause multi-systemic signs and symptoms, including peripheral and central nervous system disease. This review examines the evidence for and mechanisms of inflammation in neurologic Lyme disease, with a specific focus on the central nervous system, drawing upon human studies and controlled research with experimentally infected rhesus monkeys. Directions for future human research are suggested that may help to clarify the role of inflammation as a mediator of the chronic persistent symptoms experienced by some patients despite antibiotic treatment for neurologic Lyme disease.
ABSTRACT: Main Outcome Measures: Patients with persistent Lyme encephalopathy were compared with age-, sex-, and education-matched controls. Fully quantified assessments of rCBF and rCMR for glucose were obtained while subjects were medication-free using positron emission tomography. The CBF was assessed in 2 resting room air conditions (without snorkel and with snorkel) and 1 challenge condition (room air enhanced with carbon dioxide, ie, hypercapnia).

Results: Statistical parametric mapping analyses revealed regional abnormalities in all rCBF and rCMR measurements that were consistent in location across imaging methods and primarily reflected hypoactivity. Deficits were noted in bilateral gray and white matter regions, primarily in the temporal, parietal, and limbic areas. Although diminished global hypercapnic CBF reactivity (P < .02) was suggestive of a component of vascular compromise, the close coupling between CBF and CMR suggests that the regional abnormalities are primarily metabolically driven. Patients did not differ from controls on global resting CBF and CMR measurements.

Conclusions: Patients with persistent Lyme encephalopathy have objectively quantifiable topographic abnormalities in functional brain activity. These CBF and CMR reductions were observed in all measurement conditions. Future research should address whether this pattern is also seen in acute neurologic Lyme disease.

Fast, adaptive evolution at a bacterial host-resistance locus: The PFam54 gene array in Borrelia burgdorferi"
Ewa Wywial,1,2,* James Haven,1,3,* Sherwood R. Casjens,4 Yozen A. Hernandez,3 Shaneen Singh,1,2 Emmanuel F. Mongodin,5 Claire M. Fraser-Liggett,5 Benjamin J. Luft,6 Steven E. Schutzer,7 and Wei-Gang Qiu1,3,§

1 Department of Biology, The Graduate Center of the City University of New York, 365 Fifth Avenue, New York, NY 10016, USA
2 Department of Biology, Brooklyn College, City University of New York, 2900 Bedford Avenue, Brooklyn, NY 11210, USA
3 Department of Biological Sciences and the Center for Gene Structure and Function, Hunter College, City University of New York, 695 Park Avenue, New York, NY 10065, USA
4 Department of Pathology, Division of Molecular Cell Biology and Immunology, University of Utah School of Medicine, Salt Lake City, UT 84112, USA
5 Institute for Genome Sciences, University of Maryland BioPark, 801 West Baltimore Street, Baltimore, MD 21201, USA
6 Department of Medicine, Health Science Center, Stony Brook University, Stony Brook, NY 11794, USA
7 Department of Medicine, University of Medicine and Dentistry of New Jersey-New Jersey Medical School, 185 South Orange Avenue, Newark, NJ 07103, USA
§ Corresponding Author: Weigang Qiu, Department of Biological Sciences, Hunter College of the City University of New York, 695 Park Avenue, New York, NY 10065, USA, Phone: 1-212-772-5296, Fax: 1-212-772-5227, Email: ude.ync.retnuh.rtceneg@gnagiew
*Both authors contributed equally to the research
ABSTRACT: Microbial pathogens have evolved sophisticated mechanisms for evasion of host innate and adaptive immunities. PFam54 is the largest paralogous gene family in the genomes of Borrelia burgdorferi, the Lyme disease bacterium. One member of PFam54, the complement-regulator acquiring surface proteins 1 (BbCrasp-1), is able to abort the alternative pathway of complement activation via binding human complement-regulator factor H (FH). The gene coding for BbCRASP-1 exists in a tandem array of PFam54 genes in the B. burgdorferi genome, a result apparently of repeated gene duplications. To help elucidate the functions of the large number of PFam54 genes, we performed phylogenomic and structural analyses of the PFam54 gene array from ten B. burgdorferi genomes. Analyses based on gene tree, genome synteny, and structural models revealed rapid adaptive evolution of this array through gene duplication, gene loss, and functional diversification. Individual PFam54 genes, however, do not show high intra-population sequence polymorphisms as genes providing evasion from adaptive immunity generally do. PFam54 members able to bind human FH are not monophyletic, suggesting that human FH affinity, however strong, is an incidental rather than main function of these PFam54 proteins. The large number of PFam54 genes existing in any single B. burgdorferi genome may target different innate-immunity proteins of a single host species or the same immune protein of a variety of host species. Genetic variability of the PFam54 gene array suggests that universally present PFam54 lineages such as BBA64, BBA65, BBA66, and BBA73 may be better candidates for the development of broad-spectrum vaccines or drugs than strain-restricted lineages such as BbCRASP-1.

19. Neurology May 2008  http://www.neurology.org/content/70/13/992.long

A randomized, placebo-controlled trial of repeated IV antibiotic therapy for Lyme encephalopathy

B. A. Fallon, MD*, J. G. Keilp, PhD, K. M. Corbera, MD, E. Petkova, PhD, C. B. Britton, MD, E. Dwyer, MD, I. Slavov, PhD, J. Cheng, MD, PhD, J. Dobkin, MD, D. R. Nelson, PhD and H. A. Sackeim, PhD

From the Department of Psychiatry (B.A.F., J.G.K., K.M.C., E.P., I.S., J.C., H.A.S.), Department of Biostatistics (E.P.), Department of Neurology (C.B.B.), Department of Medicine (E.D., J.D.), and New York State Psychiatric Institute (B.A.F., J.G.K., K.M.C., E.P., I.S., J.C., H.A.S.), Columbia University, New York; and Department of Cell and Molecular Biology, University of Rhode Island, Kingston (D.R.N.).

*Dr. Fallon – Columbia University, 1051 Riverside Drive, Unit 69, New York, NY 10032, USA. baf1@columbia.edu

ABSTRACT: Background: Optimal treatment remains uncertain for patients with cognitive impairment that persists or returns after standard IV antibiotic therapy for Lyme disease.

Methods: Patients had well-documented Lyme disease, with at least 3 weeks of prior IV antibiotics, current positive IgG Western blot, and objective memory impairment.
Healthy individuals served as controls for practice effects. Patients were randomly assigned to 10 weeks of double-masked treatment with IV ceftriaxone or IV placebo and then no antibiotic therapy. The primary outcome was neurocognitive performance at week 12—specifically, memory. Durability of benefit was evaluated at week 24. Group differences were estimated according to longitudinal mixed-effects models.

Results: After screening 3368 patients and 305 volunteers, 37 patients and 20 healthy individuals enrolled. Enrolled patients had mild to moderate cognitive impairment and marked levels of fatigue, pain, and impaired physical functioning. Across six cognitive domains, a significant treatment-by-time interaction favored the antibiotic-treated group at week 12. The improvement was generalized (not specific to domain) and moderate in magnitude, but it was not sustained to week 24. On secondary outcome, patients with more severe fatigue, pain, and impaired physical functioning who received antibiotics were improved at week 12, and this was sustained to week 24 for pain and physical functioning. Adverse events from either the study medication or the PICC line were noted among 6 of 23 (26.1%) patients given IV ceftriaxone and among 1 of 14 (7.1%) patients given IV placebo; these resolved without permanent injury.

Conclusion: IV ceftriaxone therapy results in short-term cognitive improvement for patients with posttreatment Lyme encephalopathy, but relapse in cognition occurs after the antibiotic is discontinued. Treatment strategies that result in sustained cognitive improvement are needed.

18. Emerging Infectious Diseases Volume 14, Number 7–July 2008
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2600328/
Wide Distribution of a High-Virulence Borrelia burgdorferi Clone in Europe & North America.
Wei-Gang Qiu,* John F. Bruno,† William D. McCaig,* Yun Xu,† Ian Livey,‡ Martin E. Schriefer,§ and Benjamin J. Luft† Sequencing Group acknowledged (Schutzer)

*Hunter College of the City University of New York, New York, New York, USA; †Stony Brook University, Stony Brook, New York, USA; ‡Baxter Innovations GmBH, Orth/Donau, Austria; and §Centers for Disease Control and Prevention, Fort Collins, Colorado, USA
Address for correspondence: Wei-Gang Qiu, Department of Biological Sciences, Hunter College of the City University of New York, 695 Park Ave, New York, NY 10065, USA; email: weigang@genectr.hunter.cuny.edu

ABSTRACT: The A and B clones of Borrelia burgdorferi sensu stricto, distinguished by outer surface protein C (ospC) gene sequences, are commonly associated with disseminated Lyme disease. To resolve phylogenetic relationships among isolates, we sequenced 68 isolates from Europe and North America at 1 chromosomal locus (16S–23S ribosomal RNA spacer) and 3 plasmid loci (ospC,dbpA, and BBD14). The ospC-A clone appeared to be highly prevalent on both continents, and isolates of this clone were uniform in DNA sequences, which suggests a recent trans-oceanic migration. The genetic homogeneity of ospC-A isolates was confirmed by sequences at 6 additional chromosomal housekeeping loci (gap, alr, glpA, xylB, ackA, and tgt). In contrast, the ospC-B group consists of genotypes distinct to each continent, indicating geographic isolation. We conclude that the ospC-A clone has dispersed rapidly and
widely in the recent past. The spread of the ospC-A clone may have contributed, and likely continues to contribute, to the rise of Lyme disease incidence.


Severity of Lyme disease with persistent symptoms. Insights from a double-blind placebo-controlled clinical trial

Daniel Cameron, MD, Northern Westchester Hospital, Mount Kisco, NY, USA. cameron@lymeproject.com

ABSTRACT: Lyme disease is a global health concern and is the world’s leading tick borne infection caused by the spirochete, Borrelia burgdorferi, that has been associated with numerous neurologic, rheumatologic and psychiatric manifestations. The symptoms of Lyme disease have been characterized as either severe or “related to the aches and pains of daily living.” A randomized double-blind, placebo-controlled clinical trial (RCT) was conducted in a primary internal medicine practice in Westchester County, New York, USA. A total of 84 adults with Lyme disease with persistent symptoms (LDPS) were studied; 52 received amoxicillin and 34 received placebo. The subjects received either placebo or amoxicillin 3 g per day orally for 3 months. The SF-36 was used as the outcome measure of the patient’s perceived Quality of Life (QOL). For subjects enrolling in this RCT, the average SF-36 physical component summary (PCS) of QOL (40+/-.9, range 29-44) and mental component summary (MCS) of QOL (39+/-14, range 23-46) were worse than the general USA population and worse than individuals with diabetes, heart disease, depression, osteoarthritis or rheumatoid arthritis. The improvements in the SF-36 measure of QOL for subjects randomized to amoxicillin vs. placebo was significant (46% vs 18%, P=0.007). It is important for clinicians to be aware that LDPS can be severe. A significant gain in the QOL for subjects randomized to amoxicillin in this RCT without serious adverse events is consistent with the goal of improving patient’s QOL and consequently worthy of further study.


Profiling the humoral immune response to Borrelia burgdorferi infection with protein microarrays

Yun Xu, John F. Bruno*, Benjamin J. Luft – Department of Medicine, State university of New York at Stony Brook, Stony Brook, NY 11794, USA
*Corresponding author – Department of Medicine, T-15 Room 060, SUNY at Stony Brook, Stony Brook, NY 11794-8154, USA. Tel.: +1 631 444 2054; fax: +1 631 444 2493. jbruno@notes.cc.sunysb.edu

ABSTRACT: To determine the cell envelope proteins of Borrelia burgdorferi recognized by immune sera of patients with late Lyme disease, we developed a Borrelia
microarray containing proteins encoded by 90 cell envelope genes and their homologs described in the annotated genomic sequence of B. burgdorferi, strain B31. The protein microarray was used to profile the humoral immune response using sera from 13 patients with late Lyme disease and four normal controls. Although there was considerable heterogeneity in the individual sera responses, 25 of the cell envelope proteins were recognized by seven or more samples. Sera from non-infected individuals lacked reactivity against any of the proteins on the array. Among the most antigenic envelope proteins, BLAST search revealed little sequence homology to known microbial proteins from other species. The proteins that were highly seropositive included several members of the Erp gene families, BBA24 (decorin binding protein A (DbpA)) and members of the Borrelia gene family Pfam113 that code for the Mlp lipoprotein gene family. Several novel, uncharacterized B. burgdorferi antigens identified in this study were BBA14, BBG23, BB0108, BB0442 and BB003. The accurate diagnosis of Lyme disease depends on correlating objective clinical abnormalities with serological evidence of exposure to B. burgdorferi. A protein array of the envelope proteins of Borrelia burgdorferi may be very useful in specifically identifying patients with Lyme disease. This approach could contribute to a more rapid discovery of antigens not expressed in vitro that may be useful for the development of vaccine and diagnostics.

15. Infection and Immunity, January 2006
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1346608/
Identification of Borrelia burgdorferi outer surface proteins
Brooks CS-1; Vuppala SR-2; Jett AM-2; Akins DR*-2 Sequencing Group acknowledged (Schutzer)

1Department of Biology, Austin Peay State University, Clarksville, Tennessee 37044,
2Department of Microbiology and Immunology, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma 731042
*Corresponding author – Mailing address: Department of Microbiology and Immunology, The University of Oklahoma Health Sciences Center, Oklahoma City, OK 73104. Phone: (405) 271-2133 ext. 46640. Fax: (405) 271-3117. E-mail: darrin-akins@ouhsc.edu

ABSTRACT: Several Borrelia burgdorferi outer surface proteins have been identified over the past decade that are up-regulated by temperature- and/or mammalian host-specific signals as this spirochete is transmitted from ticks to mammals. Given the potential role(s) that these differentially up-regulated proteins may play in B. burgdorferi transmission and Lyme disease pathogenesis, much attention has recently been placed on identifying additional borrelial outer surface proteins. To identify uncharacterized B. burgdorferi outer surface proteins, we previously performed a comprehensive gene expression profiling analysis of temperature-shifted and mammalian host-adapted B. burgdorferi. The combined microarray analyses revealed that many genes encoding known and putative outer surface proteins are down-regulated in mammalian host-adapted B. burgdorferi. At the same time, however, several different genes encoding putative outer surface proteins were found to be up-regulated during the transmission and infection process. Among the putative outer surface proteins identified, biochemical and surface localization analyses confirmed that seven (Bb0405, Bb0689, BbA36, BbA64, BbA66, BbA69, and BbI42) are localized to the surface of B. burgdorferi. Furthermore, enzyme-linked immunosorbent assay analysis using serum from tick-infested baboons indicated that all seven outer surface proteins identified are immunogenic and that antibodies are generated against all seven during a natural infection. Specific antibodies generated against all seven of these surface proteins were found to be bactericidal against B. burgdorferi, indicating that these newly identified outer surface proteins are prime
candidates for analysis as second-generation Lyme disease vaccinogens.


WAIS-III and WMS-III performance in chronic Lyme disease
John G. Keilp a1 a2 c1, Kathy Corbera a1 a3, Iordan Slavov a1 a3, Michael J. Taylor a5, Harold A. Sackeim a1 a4, and Brian A. Fallon a1 a3

a1 Columbia University College of Physicians and Surgeons, Department of Psychiatry, New York, New York
a2 New York State Psychiatric Institute, Department of Neuroscience, New York, New York
a3 New York State Psychiatric Institute, Department of Therapeutics, New York, New York
a4 New York State Psychiatric Institute, Department of Biological Psychiatry, New York, New York
a5 Department of Psychiatry, University of California at San Diego, California
c1 Reprint requests to: John Keilp, Ph.D., Columbia University College of Physicians and Surgeons, Department of Psychiatry, Box 42, NYSPI, 1051 Riverside Drive, New York, NY 10032. E-mail: jgk13@columbia.edu

ABSTRACT: There is controversy regarding the nature and degree of intellectual and memory deficits in chronic Lyme disease. In this study, 81 participants with rigorously diagnosed chronic Lyme disease were administered the newest revisions of the Wechsler Adult Intelligence Scale (WAIS-III) and Wechsler Memory Scale (WMS-III), and compared to 39 nonpatients. On the WAIS-III, Lyme disease participants had poorer Full Scale and Performance IQ's. At the subtest level, differences were restricted to Information and the Processing Speed subtests. On the WMS-III, Lyme disease participants performed more poorly on Auditory Immediate, Immediate, Auditory Delayed, Auditory Recognition Delayed, and General Memory indices. Among WMS-III subtests, however, differences were restricted to Logical Memory (immediate and delayed) and Family Pictures (delayed only), a Visual Memory subtest. Discriminant analyses suggest deficits in chronic Lyme are best characterized as a combination of memory difficulty and diminished processing speed. Deficits were modest, between one-third and two-thirds of a standard deviation, consistent with earlier studies. Depression severity had a weak relationship to processing speed, but little other association to test performance. Deficits in chronic Lyme disease are consistent with a subtle neuropathological process affecting multiple performance tasks, although further work is needed to definitively rule out nonspecific illness effects. (JINS, 2006, 12, 119-129.).

13. Journal of Clinical Microbiology, February 2005
http://jcm.asm.org/content/43/2/850.long
Evidence of Borrelia Autoimmunity-Induced Component of Lyme Carditis and Arthritis.
Elizabeth S. Raveche1, Steven E. Schutzer,1*, Helen Fernandes1, Helen Bateman1, Brian A. McCarthy1, Steven P. Nickell2, and Madeleine W. Cunningham3.

1 Departments of Pathology and Medicine, New Jersey Medical School, University of Medicine and Dentistry of New Jersey, Newark, New Jersey, 2 Department of Molecular Genetics and Microbiology, University of New Mexico, Albuquerque, New Mexico, 3
ABSTRACT: We investigated the possibility that manifestations of Lyme disease in certain hosts, such as arthritis and carditis, may be autoimmunity mediated due to molecular mimicry between the bacterium Borrelia burgdorferi and self-components. We first compared amino acid sequences of Streptococcus pyogenes M protein, a known inducer of antibodies that are cross-reactive with myosin, and B. burgdorferi and found significant homologies with OspA protein. We found that S. pyogenes M5-specific antibodies and sera from B. burgdorferi-infected mice reacted with both myosin and B. burgdorferi proteins by Western blots and enzyme-linked immunosorbent assay. To investigate the relationship between self-reactivity and the response to B. burgdorferi, NZB mice, models of autoimmunity, were infected. NZB mice infected with B. burgdorferi developed higher degrees of joint swelling and higher anti-B. burgdorferi immunoglobulin M cross-reactive responses than other strains with identical major histocompatibility complex (DBA/2 and BALB/c). These studies reveal immunological cross-reactivity and suggest that B. burgdorferi may share common epitopes which mimic self-proteins. These implications could be important for certain autoimmunity-susceptible individuals or animals that become infected with B. burgdorferi.

http://www.pnas.org/content/101/39/14150.long

Evidence-based guidelines for the management of Lyme disease
International Lyme & Associated Diseases Society Lyme Disease Treatment Guidelines
ILADS Working Group: Dan Cameron, MD, MPH [Internal Medicine and Epidemiology, Mt. Kisco, New York]; Andrea Gaito, MD [Rheumatology, Basking Ridge, New Jersey]; Nick Harris, PhD [Immunology, Palo Alto, California]; Gregory Bach, DO [Family and Integrative Medicine, Colmar, Pennsylvania]; Sandra Bellovin, MD [Family Practice, Portsmouth, Virginia]; Kenneth Bock, MD [Family Practice, Rhinebeck, New York]; Steven Bock, MD [Family Practice, Rhinebeck, New York]; Joseph Burrousasco, MD [Internal Medicine, East Hampton, New York]; Constance Dickey, RN [Registered Nurse, Hampden, Maine]; Richard Horowitz [Internal Medicine, Hyde Park, New York]; Steven Phillips, MD [Internal Medicine, Ridgefield, Connecticut]; Lawrence Meer-Scherrer MD [Internal Medicine, Flamatt, Switzerland]; Bernard Raxlen, MD [Psychiatry, Greenwich, Connecticut]; Virginia Sher, MD [Psychiatry, Holland, Pennsylvania]; Harold Smith, MD [Emergency Medicine, Danville, Pennsylvania]; Pat Smith [President, Lyme Disease Association]*; Ray Stricker MD [Hematology and Immunotherapy, San Francisco, California]

1-ILADS, P.O. Box 341461, Bethesda, MD 20827-1461, USA.
*Pat Smith, LDA, was co-author on article

ABSTRACT: This report, completed in November 2003, is intended to serve as a resource for physicians, public health officials and organizations involved in the evaluation and treatment of Lyme disease.

Genetic exchange and plasmid transfers in Borrelia burgdorferi sensu stricto revealed by three-way genome comparisons and multilocus sequence typing.  

Wei-Gang Qiu *, †, Steven E. Schutzer ‡, John F. Bruno §, Oliver Attie *, Yun Xu §, John J. Dunn ¶, Claire M. Fraser ∥, Sherwood R. Casjens **, and Benjamin J. Luft §

Author Affiliations: *Department of Biological Sciences, Hunter College of the City University of New York, 695 Park Avenue, New York, NY 10021; ‡Department of Medicine, New Jersey Medical School, 185 South Orange Avenue, Newark, NJ 07103; §Department of Medicine, Health Science Center, Stony Brook University, Stony Brook, NY 11794; ¶Biology Department, Brookhaven National Laboratory, Upton, NY 11793; ∥The Institute for Genomic Research, 9712 Medical Center Drive, Rockville, MD 200850; and **Department of Pathology, Division of Molecular Cell Biology and Immunology, University of Utah Medical School, Salt Lake City, UT 84132

ABSTRACT: Comparative genomics of closely related bacterial isolates is a powerful method for uncovering virulence and other important genome elements. We determined draft sequences (8-fold coverage) of the genomes of strains JD1 and N40 of Borrelia burgdorferi sensu stricto, the causative agent of Lyme disease, and we compared the predicted genes from the two genomes with those from the previously sequenced B31 genome. The three genomes are closely related and are evolutionarily approximately equidistant (0.5% pairwise nucleotide differences on the main chromosome). We used a Poisson model of nucleotide substitution to screen for genes with elevated levels of nucleotide polymorphisms. The three-way genome comparison allowed distinction between polymorphisms introduced by mutations and those introduced by recombination using the method of phylogenetic partitioning. Tests for recombination suggested that patches of high-density nucleotide polymorphisms on the chromosome and plasmids arise by DNA exchange. The role of recombination as the main mechanism driving B. burgdorferi diversification was confirmed by multilocus sequence typing of 18 clinical isolates at 18 polymorphic loci. A strong linkage between the multilocus sequence genotypes and the major alleles of outer-surface protein C (ospC) suggested that balancing selection at ospC is a dominant force maintaining B. burgdorferi diversity in local populations. We conclude that B. burgdorferi undergoes genome-wide genetic exchange, including plasmid transfers, and previous reports of its clonality are artifacts from the use of geographically and ecological isolated samples. Frequent recombination implies a potential for rapid adaptive evolution and a possible polygenic basis of B. burgdorferi pathogenicity.


Regional Cerebral Blood Flow and Cognitive Deficits in Chronic Lyme Disease.  
Brian A. Fallon, M.D., John Keilp, Ph.D., Isak Prohovnik, Ph.D., Ronald Van Heertum, M.D. and J. John Mann, M.D.
From the Lyme Disease Research Program, The NYS Psychiatric Institute, New York, New York. Address correspondence to Dr. Brian A. Fallon, NYS Psychiatric Institute, 1051 Riverside Drive, #69, New York, NY 10032

ABSTRACT: This study examined brain functioning in patients with Lyme encephalopathy. Eleven patients underwent neuropsychological tests and Xenon133-regional cerebral blood flow (rCBF) studies, using an external detector system. Each rCBF scan was age- and sex-matched to two archival, normal controls. While few differences were noted on gray-matter flow indices (ISI, fg), Lyme patients demonstrated significant flow reductions in white matter index (k2) (p=.004), particularly in the posterior temporal and parietal lobes bilaterally (p=.003). Flow
reductions in white matter areas were significantly associated with deficits in memory ($r=.66$, $p=.027$) and visuospatial organization ($r=.62$, $p=.041$). Results suggest that Lyme encephalopathy may be a disease primarily affecting the cerebral white matter.

http://www.lyme.org/journal/journal/vol9s-s02/v9nss-02-bbqi.pdf
Borrelia burgdorferi Persists in the Gastrointestinal Tract of Children and Adolescents with Lyme Disease.
Martin Fried, MD*; Dorothy Pietrucha, MD†; Gaye Madigan, RN‡; Aswine Bal, MD§

*Departments of Pediatric Gastroenterology, †Pediatric Neurology, ‡Academic Affairs, and §Pediatric Infectious Disease, Jersey Shore Medical Center, Neptune, New Jersey

ABSTRACT: This study documents the persistence of B burgdorferi DNA in the gastrointestinal tract of pediatric patients who have already been treated with antibiotics for Lyme disease. Ten consecutive patients between the ages of 9 and 13 years presented with an erythema migrans (EM) rash, a positive western blot for Lyme disease, chronic abdominal pain, heartburn, or bright red blood in the stool. Endoscopy assessed the gastrointestinal (GI) mucosa for inflammation and biopsies were examined for B burgdorferi using a Dieterle stain and with polymerase chain reaction (PCR) to the outer surface protein A (Osp A) of B burgdorferi. As controls, 10 consecutive patients with chronic abdominal pain were also tested by GI biopsies and with PCR. B burgdorferi persisted in the GI tract in all 10 patients with Lyme disease as shown by Dieterle stain of biopsies and with PCR. None of the control subjects’ biopsies were PCR positive for B. burgdorferi. Chronic gastritis, chronic duodenitis, and chronic colitis were found in Lyme disease patients and associated with the detection of B burgdorferi DNA in the GI tract despite prior antibiotic treatments. We have concluded that the DNA of B burgdorferi persisted in patients with Lyme disease even after antibiotic treatment.

http://neuro.psychiatryonline.org/doi/pdf/10.1176/jnp.13.4.500
A Controlled Study of Cognitive Deficits in Children with Chronic Lyme Disease.
Felice A Tager, PhD, Brian A Fallon, MD.

From the Columbia University Department of Psychiatry, Division of Behavioral Medicine, New York, New York. Address correspondence to Dr. Tager, Columbia Presbyterian Medical Center, 622 West 168th Street, Box 427, New York, NY 10032. E-mail: ft49@columbia.edu.

ABSTRACT: Although neurologic Lyme disease is known to cause cognitive dysfunction in adults, little is known about its long-term sequelae in children. Twenty children with a history of new-onset cognitive complaints after Lyme disease were compared with 20 matched healthy control subjects. Each child was assessed with measures of cognition and psychopathology. Children with Lyme disease had significantly more cognitive and psychiatric disturbances. Cognitive deficits were still found after controlling for anxiety, depression, and fatigue. Lyme disease in children may be accompanied by long-term neuropsychiatric disturbances, resulting in psychosocial and academic impairments. Areas for further study are discussed.
ABSTRACT: In these studies, we evaluated repeated HBOT for its ability to kill Bb in vitro, and in vivo, in a murine model of Lyme disease. Several North American tick-derived and recently obtained patient isolates were studied separately in our assay systems. To test for in vitro susceptibility, one-half to one million Bb were cultured in a small volume (0.1 – 0.2 ml) of BSK media using small snap-cap test tubes. With the caps removed, these cultures were then exposed, for one hour (twice daily for 2 consecutive days), to pure, filtered oxygen pressurized to 2-3 times normal atmospheric conditions. This was achieved using a specially constructed, miniaturized cylindrical chamber (length = 12 inches; diameter = 8 inches), equipped to accept any pressurized gas mixture through its portal opening. After the final HBOT, all cultures received an additional 0.5 ml of BSK media (making the final volume now 0.6 – 0.7 ml), and their caps were snapped shut. Matching control cultures received no HBOT. All cultures were incubated at 33°C for 2-3 days and were examined microscopically for live Bb. Our results showed that 14 of 17 strains of Bb had their growth inhibited by 33-94%, while there was little or no inhibition of 3 Bb strains. For the in vivo studies, separate groups of C3H or C57 mice were infected intradermally with 100,000 Bb. Two to 4 weeks later, one group of infected mice received two, 1.0-1.5 hour HBO exposures, for two consecutive or alternating days. The treated mice were sacrificed one day after the last treatment, and extract cultures of their urinary bladders were prepared in BSK media. It was found that no Bb grew out of 80% of these extract cultures, whereas live Bb organisms were recoverable from 90% of extract cultures prepared from matched, infected control mice not treated with HBO. These data suggest that HBOT may be considered as a clinically useful form of adjunct therapy in the treatment of Lyme disease.
were tested at baseline and 4 months later. During this interval, the private physician determined treatment (intravenous, intramuscular, oral, or none). Assessments included standardized measures of cognition, depression, anxiety, and functional status.

Between times 1 and 2, 5 patients were given no antibiotics and 18 were given additional antibiotics: 7 intravenously, 4 intramuscularly, and 7 orally. At time 1, there were no statistically significant group differences in cognition, depression, or anxiety between those who later received antibiotics and those who didn’t. At time 1, the 23 patients were also functionally disabled. At time 2, compared with patients who received no antibiotics, patients given antibiotics scored better on overall and individual measures of cognition. Patients given intravenous antibiotics showed the greatest functional improvement (pain, physical functioning, energy) and the most cognitive improvement, even when controlling for baseline differences in cognition between the treatment groups. Patients who did not have a reactive Western blot currently or historically were just as likely to improve cognitively as patients with reactive Western blot results.

This uncontrolled study suggests that repeated antibiotic treatment can be beneficial, even among patients who have been previously treated and even among patients who are currently Western blot negative, with the intravenous route of treatment being the most effective. A double-blind placebo-controlled study is needed to confirm these results.

5. JAMA, Nov. 24, 1999, Vol.282, No.20
Borrelia Burgdorferi–Specific Immune Complexes in Acute Lyme Disease.
Steven E. Schutzer, MD; P. K. Coyle, MD; Patrick Reid, MS; Bart Holland, PhD

Author Affiliations: Department of Medicine, Division of Allergy and Immunology (Dr Schutzer and Mr Reid) and Department of Preventive Medicine (Dr Holland), University of Medicine and Dentistry of New Jersey-New Jersey Medical School, Newark (Dr Schutzer and Mr Reid); and the Department of Neurology, State University of New York, Stony Brook (Dr Coyle).

ABSTRACT: Context Diagnosis of infection with Borrelia burgdorferi, the cause of Lyme disease (LD), has been impeded by the lack of effective assays to detect active infection.
Objectives: To determine whether B burgdorferi specific immune complexes are detectable during active infection in LD.
Design, Setting, and Patients: Cross-sectional analysis of serum samples from 168 patients fulfilling Centers for Disease Control and Prevention surveillance criteria for LD and 145 healthy and other disease controls conducted over 8 years. Tests were performed blinded.
Main Outcome Measure Detection of B burgdorferi immune complexes by enzyme-linked immunosorbent assay and Western blot.
Results: The B burgdorferi immune complexes were found in 25 of 26 patients with early seronegative erythema migrans (EM) LD; 105 of 107 patients with seropositive EM LD; 6 of 10 patients who were seronegative with culture-positive EM; 0 of 12 patients who were treated and recovered from LD; and 13 of 13 patients with neurologic LD without EM. Among 147 controls, B burgdorferi immune complex was found in 0 of 50 healthy individuals; 0 of 40 patients with persistent fatigue; 0 of 7 individuals with frequent tick exposure; and 2 of 50 patients with other diseases.
Conclusion: These data suggest that B burgdorferi immune complex formation is a common process in active LD. Analysis of the B burgdorferi immune complexes by a simple technique has the potential to support or exclude a diagnosis of early as well as active LD infection.

Funding/Support: This work was supported in part by grants A41518, NS34092, AI31561, and AR40470 from the National Institutes of Health and grant U50/CCU206582 from the Centers for Disease Control and Prevention, and by the Lyme Disease Association of New Jersey.

Absence of Borrelia Burgdorferi-specific immune complexes in chronic fatigue syndrome.
Schutzer SE-1, Natelson BH.

1 Department of Medicine, University of Medicine and Dentistry, New Jersey Medical School, Newark 07103, USA. schutzer@umdnj.edu

ABSTRACT: Chronic fatigue syndrome (CFS) and Lyme disease often share clinical features, especially fatigue, contributing to concern that Borrelia burgdorferi (Bb), the cause of Lyme disease, may underlie CFS symptoms. We examined 39 CFS patients and 40 healthy controls with a Bb immune complex test. Patients and controls were nonreactive. Centers for Disease Control and Prevention-defined CFS patients lacking antecedent signs of Lyme disease–erythema migrans, Bell’s palsy, or large joint arthritis–are not likely to have laboratory evidence of Bb infection.

http://www.psych.theclinics.com/article/S0193-953X%2805%2970032-0/fulltext
The Underdiagnosis of Neuropsychiatric Lyme Disease in Children and Adults.
Brian A. Fallon, MD, MPH-1, Janice M. Kochevar, NP, Andrea Gaito, MD, Jenifer A. Nields, MD

1-Department of Psychiatry, Columbia University Medical Center and the Lyme Disease Research Program, New York, New York (BAF), 2-private practice, Armonk, New York (JMK), 3-Department of Medicine, Seton Hall University, and private practice, Basking Ridge, New Jersey (AG), 4-Department of Psychiatry, Yale University School of Medicine, New Haven, Connecticut (JAN)

ABSTRACT: Lyme disease is a tick-borne illness caused by the spirochete Borrelia burgdorferi. Reported throughout the United States, the greatest incidence of Lyme disease occurs in certain areas, such as the Northeast, the upper Midwest, and the Pacific Coastal states. It has been dubbed “The New Great Imitator” because, like another spirochetal illness neurosyphilis—the original Great Imitator, Lyme disease has a vast array of multisystem manifestations, including neuropsychiatric ones. Failure to recognize Lyme disease early in its course can result in the development of a chronic illness that is only temporarily or partially responsive to antibiotic
therapy. The goal of this article is to present the typical and atypical manifestations of Lyme disease in children and adults in order to help the clinician more rapidly unmask the correct diagnosis behind the puzzling presentations of some patients.


A proposal for the reliable culture of Borrelia burgdorferi from patients with chronic Lyme disease, even from those previously aggressively treated.

Phillips SE-1, Mattman LH, Hulinska D, Moayad H

1Greenwich Hospital, CT 06830, USA.

ABSTRACT: Since culture of Borrelia burgdorferi from patients with chronic Lyme disease has been an extraordinarily rare event, clarification of the nature of the illness and proving its etiology as infectious have been difficult. A method for reliably and reproducibly culturing B. burgdorferi from the blood of patients with chronic Lyme disease was therefore sought by making a controlled blood culture trial studying 47 patients with chronic Lyme disease. All had relapsed after long-term oral and intravenous antibiotics. 23 patients with other chronic illness formed the control group. Positive cultures were confirmed by fluorescent antibody immuno-electron microscopy using monoclonal antibody directed against Osp A, and Osp A PCR. 43/47 patients (91%) cultured positive. 23/23 controls (100%) cultured negative. Although persistent infection has been, to date, strongly suggested in chronic Lyme disease by positive PCR and antigen capture, there are major problems with these tests. This new method for culturing B. burgdorferi from patients with chronic Lyme disease certainly defines the nature of the illness and establishes that it is of chronic infectious etiology. This discovery should help to reestablish the gold standard in laboratory diagnosis of Lyme disease.


Borrelia burgdorferi DNA in the Urine of Treated Patients with Chronic Lyme Disease Symptom: A PCR Study of 97 Cases

Bayer ME-1, Zhang L, Bayer MH.

1-Fox Chase Cancer Center, Philadelphia, PA 19111, USA.

Author affiliation: Fox Chase Cancer Center, Philadelphia, PA 19111, USA

ABSTRACT: All patients had shown erythema chronica migrans following a deer tick bite. Most of the patients had been antibiotic-treated for extended periods of time. ...of the 97 patients, 72 (74.2%) were found with positive PCR and the rest with negative PCR. The 62 healthy volunteers were PCR negative. It is proposed that a sizeable group of patients diagnosed on clinical grounds as having chronic Lyme disease may still excrete Borrelia DNA, and may do so in spite of intensive antibiotic treatment.
LDA Grant Summary Stats: 1992 – 2020

LDA supports research, education and treatment for children without insurance via it’s grant awards programs.

Research Grant Stats

Results:

119 grants distributed to researchers across the USA since 1992 LDA grants have resulted in publications in 53 Scientific Peer-Reviewed Journals (Click here for publications), and have also led to scientific conference presentations by researchers. (Click here for conferences)

Decriptions of LDA grant awards
Click here for awards

RECIPIENTS (48)

<p>| Alfredo M. Angeles-Boza, PhD | James Krueger, MD, PhD / Schutzer, MD |</p>
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Name</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gregory Bach, DO</td>
<td></td>
<td>Michael Lappin, DVM, PhD, DACVIM</td>
<td></td>
</tr>
<tr>
<td>Marylynn Barkley, MD, PhD</td>
<td></td>
<td>Benjamin Luft, MD</td>
<td></td>
</tr>
<tr>
<td>Effie E. Bastounis, PhD</td>
<td></td>
<td>Joanna Lyon, MA</td>
<td></td>
</tr>
<tr>
<td>Manfred Bayer, MD</td>
<td></td>
<td>Alan MacDonald, MD</td>
<td></td>
</tr>
<tr>
<td>Edward Breitschwerdt, DVM</td>
<td></td>
<td>Mark E. McCaulley, MD</td>
<td></td>
</tr>
<tr>
<td>Steve Burke, MD</td>
<td>Zhaid B.M. Niazi, MD / Charles Pavia, PhD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joseph Burrascano, Jr, MD</td>
<td></td>
<td>William V. Padula, OD</td>
<td></td>
</tr>
<tr>
<td>Daniel Cameron, MD</td>
<td></td>
<td>Nikhat Parveen, PhD</td>
<td></td>
</tr>
<tr>
<td>Cary Institute of Ecosystem Studies (Rick Ostfeld, PhD)</td>
<td></td>
<td>Jose E. Petri, PhD</td>
<td></td>
</tr>
<tr>
<td>Nicole Chinnici</td>
<td></td>
<td>Mario Phillip, MD</td>
<td></td>
</tr>
<tr>
<td>Kerry Clark, MPH, PhD</td>
<td></td>
<td>Steven Phillips, MD</td>
<td></td>
</tr>
<tr>
<td>Christine Ann Denny, PhD</td>
<td></td>
<td>Maria M. Picken, MD, PhD</td>
<td></td>
</tr>
<tr>
<td>Sam Donta, MD</td>
<td></td>
<td>Elizabeth Raveche, MD/ Schutzer, MD</td>
<td></td>
</tr>
<tr>
<td>Paul Duray, MD</td>
<td></td>
<td>Aaron Rybski, L.E.H.P.</td>
<td></td>
</tr>
<tr>
<td>Marina Eremeeva, MD, PhD, ScD</td>
<td></td>
<td>Eva Sapi, PhD</td>
<td></td>
</tr>
<tr>
<td>Brian Fallon, MD</td>
<td></td>
<td>Ritchie Schoemaker, MD</td>
<td></td>
</tr>
<tr>
<td>Karl Ford, PhD</td>
<td></td>
<td>H. Ralph Schumacher, MD / Bayer, MD</td>
<td></td>
</tr>
<tr>
<td>Martin Fried, MD</td>
<td></td>
<td>Steven Schutzer, MD</td>
<td></td>
</tr>
<tr>
<td>David E. Fulford, PhD</td>
<td></td>
<td>Travis Taylor, PhD</td>
<td></td>
</tr>
<tr>
<td>Andrea Gaito, MD</td>
<td></td>
<td>David Younger, MD</td>
<td></td>
</tr>
<tr>
<td>Alan R. Giese, PhD</td>
<td></td>
<td>Elyes Zhioua, PhD</td>
<td></td>
</tr>
<tr>
<td>Dolores E. Hill, PhD</td>
<td></td>
<td>Ying Zhang, MD</td>
<td></td>
</tr>
<tr>
<td>Richard Horowitz, MD</td>
<td></td>
<td>Joshua Zimmerman, MD, PhD</td>
<td></td>
</tr>
</tbody>
</table>

**FACILITIES (36) in 19 STATES**
<table>
<thead>
<tr>
<th>Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allegheny Univ of the Health Sciences (PA)</td>
<td>Northeast Wildlife DNA Laboratory; Pike County Commissioners (PA)</td>
</tr>
<tr>
<td>Boston University Medical Center (MA)</td>
<td>Padula Institute of Vision Rehabilitation</td>
</tr>
<tr>
<td>Brigham &amp; Woman's Hospital (MA)</td>
<td>Rockefeller University (NY)</td>
</tr>
<tr>
<td>Cary Institute of Ecosystem Studies (NY)</td>
<td>Science Center University City (PA)</td>
</tr>
<tr>
<td>Colorado State University</td>
<td>Shenandoah School of Pharmacy (VA)</td>
</tr>
<tr>
<td>Columbia Univ College of Physicians &amp; Surgeons</td>
<td>Stony Brook University (NY)</td>
</tr>
<tr>
<td>Edinboro University of Pennsylvania</td>
<td>Tulane Regional Primate Center (LA)</td>
</tr>
<tr>
<td>Fox Chase Cancer Center (PA)</td>
<td>University of California, Davis</td>
</tr>
<tr>
<td>Georgia Southern University Research &amp; Service Fdn.</td>
<td>University of Connecticut</td>
</tr>
<tr>
<td>Jersey Shore Medical Center (NJ)</td>
<td>University of Medicine &amp; Dentistry of NJ</td>
</tr>
<tr>
<td>Johns Hopkins University (MD)</td>
<td>University of New Haven (CT)</td>
</tr>
<tr>
<td>Kendall County Health Department (IL)</td>
<td>University of North Florida</td>
</tr>
<tr>
<td>Lyndon State University (VT)</td>
<td>University of Pennsylvania</td>
</tr>
<tr>
<td>New York University</td>
<td>University of Rhode Island</td>
</tr>
<tr>
<td>New York Medical College</td>
<td>University of South Dakota</td>
</tr>
<tr>
<td>New York State Psychiatric Institute</td>
<td>University of Toledo (OH)</td>
</tr>
<tr>
<td>NIH/NASA* (MD)</td>
<td>University of Washington</td>
</tr>
<tr>
<td>North Carolina State University</td>
<td>US Dept. of Agriculture (UDSA)</td>
</tr>
</tbody>
</table>

* National Institutes of Health (NIH), National Aeronautics &
## Education Grant Stats

**PURPOSES of Education Grants**

- Publications – includes (*Lyme Times*, *The Basics*, TX Lyme Disease brochure, TBD textbook)
- Billboards
- Curriculum project
- Meetings
- Websites
- Distribution of materials to school nurses
- Projects in the schools
- Support medical conferences & Continuing Medical Education (CME) credits
- Symposia

**Click here** to see how LDA puts your money to work funding educational grants for educational programs!

**Places: 22 States / 2 Countries**

- CA, CO, CT, FL, IA, IL, KS, LA, ME, MO, MD, MN, NJ, NY, NC, OH, OR, PA, TX, GA, VA, VT/ UK

**143 Grants Awarded Since 1999:**

<table>
<thead>
<tr>
<th>Allegheny Health (1)</th>
<th>Manasar, Armand, DDS, Bard Conf, NY (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrant, Karan MSN, Univ of Louisiana, Monroe (1)</td>
<td>Maryland Lyme Information &amp; Support Grp (5)</td>
</tr>
<tr>
<td>Berenbaum, Sandy, CSW-R, BCD, Leventhal, Judith PhD, Exman, Pat, (CT) (1)</td>
<td>Mid-Coast Lyme Disease Support &amp; Ed., ME (7)</td>
</tr>
<tr>
<td><strong>CALDA/LymeDisease.org (16)</strong></td>
<td><strong>Mid-Shore Lyme Disease Assoc., Inc., MD (1)</strong></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td><strong>Central Jersey Lyme Support (Kahn) (1)</strong></td>
<td><strong>Mineral Area College (MO) (Conference) (1)</strong></td>
</tr>
<tr>
<td><strong>Clinic of Angels, FL (1)</strong></td>
<td><strong>Minnesota Lyme Action Support/MLDA (4)</strong></td>
</tr>
<tr>
<td><strong>Colorado Tick-Borne Disease Awareness Assn. (4)</strong></td>
<td><strong>Mountain Valley Lyme Disease Awareness Coalition (1)</strong></td>
</tr>
<tr>
<td><strong>Columbia University Lyme and Tick-Borne Diseases Research Center (NY)(1)</strong></td>
<td><strong>Mountain Valley Lyme Disease Support &amp; Ed, ME (1)</strong></td>
</tr>
<tr>
<td><strong>Florida Lyme Advocacy, Inc. (2)</strong></td>
<td><strong>NE Ohio Lyme Foundation (2)</strong></td>
</tr>
<tr>
<td><strong>Friends of Ridgefield Community Programs/Lyme Connections, CT(4</strong></td>
<td><strong>New York University, David Younger, MD (1)</strong></td>
</tr>
<tr>
<td><strong>Georgia Lyme Disease Association (2)</strong></td>
<td><strong>North Carolina Lyme Disease Foundation (1)</strong></td>
</tr>
<tr>
<td><strong>H. Holtry (PA) (2)</strong></td>
<td><strong>North Texas Lyme Group (1)</strong></td>
</tr>
<tr>
<td><strong>Harford Cnty Lyme Disease Support Grp, Inc., MD (3)</strong></td>
<td><strong>Oregon Lyme Disease Network, Inc. (1)</strong></td>
</tr>
<tr>
<td><strong>Inglis, Wendy PT, NJ (1)</strong></td>
<td><strong>Partnership for Tick-Borne Diseases Education y(MN) (2)</strong></td>
</tr>
<tr>
<td><strong>Int'l Lyme &amp; Assoc. Diseases Society, ILADS, MD (5)</strong></td>
<td><strong>Patricia McCleary, SLAM, Sturbridge LymeAwareness (6)</strong></td>
</tr>
<tr>
<td><strong>Karl Ford, PhD (1)</strong></td>
<td><strong>Reid, Jennifer CT (1)</strong></td>
</tr>
<tr>
<td><strong>LDA Dr. Referral Prog. Grant and/or Website (NY)(10)</strong></td>
<td><strong>S.W. Barthold, DVM, PhD (CA) (1)</strong></td>
</tr>
<tr>
<td><strong>Lyme Association of Greater Kansas City, Inc. (15)</strong></td>
<td><strong>Seybold, Lynn, BSN, RN Univ. of Pittsburg, School of Nursing (PA) (1)</strong></td>
</tr>
<tr>
<td>Organization</td>
<td>Author/Institution</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Lyme Disease Assoc. of Southeastern PA, Inc.</td>
<td>Singh, Harjit, MD Hackettstown Regional Medical Ctr (NJ)</td>
</tr>
<tr>
<td>Lyme Disease Network of NJ, Inc., Lymenet.org</td>
<td>Stolow-Bedard, Jen, NY</td>
</tr>
<tr>
<td>Lyme Disease United Coalition IA</td>
<td>Texas Lyme Disease Association, Inc.</td>
</tr>
<tr>
<td>Lyme Rights, NY</td>
<td>Time For Lyme, Inc., CT</td>
</tr>
<tr>
<td>Lyme Society</td>
<td>University of Texas Dallas</td>
</tr>
<tr>
<td>Lyme Society of the UK (England)</td>
<td>University of Texas Dallas</td>
</tr>
<tr>
<td>Lyme West NY</td>
<td>VTLyme.org</td>
</tr>
<tr>
<td>Macon County Soil &amp; Water Conservation District, IL</td>
<td>Western Tide Water Med Reserve Grp, VA</td>
</tr>
<tr>
<td>Maine Lyme</td>
<td></td>
</tr>
</tbody>
</table>

**Lyme Conference Educational Grants**

95 Lyme Conference Educational Grants Awarded since 2015 / Number of Recipients per State:

**2019**  - 30 Scholarships (States TBA)
Total $ TBA

**2018**  NH (4), MA (2) ME, AZ, FL (2), VT (2), OH, NY GA, CO, ME
Total $12, 217

**2017**  4-NY, OH, 2-NJ, 2-MA, ME, PA, CO, VT, MD, CA
Total $11,372.32

**2016**  CA, CO, ME, MD, 2-MN, MO, 2-NJ, 3-NY, OH, VT, 2-WA, WI
Total: $18,141.19

**2015**  NC, AZ, 2-PA, MD, OH, CA, 3-NJ, 3-NY, 3-MA
Total: $10,712.98
LymeAid 4 Kids Grant Stats

$383,000+ Distributed Since 2004!

Click here See how LDA puts your money to work helping children with Lyme!

In 2019, 38 applicants were awarded grants for a total of $38,000:

<table>
<thead>
<tr>
<th>State</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>1</td>
</tr>
<tr>
<td>8 Maryland</td>
<td></td>
</tr>
<tr>
<td>2 Connecticut</td>
<td>2</td>
</tr>
<tr>
<td>1 New York</td>
<td></td>
</tr>
<tr>
<td>1 Florida</td>
<td></td>
</tr>
<tr>
<td>23 Pennsylvania</td>
<td></td>
</tr>
<tr>
<td>1 Idaho</td>
<td></td>
</tr>
<tr>
<td>1 Virginia</td>
<td></td>
</tr>
</tbody>
</table>

In 2018, 7 applicants were awarded grants for a total of $7,000:

<table>
<thead>
<tr>
<th>State</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvania</td>
<td>1</td>
</tr>
<tr>
<td>1 North Carolina</td>
<td></td>
</tr>
<tr>
<td>2 Maryland</td>
<td>2</td>
</tr>
<tr>
<td>1 Tennessee</td>
<td></td>
</tr>
<tr>
<td>2 Mississippi</td>
<td>2</td>
</tr>
</tbody>
</table>

In 2017, 18 applicants were awarded grants for a total of $17,400:

<table>
<thead>
<tr>
<th>State</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon</td>
<td>4</td>
</tr>
<tr>
<td>Maryland</td>
<td>4</td>
</tr>
<tr>
<td>Connecticut</td>
<td>5</td>
</tr>
<tr>
<td>1 Indiana</td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>1</td>
</tr>
<tr>
<td>1 Kansas</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1</td>
</tr>
<tr>
<td>1 Idaho</td>
<td></td>
</tr>
</tbody>
</table>

In 2016, 45 applicants were awarded grants for a total of $45,000:
<table>
<thead>
<tr>
<th>State</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine</td>
<td>1</td>
</tr>
<tr>
<td>Ohio</td>
<td>2</td>
</tr>
<tr>
<td>Connecticut</td>
<td>1</td>
</tr>
<tr>
<td>Michigan</td>
<td>1</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>4</td>
</tr>
<tr>
<td>New York</td>
<td>6</td>
</tr>
<tr>
<td>Illinois</td>
<td>1</td>
</tr>
<tr>
<td>North Carolina</td>
<td>2</td>
</tr>
<tr>
<td>Florida</td>
<td>1</td>
</tr>
<tr>
<td>California</td>
<td>5</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>3</td>
</tr>
<tr>
<td>Oregon</td>
<td>2</td>
</tr>
<tr>
<td>Texas</td>
<td>1</td>
</tr>
<tr>
<td>Mississippi</td>
<td>1</td>
</tr>
<tr>
<td>Tennessee</td>
<td>2</td>
</tr>
<tr>
<td>New Jersey</td>
<td>5</td>
</tr>
<tr>
<td>Virginia</td>
<td>7</td>
</tr>
</tbody>
</table>

In 2015, 26 applicants were awarded grants for a total of $26,000:

<table>
<thead>
<tr>
<th>State</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine</td>
<td>6</td>
</tr>
<tr>
<td>Ohio</td>
<td>4</td>
</tr>
<tr>
<td>Connecticut</td>
<td>1</td>
</tr>
<tr>
<td>Michigan</td>
<td>1</td>
</tr>
<tr>
<td>Washington</td>
<td>2</td>
</tr>
<tr>
<td>New York</td>
<td>2</td>
</tr>
<tr>
<td>Illinois</td>
<td>1</td>
</tr>
<tr>
<td>North Carolina</td>
<td>1</td>
</tr>
<tr>
<td>Indiana</td>
<td>3</td>
</tr>
<tr>
<td>California</td>
<td>1</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>1</td>
</tr>
<tr>
<td>Oregon</td>
<td>3</td>
</tr>
</tbody>
</table>

Click here for prior LymeAid 4 Kids Grants

NOTE: This document is a work in progress. Grants are awarded based on application submission, process of expert review when required, & subject to LDA Board of Directors’ approval (all grants may not be listed)

---

**LymeAid 4 Kids Provided $383,000 in Grants Since 2004**

About LymeAid 4 Kids (LA4K) – The Lyme Disease Association started LA4K fund in 2003 and has helped children all over the U.S. and in Canada. Developed with the help of author Amy Tan, the fund is for children who do not have/receive insurance coverage for Lyme disease treatment for children and have economic difficulties. Donations can be made on-line to LDA help this LA4K fund as there are so many applicants, the
fund does run out of money frequently. Click here for application

Total Funds distributed since 2004 totals $383,000

In 2019, 38 applicants were awarded grants for a total of $38,000:
1 California
2 Connecticut
1 Florida
1 Idaho
8 MD
1 NY
23 PA
1 VA

In 2018, 7 applicants were awarded grants for a total of $7000:
1 Pennsylvania
2 Maryland
1 North Carolina
1 Tennessee
2 Mississippi
In 2017, 18 applicants were awarded grants for a total of $17,400:
4 Oregon
5 Connecticut
1 New York
1 Pennsylvania
4 Maryland
1 Indiana
1 Kansas
1 Idaho

In 2016, 45 applicants were awarded grants for a total of $45,000:
6 New York
2 Ohio
2 Oregon
1 Texas
5 California
1 Illinois
2 North Carolina
1 Michigan
1 Mississippi
2 Tennessee
5 New Jersey
7 Virginia
4 Pennsylvania
3 Massachusetts
1 Maine
1 Connecticut
1 Florida

In 2015, 26 applicants were awarded grants for a total of $26,000:
6 Maine
4 Ohio
1 Connecticut
1 Michigan
2 Washington
2 New York
1 Illinois
1 North Carolina
3 Indiana
1 California
1 Oklahoma
3 Oregon

In 2014, 9 applicants were awarded grants for a total of $9000:
1 Texas
1 Washington
1 Wisconsin
1 Maryland
1 Illinois
2 Connecticut
1 New York
1 California

In 2013, 11 applicants were awarded grants for a total of $9,000:
5 California
1 New Jersey
2 New York
1 Wisconsin

In 2012, 11 applicants were awarded grants for a total of $11,000:
3 Idaho
1 Illinois
1 Iowa
2 New York
1 Massachusetts
1 Tennessee
1 Wisconsin
1 Florida

In 2011, 35 applicants were awarded grants for a total of $35,000:
1 British Columbia
3 California
2 Connecticut
2 Georgia
5 Iowa
4 Illinois
2 Massachusetts
2 Missouri
1 New Hampshire
4 New Jersey
1 New York
3 Ohio
2 Pennsylvania
1 Rhode Island
1 Texas
1 Washington

In 2010, 29 applicants were awarded grants for a total of $29,000:
3 California for a total of $3,000
5 Connecticut for a total of $5,000
1 Georgia for a total of $1,000
3 Illinois for a total of $3,000
1 Maine for a total of $1,000
1 Missouri for a total of $1,000
2 New Hampshire for a total of $2,000
3 New Jersey for a total of $3,000
4 New York for a total of $4,000
1 Pennsylvania for a total of $1,000
1 Rhode Island for a total of $1,000
1 South Carolina for a total of $1,000
3 Virginia for a total of $3,000

In 2009, 20 applicants were awarded grants for a total of $20,000:
4 Connecticut for a total of $4,000
3 Massachusetts for a total of $3,000
1 Rhode Island for a total of $1,000
2 New Jersey for a total of $2,000
2 California for a total of $2,000
2 New York for a total of $2,000
3 Pennsylvania for a total of $3,000
2 Nevada for a total of $2,000
1 British Columbia for a total of $1,000

In 2008, 36 applicants were awarded grants for a total of $36,000:
1 Ohio for a total of $1,000
1 Rhode Island for a total of $1,000
1 Maine for a total of $1,000
3 Massachusetts for a total of $3,000
6 New York for a total of $6,000
1 Tennessee for a total of $1,000
2 California for a total of $2,000
2 Pennsylvania for a total of $2,000
4 Connecticut for a total of $4,000
1 Florida for a total of $1,000
4 Kansas for a total of $4,000
1 New Hampshire for a total of $1,000
4 Texas for a total of $4,000
3 Georgia for a total of $3,000
2 New Jersey for a total of $2,000

In 2007, 45 applicants were awarded grants for a total of $45,000:
1 California for a total of $1,000
6 Connecticut for a total of $6,000
1 Florida for a total of $1,000
2 Georgia for a total of $2,000
4 Illinois for a total of $4,000
3 Indiana for a total of $3,000
1 Iowa for a total of $1,000
2 Massachusetts for a total of $2,000*
3 New Hampshire for a total of $3,000
1 New Mexico for a total of $1,000
5 New York for a total of $5,000
2 Ohio for a total of $2,000
8 Pennsylvania for a total of $8,000
1 Rhode Island for a total of $1,000
1 Texas for a total of $1,000
1 West Virginia for a total of $1,000
1 Wisconsin for a total of $1,000
2 Canada, (have US doctors) for a total of $2,000

*$780 of this total was not used and returned to the fund

In 2006, 19 applicants were awarded grants for a total of $19,000:
1 Connecticut for a total of $1,000
3 Pennsylvania for a total of $3,000
8 Massachusetts for a total of $8,000
3 New York for a total of $3,000
1 California for a total of $1,000
1 Arizona for a total of $1,000
1 Maryland for a total of $1,000
1 Illinois for a total of $1,000

In 2005, 28 applicants were awarded grants for a total of $28,000:
2 Rhode Island for a total of $2,000
1 Texas for a total of $1,000
2 New Jersey for a total of $2,000
1 Maine for a total of $1,000
6 California for a total of $6,000
3 Massachusetts for a total of $3,000
5 Connecticut for a total of $5,000
2 New York for a total of $2,000
4 Pennsylvania for a total of $4,000
2 Canada (have US doctors) for a total of $2,000

In 2004, 9 applicants were awarded grants for a total of $9,000:
1 West Virginia for a total of $1,000
3 Texas for a total of $3,000
2 Connecticut for a total of $2,000
1 Massachusetts for a total of $1,000
1 Illinois for a total of $1,000
1 North Carolina for a total of $1,000

For more information on LymeAid 4 Kids click here
Patricia V. Smith, a Monmouth University graduate, is in her 23rd year as President of the all-volunteer run national non-profit Lyme Disease Association (LDA) and is a member of the HHS Tick-borne Disease Working Group in Washington, DC, where she co-chaired the Disease Vectors, Surveillance, & Prevention Subcommittee. She is a member of Columbia University’s Lyme & Tick-Borne Diseases Research Center Advisory Committee, member of the Food & Drug Administration’s (FDA) PESP Partnership to promote avoidance of tick exposure, and member of the Tick IPM Working Group with federal and non federal members, from the IPM Institute of North America, to eradicate tick-borne diseases. She was appointed in 2016 as a member of the US Army Medical Research and Materiel Command (USAMRMC) Tick-Borne Disease Research Program (TBDRP) as a member of the Congressionally Directed Medical Research Program Programmatic Panel. She has twice testified before Congressional committees in Washington on Lyme disease.

Ms. Smith is also former Chair, (NJ) Governor’s Lyme Disease Advisory Council. She was EPA’s PESP 2011 Lyme prevention conference session co-chair with CDC. In 2011 she presented a Lyme session to the New Jersey Education Association’s Annual Meeting. She is a member & former officer of ILADS, International Lyme & Associated Diseases Society, a professional medical and research organization. She was a member of the on-line journal Contagion Infectious Disease Today Chronic Lyme Expert Panel on video.

Ms. Smith is former President/12-year member of the Wall NJ Board of Education where she earned state board member-
certified status. She is a former officer of Monmouth County School Boards Assn. and was a member of the Federal Relations Network for New Jersey School Boards Association/National School Boards Assn.

During her LDA presidency, Ms. Smith has led the effort to raise funds for researchers nationally, with 119 research grants awarded – research acknowledged in 53 scientific journals. She has organized 20 continuing medical education (CME) accredited Lyme scientific conferences for doctors and researchers with international faculty, held in different areas of the US, most jointly sponsored by Columbia University, the 20th in Philadelphia in September 2019. She has spoken at many conferences on Lyme including those presented by the University of New Haven (CT), the California Lyme Disease Association (now LymeDisease.org), Midcoast Maine Lyme Education and Support, Colorado Tick-Borne Awareness Association, Lyme Connections, Lyme Society, Inc., and International Lyme & Associated Diseases Society, ILADS. She has been a speaker at hundreds of public, school, business, & government events.

Ms. Smith led the LDA in its effort with a partner organization, to endow the Columbia Lyme & Tick-Borne Diseases Research Center in New York, which opened in 2007. She developed the ABCs of Lyme Disease pamphlet for parents and educators (updated in 2019) and co-authored an article in it, and she also developed the LymeR Primer brochure now featuring 20 tick-borne diseases, the Tick Mark bookmark, and helped design LDA Tick Awareness cards. More than 2.5 million education items have been distributed.

Ms. Smith has testified for and secured passage of state and federal bills for Lyme research and physician’s right to treat. She has been invited to state capitals in CT, MA, MD, MN, NH, NJ, NY, PA, RI, to present oral testimony and education on Lyme and has provided written testimony in many others. Based on her written testimony, LDA was included in
ground breaking Maine legislation as a website resource on Lyme disease on Maine’s DPH website. She was invited to testify on two occasions before the NY Assembly Health Care Committee and also before the Rhode Island (Governor’s) Lyme Disease Advisory Commission and has spoken before the California Lyme Disease Advisory Council. Over time, she has personally met with many State Health Commissioners and with Governors in NH, RI CT on Lyme issues and with then Governor Pataki’s office on many occasions along with several NY state legislators. She has also presented before the Pennsylvania House of Representatives Majority Policy Committee and was an invited speaker for Lyme forums hosted by a member of the Massachusetts House of Representatives and the Majority Caucus Administrator for the Pennsylvania House of Representatives and the Minnesota State Senate Health Committee.

She has twice been invited to present to CDC Vector-Borne Diseases Division, Ft. Collins (2007, 2013); met with then CDC Director Dr. Julie Gerberding/5 Congressmen in DC; organized & led a team that met with HHS Asst. Sec. of Health with CDC/NIH officials teleconferenced in; met with military leaders in DC; and briefed the Senate HELP Committee Members and House Subcommittee on Health. She met several times with US Army CHPPM/Public Health Command at Aberdeen Proving Grounds. She met in DC with the NIH Program Director and research coordinator and presented educational PowerPoints on Lyme to employees at the Environmental Protection Agency (2008, 2014), to the Dept. of Energy, and to Homeland Security in 2014. In 2014, she helped develop language for a federal bill on Lyme and led the nationwide effort which successfully passed the bill through the House. Ms. Smith spoke at a number of press conferences with Senator Charles (Chuck) Schumer (NY)—now Senate Minority Leader—including one in 2014 on the doxycycline shortage for Lyme patients. In 2012, she testified before the House Foreign Affairs Committee, Africa, Global Health & Human Rights Subcommittee on issues affecting Lyme patients. In 2013, she testified before the House Energy &
Commerce Health Subcommittee on HR 610 to establish a federal Lyme & Tick-Borne Diseases Advisory Committee. She co-authored an article which was read into the Congressional Record on Lyme disease research priorities from the patient perspective. In 2015, she spoke at the American Association for the Advancement of Science in DC on patient research priorities. In 2016, she spoke before the Women in Government’s annual conference. In 2016, she led the negotiations with House leadership for the Lyme language subsequently passed in the 21st Century Cures Act which creates a federal working group on tick-borne diseases with patient and advocates reps at the same table as government officials.

Chosen Jackson NJ’s Chamber of Commerce 2008 Woman of the Year, she has also received commendation from the NJ legislature, a Special Congressional Recognition certificate from RI Cong. Langevin, and had a flag flown over the US Capitol by request of NJ Cong. Chris Smith in honor of her Lyme work. Ms. Smith helped to organize and presented at educational forums held by 3 congressmen (Langevin, Pitts, C. Smith). She has received awards from Dr. Brian Fallon, Columbia, from various Lyme groups, and was given the Courage in Advocacy Award in 2015 from Connecticut based Lyme Connection and Focus on Lyme Excellence in Advocacy (AZ) award in 2017.

Other activities include providing input into a NJ law requiring teacher education for staff who teach students with Lyme disease, performing school in-services for educators on Lyme disease, and working with parents of students who are classified due to Lyme disease. Working with author Amy Tan, she created LDA’s LymeAid 4 Kids, a fund for children with no health coverage for Lyme, a fund that has awarded $383,000 for uninsured children to date. Click for Publications
Richard H. Smith, BA
Executive Vice President, Treasurer

Richard has a BA from Rutgers University. After being honorably discharged from the US Army (Army Security Agency), he worked for New Jersey American Water Company for 38 years. He also served as the president of the local utility union for several years. He is past president of his local homeowners association and has served on the LDA Board of Directors for 7 years.

Corey Lakin, AB
2nd Vice President, Technical Support, LDA

Corey Lakin, graduated from the University of Chicago with an AB in Geophysical Science. He was a scientist with the New Jersey State Department of Environmental Protection (Ret.). Corey has been an LDA Board of Directors member for 20 years and currently serves as LDA’s second vice president for technology. He is responsible for the audio visual portion of the LDA’s scientific conferences.

Ruth Waddington, RN
Corresponding Secretary, LDA
Ruth graduated from Ocean County College with an associates in applied science degree, AAS, and passed the Nursing Boards to become an RN. She is currently employed as a nurse in a large OB/GYN group practice. She was formerly office manager & nurse for an internal medicine/geriatric medical office 31 years until the practice closed. She was also a nurse in a pediatric office and worked at Monmouth Medical Center in Long Branch, New Jersey, in labor & delivery and in post op surgery and neurosurgery. She is currently employed at a Family Medicine practice. Ruth has been an LDA Board of Directors members for 18 years and has served as its Corresponding Secretary for that time.

Jeannine Phillips, BA
Recording Secretary

Jeannine completed her BA in chemistry and has post graduate work in chemistry, physics, marine and environmental sciences. She has been awarded numerous grants for environmental and water studies. Her career has spanned organic chemistry custom syntheses, analytical chemistry such as pollution, food, water quality and pharmaceutical analyses, as well as trace metal analysis of Atlantic fish stock. Jeannine has performed process validation studies and research for the pharmaceutical industry. Volunteer service includes former vice chair of local environmental commission and officer of local watershed association. Currently, she chairs LymeQuest Support Group & Advocacy Project. She has been a LDA Board of Directors member Board member for 17 years and currently serves as Recording Secretary. She has received the Woman of Distinction Award, (Mayor and Town Council, 2003) and Outstanding Citizen Volunteer (Mayor and Town Council Award, 2011).
Tim received an MBA degree from George Washington University in Washington, DC, and held several analytical positions within the Federal government. At the Department of Labor, Tim was as an Economist in the Bureau of Labor Statistics and a Loss Prevention Analyst/Operational Auditor in the Office of Inspector General. He helped set up an Information Resources Management Review Program in the General Services Administration, working closely with OMB to design the program. Tim wrote a significant portion of the guidance for Federal agencies to follow in establishing and operating an IRM Review Program.

Tim worked for fifteen years in DHHS, first as a team leader in helping to oversee HHS’ operating divisions’ activities relating to information technology, including planning and procurement. Tim was a Supervisory Analyst in FDA’s Office of Legislation, serving as a one-person team as the liaison for the Center for Veterinary Medicine, and later working for the CFSAN-CVM team, handling dietary supplements as well as CVM issues. Tim was the principal liaison to Congress for a number of cross-cutting issues, including antimicrobial resistance and transmissible spongiform encephalopathies. Tim worked closely with CVM in developing animal feed regulations to control the possible spread of BSE, and also was the liaison to Congress in developing and passing animal drug user fee legislation, as well as legislation for Minor Use, Minor Species drug approvals.

After serving a Brookings fellowship on Capitol Hill, Tim returned to the Hill to work as Deputy Chief of Staff and Legislative Director for Congressman Chris Smith (NJ). Congressman Smith did and does chair House caucuses on Alzheimer’s disease, autism, Lyme disease, and numerous international affairs caucuses, as well as chairing the foreign affairs subcommittee with jurisdiction for global health. Tim had the staff lead in successfully moving Congressman Smith’s autism legislation and getting autism placed in the Congressionally Directed Medical Research Program. Tim also helped to develop several bills for Congressman Smith to try to improve the seriously impaired environment for making progress in the ability to manage Lyme and other tick-borne diseases. Since leaving Capitol Hill, he works part-time for the
Franciscan Foundation for the Holy Land and helped the Lyme Disease Association. He has served on the LDA Board of Directors for 3 years.

---

**Lyme Disease Association (LDA) Grant Program**

The LDA’s grant program is divided into three categories: Research, Education, and LymeAid 4 Kids grants. [Click here](#) for the summary of stats on grants awarded through 2019.

**Research**

Since the LDA officially opened its doors in 1992, it has awarded 119 research grants from coast to coast. The Lyme Disease Association is one of the largest sources of private, nonprofit tick-borne diseases research funding in the United States. We strive to fund the most relevant research and cutting-edge research aimed at investigating the prevention and treatment of tick-borne diseases. We choose projects led by top scientists who are able to publish in peer review to move the field forward.

LDA in partnership with an affiliate endowed the first center in the world to study chronic Lyme disease, which opened at Columbia University in 2007. The Center brings together researchers from various disciplines and from around the US.

Since 1999, the LDA has sponsored 20 scientific/medical conferences, eighteen jointly with Columbia University Vagelos College of Physicians and Surgeons. All provided Continuing Medical Education (CME) credits for physicians. LDA has funded cutting-edge research projects with over 36 different
researchers and institutions throughout the country, such as: Columbia University College of Physicians & Surgeons, NJ Medical School, Fox Chase Cancer Center, University of California, Davis, University of Pennsylvania, Bringham & Woman’s Hospital, NY Medical College, Rockefeller University, Tulane Regional Primate Center, University of North Florida, NIH/NASA and USDA.


One project resulted in data used to apply for/receive $4.7 million NIH grant. Significant genome mapping initially funded by LDA, has shown that different strains of Borrelia have the ability to exchange genetic material among themselves, a trait greatly benefiting their survival and probably confounding the body’s ability to eradicate the organism.

Other areas of work include: Testing, Treatment trials, Persistence of tick-borne diseases in GI tract, Mapping the genome of Borrelia strains, Brain imaging in the study of Lyme disease, PCR studies, Endocrine studies of Lyme, Underdiagnosis of neuropsychiatric Lyme disease in children and adults, Natural tick control, Identifying organisms in ticks nationwide, Immune complexes, Magnetic field effects on Borrelia, Infection rate of mammals, and Protein arrays.

Currently, there are more than a half-dozen projects that are
ongoing. The researchers, projects, and science are ready to find a cure. Now we need the funding to make it a reality.

(Image of PET Scan overlay above courtesy of Brian Fallon, MD, Columbia University)

**Education**

To help increase awareness and education throughout the country, the LDA believes it is essential to work with and assist other Lyme organizations and individuals.

To date, LDA has awarded 238 educational grants, including 95 educational scholarships to the LDA/Columbia continuing medical education conferences. Other grants have been to groups from across the country and some to universities. Many of the grants were used to support the following types of activities: publications (including *Compendium of Tick-Borne Disease: A Thousand Pearls*, “Lyme Times,” “The Basics,” TX Lyme Disease brochure), school curriculum project, Lyme disease websites, distribution of materials to school nurses, host various educational projects in schools, support medical conferences including several offering CME awards, sponsor physicians for CME medical conferences, sponsor Lyme disease symposia, provide educational in-service meetings for schools, companies, and general public.

**Diagnosis/Treatment for children without insurance**
About LymeAid 4 Kids (LA4K) – The Lyme Disease Association started LA4K fund in 2004 and has helped children all over the U.S. and in Canada. Developed with the help of author Amy Tan, the fund is for children who do not have/receive insurance coverage for Lyme disease treatment for children and have economic difficulties. Donations can be made online to LDA help this LA4K fund as there are so many applicants, the fund does run out of money frequently. **Total Funds distributed since 2004 totals $383,000.**

Click here for LymeAid 4 Kids Grant Application – No more 2019 applications are being accepted. Check back in end of January 2020 for status.

The LDA is an all-volunteer 501(c)(3) organization that has raised ~$6.4 million dollars for Lyme disease research, prevention, and education.

---

**About the LDA**

The Lyme Disease Association, Inc. (LDA) is designated by the IRS as a 501(c)(3) non-profit, a charity focusing on research, education, prevention and patient support.

**History**

The Lyme Disease Association began as Lyme Disease Association of Central Jersey in 1991 and then became Lyme Disease Association of New Jersey in 1993. Formed by patients and doctors who saw the need to organize, fund research and educate people, by 1997, it had influence far beyond NJ borders. In 2000, the Board changed the name to Lyme Disease Association, Inc. (LDA) with a broader mission expanding
research funding (LDA-funded research has appeared in 53 scientific journal publications to date) and including expanded patient support (LA4K). At that time, LDA decided to remain an all volunteer organization without paid employees so that almost all of its incoming revenue would be dedicated to the mission. It remains volunteer-run with some professional consultants who provide specific expertise when needed.

Mission Statement

The Lyme Disease Association, Inc. (LDA) has been granted 501(c)(3) non-profit status by the IRS. Its mission is promoting awareness of and controlling the spread of Lyme and other tick-borne diseases (TBD) and their complications through education and other means; raising and distributing funds for Lyme and tick-borne diseases (TBD) research, education and other related Lyme and TBD issues; assisting underprivileged patients in connection with Lyme and other TBD.

Accomplishments

On average, 97% of funds raised go directly to programs. LDA presents fully accredited annual scientific/medical conferences, funds research nationally, provides monies for children without insurance coverage for Lyme, provides free literature, has free information line, hosts free online doctor referral and heads an umbrella organization, LDAnet, of 45 associated organizations nationwide that work together on national issues. The LDA is a GuideStar Exchange Gold participant, signifying GuideStar’s highest level of transparency. LDA has also been designated as a federally approved national charity for workplace giving in the Combined Federal Campaign. (CFC) for 14 years. Additionally, LDA is an EPA partner in its PESP program to safely eradicate tick populations and reduce the risk of pesticides and is a part of an integrated pest management tick working group with government and public members. To that end, it helped in the planning of the EPA’s prevention conference and spoke at and co-hosted a session of the conference with the Centers for Disease Control (CDC). The LDA President was also a co-author of the article produced from a network developed under EPA, Network to Reduce Lyme Disease in School Aged Children. The article “You Can Make A Difference to A Child by Reducing the Risk of Lyme Disease appeared in the May 2010 journal of the National Association of School Nurses.

In its search for a cure for chronic Lyme disease and for prevention, the LDA has funded dozens of research projects coast-to-coast at institutions including Columbia
University College of Physicians & Surgeons (NY), New Jersey Medical School (NJ), University of Washington (WA), Northeast Wildlife DNA Laboratory (PA), University of California, Davis (CA), Georgia Southern University Research & Service Foundation (GA), Johns Hopkins University (MD), Kendall County Health Department (IL), University of New Haven (CT), and Stony Brook University (NY), New York Medical College (NY), Boston Medical (MA), Rockefeller University (NY), University of North Florida (FL), and Shanandoah School of Pharmacy (VA). Much of LDA-funded research has been featured in peer-reviewed journal publications (50 to date), e.g., Journal of the American Medical Association, Proceedings of the National Academy of Science, Emerging Infectious Diseases, Psychiatric Clinics of North America, Infection, Journal of Neuropsychiatry & Clinical Neurosciences, Journal of Clinical Microbiology, Journal of International Neuropsychological Society, Neurology, Immunology, Open Neurology Journal, PLOS One, & Genetics. 118 research grants have been awarded since LDA's inception.

Genome work initially funded by LDA has shown that different strains of Borrelia have the ability to exchange genetic material among themselves, a trait greatly benefiting their survival and probably confounding the body's ability to eradicate the organism. LDA funding of genome mapping has led to 17 strains being mapped.

In 2007, Columbia University announced the opening of the Lyme & Tick-Borne Diseases Research Center in New York, the first in the world devoted to the study of chronic Lyme disease. LDA co-funded the Center. LDA has given a grant to create a tissue bank there to store samples for Lyme disease research, now ongoing. The LDA has funded cutting edge published work with University of New Haven into the presence of Borrelia burgdorferi biofilms, which may be one of the survival mechanisms of the Lyme organism even after long-term treatment and loaned the University specialized equipment for its work.

The LDA has presented 20 fully CME accredited (continuing medical education) scientific conferences for researchers, doctors, and health care providers, featuring international speakers on the topic of Lyme and other tick-borne diseases, most jointly sponsored by Columbia University Vagelos College of Physicians and Surgeons. The 14th LDA conference was held in Minnesota in 2013, the first CME conference in the Upper Midwest and the 15th and 16th were held in Providence, RI in 2014 and 2015. The 2016 conference was held in St. Paul, Minnesota, the 2017 conference was held in Philadelphia, Pennsylvania, and the 2018 conference was held in Providence, Rhode Island. The 20th LDA conference was held on Sept 21 & 22, 2019
in Philadelphia, Pennsylvania. The LDA website contains video clips of the various conferences. A few conferences have had certifications for other professionals such as social workers, psychologists, dentists, nurses.

Since children ages 5-14 are at the highest risk of acquiring Lyme disease, the LDA created LymeAid 4 Kids, a fund that helps children without insurance. Initiated in conjunction with internationally acclaimed author Amy Tan, a Lyme victim, the LDA fund has awarded $383,000 in grants. LDA has compiled a website section, Lyme in the Schools, containing tools which can be accessed for free by schools, parents, and the general public. Resource articles, statistics, and an LDA educational PowerPoint, How A Tick Can Make You Sick, can be run for free in the classroom from the computer as can a prevention video for kids that the UMDNJ created in partnership with the LDA under an EPA grant. LDA’s book for children with chronic Lyme, Lyme Disease Is No Fun, Let’s Get Well! can be ordered on the site as can free pamphlet for parents and educators, The ABCs of Lyme Disease.

The LDA’s extensive resource list also includes free materials (postage charge as of 2014) such as newly updated LymeR Primer, Tickmark, and Tick Card; National Case Map, Case Number graphs, Personal & Property Prevention Posters, Symptoms Lists and at cost materials including conference DVDs, and books. The site also houses an extensive collection of tick and rash pictures and tick-borne microbes. Finding doctors who are experienced in treating tick-borne diseases is difficult, thus LDA created an automatic doctor referral system to help people nation wide.

LDA has educated through public, school, corporate and government seminars. It has developed billboards including an electronic one on Times Square in 2012 featuring the spread of chronic Lyme. Annually, LDA awards education grants to many other Lyme groups, universities and other organizations to further their mission against tick-borne diseases. 238 education grants have been awarded to date, including 95 educational conference scholarships to the LDA/Columbia continuing medical education conferences.

LDA reps have been asked to testify in many states, and been invited to be a part of press conferences with congressmen, governors and other officials. LDA had led the charge on the introduction and passage of many pieces legislation at the federal and state levels, including the 2014 Lyme bill that passed the House, and has been successful in meeting with officials at all levels of government. The LDA President testified before the US House of Representatives Foreign Affairs Global
Health & Human Rights Subcommittee Lyme hearing in 2012 and before the US House of Representatives Energy & Commerce Health Subcommittee in 2013. LDA has been twice invited to meet with the Vector-Borne Division of the CDC in Ft. Collins, CO, to discuss the spread of tick-borne diseases and other issues. LDA led the team to negotiate the Lyme language which passed in the the 21st Century Cures Act in 2016 which creates a federal Tick-Borne Diseases Working Group which has a patient voice at the table. The LDA President was appointed a ~3 year term on the Congressionally Directed Medical Research Program panel to oversee disbursements of funds for Lyme disease research. Most recently, the LDA President was appointed as a committee member to the Federal Health and Human Services (HHS) Tick-borne Disease Working Group which presented its first report to Congress in November of 2018.

State Activities

United States
New Jersey

New Hampshire
New York

Oregon
West Virginia
Educational Grants & Scholarships Given Since 1999

To help increase awareness and education throughout the country, LDA believes it is essential to work with and assist other Lyme organizations.
Publications – includes (Lyme Times, The Basics, TX Lyme Disease brochure)
Billboard
Curriculum project
Meetings
Websites
Distribution of materials to school nurses
Projects in the schools
Support medical conferences including Continuing Medical Education (CME) credits
Symposia

**PLACES: 22 STATES / 2 COUNTRIES**
CA, CO, CT, FL, IA, IL, KS, LA, ME, MO, MD, MN, NJ, NY, NC, OH, OR, PA, TX, GA, VA, VT/ UK

**NUMBER of GRANTS PER RECIPIENT:**

<table>
<thead>
<tr>
<th>Recipient</th>
<th>Number of Grants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allegheny Health</td>
<td>Allegheny Health (1)</td>
</tr>
<tr>
<td>Manasar, Armand, DDS, Bard Conf, NY</td>
<td>Manasar, Armand, DDS, Bard Conf, NY (1)</td>
</tr>
<tr>
<td>Arrant, Karan MSN, Univ of Louisiana, Monroe</td>
<td>Arrant, Karan MSN, Univ of Louisiana, Monroe (1)</td>
</tr>
<tr>
<td>Maryland Lyme Information &amp; Support Grp</td>
<td>Maryland Lyme Information &amp; Support Grp (5)</td>
</tr>
<tr>
<td>Berenbaum, Sandy, CSW-R, BCD, Leventhal, Judith PhD, Exman, Pat, (CT)</td>
<td>Berenbaum, Sandy, CSW-R, BCD, Leventhal, Judith PhD, Exman, Pat, (CT) (1)</td>
</tr>
<tr>
<td>Mid-Coast Lyme Disease Support &amp; Ed., ME</td>
<td>Mid-Coast Lyme Disease Support &amp; Ed., ME (7)</td>
</tr>
<tr>
<td>CALDA/LymeDisease.org</td>
<td>CALDA/LymeDisease.org (16)</td>
</tr>
<tr>
<td>Mid-Shore Lyme Disease Assoc., Inc., MD</td>
<td>Mid-Shore Lyme Disease Assoc., Inc., MD (1)</td>
</tr>
<tr>
<td>Central Jersey Lyme Support (Kahn)</td>
<td>Central Jersey Lyme Support (Kahn) (1)</td>
</tr>
<tr>
<td>Mineral Area College (MO) (Conference)</td>
<td>Mineral Area College (MO) (Conference) (1)</td>
</tr>
<tr>
<td>Clinic of Angels, FL</td>
<td>Clinic of Angels, FL (1)</td>
</tr>
<tr>
<td>Minnesota Lyme Action Support/MLDA</td>
<td>Minnesota Lyme Action Support/MLDA (4)</td>
</tr>
<tr>
<td>Organization</td>
<td>Organization</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Colorado Tick-Borne Disease Awareness Assn. (4)</td>
<td>Mountain Valley Lyme Disease Awareness Coalition (1)</td>
</tr>
<tr>
<td>Columbia University Lyme and Tick-Borne Diseases Research Center (NY) (1)</td>
<td>Mountain Valley Lyme Disease Support &amp; Ed, ME (1)</td>
</tr>
<tr>
<td>Florida Lyme Advocacy, Inc. (2)</td>
<td>NE Ohio Lyme Foundation (2)</td>
</tr>
<tr>
<td>Friends of Ridgefield Community Programs/Lyme Connections, CT (4)</td>
<td>New York University, David Younger, MD (1)</td>
</tr>
<tr>
<td>Georgia Lyme Disease Association (2)</td>
<td>North Carolina Lyme Disease Foundation (1)</td>
</tr>
<tr>
<td>H. Holtry (PA) (2)</td>
<td>North Texas Lyme Group (1)</td>
</tr>
<tr>
<td>Harford Cnty Lyme Disease Support Grp, Inc., MD (3)</td>
<td>Oregon Lyme Disease Network, Inc. (1)</td>
</tr>
<tr>
<td>Inglis, Wendy PT, NJ (1)</td>
<td>Partnership for Tick-Borne Diseases Education (MN) (2)</td>
</tr>
<tr>
<td>Int'l Lyme &amp; Assoc. Diseases Society, ILADS, MD (5)</td>
<td>Patricia McCleary, SLAM, Sturbridge Lyme Awareness (6)</td>
</tr>
<tr>
<td>Karl Ford, PhD (1)</td>
<td>Reid, Jennifer CT (1)</td>
</tr>
<tr>
<td>LDA Dr. Referral Prog. Grant and/or Website (NY) (10)</td>
<td>S.W. Barthold, DVM, PhD (CA) (1)</td>
</tr>
<tr>
<td>Lyme Association of Greater Kansas City, Inc. (15)</td>
<td>Seybold, Lynn, BSN, RN Univ. of Pittsburg, School of Nursing (PA) (1)</td>
</tr>
<tr>
<td>Lyme Disease Assoc. of Southeastern PA, Inc. (9)</td>
<td>Singh, Harjit, MD Hackettstown Regional Medical Ctr (NJ) (1)</td>
</tr>
<tr>
<td>Lyme Disease Network of NJ, Inc., Lymenet.org (7)</td>
<td>Stolow-Bedard, Jen, NY (1)</td>
</tr>
<tr>
<td>Organization</td>
<td>Recipient</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lyme Disease United Coalition IA (1)</td>
<td>Texas Lyme Disease Association, Inc. (2)</td>
</tr>
<tr>
<td>Lyme Rights, NY (1)</td>
<td>Time For Lyme, Inc., CT (1)</td>
</tr>
<tr>
<td>Lyme Society (1)</td>
<td>University of Texas Dallas (1)</td>
</tr>
<tr>
<td>Lyme Society of the UK (England) (1)</td>
<td>University of Texas Dallas (1)</td>
</tr>
<tr>
<td>Lyme West NY (1)</td>
<td>VTLyme.org (2)</td>
</tr>
<tr>
<td>Macon County Soil &amp; Water Conservation District, IL (2)</td>
<td>Western Tide Water Med Reserve Grp, VA (3)</td>
</tr>
<tr>
<td>Maine Lyme (1)</td>
<td></td>
</tr>
</tbody>
</table>

**RECIPIENTS: 143 EDUCATIONAL GRANTS**

1. **Ohio 2019** – NE Ohio Lyme Disease Foundation
2. **Vermont 2019** – VTLyme.org
3. **Kansas 2019** – Lyme Association of Greater Kansas City
4. **Connecticut 2019** – Lyme Connection
5. **Pennsylvania 2019** – Southeastern Pennsylvania Lyme Disease Association
6. **Colorado 2018** – Colorado Tick-Borne Disease Awareness Association (CONFERENCE COMPLETED)
7. **Kansas 2018** – Lyme Association of Greater Kansas City (NEW) (COMPLETED)
8. **Maine 2018** – Midcoast Lyme Disease Education & Support (CONFERENCE COMPLETED)
9. **Maine 2018** – Midcoast Lyme Disease Education & Support (CONFERENCE COMPLETED)
10. **New York 2018** – Lyme West NY (NEW) (BILLBOARD COMPLETED)
11. **Vermont 2018** – VTLyme.org (NEW)
12. **Ohio 2018** – NE Ohio Lyme Foundation (CONFERENCE COMPLETED)
13. **Texas 2017** – University of Texas Dallas online education (ONGOING)
14. **Pennsylvania 2017** – Allegheny Health CME conference (NEW)
15. **New York 2017** – Lyme Society conference (CONFERENCE COMPLETED)
16. **Maine 2017** – Midcoast Lyme Disease Education & Support (CONFERENCE COMPLETED)
17. **Colorado 2017** – Colorado Tick-Borne Disease Awareness Association (CONFERENCE COMPLETED)
18. **Kansas 2017** – Lyme Association of Greater Kansas City, for schools and other educational programs (NEW)
19. **Minnesota 2017** – Partnership for Tick-Borne Diseases Education, CME Provider (COMPLETED)
20. **Maine 2017** – Midcoast Lyme Disease Education & Support (CONFERENCE COMPLETED)
21. **California 2017** – LymeDisease.org, Education grant (COMPLETED)
22. **Connecticut 2017** – Lyme Connections, formerly Ridgefield LD Task Force, Education grant (NEW)
23. **Colorado 2017** – Colorado Tick-Borne Disease Awareness Association (CONFERENCE COMPLETED)
24. **Kansas 2017** – Lyme Association of Greater Kansas City, for schools and other educational programs (NEW)
25. **Maine 2016** – Midcoast Lyme Disease Education & Support (CONFERENCE COMPLETED)
26. **Colorado 2016** – Colorado Tick-Borne Disease Awareness Association, Tick-borne disease forum (COMPLETED)
27. **Kansas 2016** – Lyme Association of Greater Kansas City (COMPLETED)
28. **Minnesota 2016** – Partnership for Tick-Borne Diseases Education, for CME Provider for 1000 brochure printing (COMPLETED)
29. **Maryland 2015** – Harford Cnty Lyme Disease Support Grp, Inc., Education grant (COMPLETED)
30. **Maine 2015** – Mountain Valley Lyme Disease Awareness Coalition, Education grant (COMPLETED)
31. **Maine 2015** – Mid-Coast Lyme Disease Support & Ed., Education grant for Lyme Conference (COMPLETED)
32. Maine 2015 – Mid-Coast Lyme Disease Support & Ed., Education grant for Lyme Conference (COMPLETED)
33. Kansas 2015 – Lyme Association of Greater Kansas City, Educational projects in the schools in Kansas and Missouri (COMPLETED)
34. California 2015 – LymeDisease.org, Education grant (COMPLETED)
35. New York 2015 – LDA Dr. Referral and Website grant (COMPLETED)
36. New York 2015 – LDA Dr. Referral and Website grant (COMPLETED)
38. Maryland 2015 – Information and Support Group of Maryland, Education grant (COMPLETED)
39. New Jersey 2015 – Central Jersey Lyme Support (Kahn) (SEMINAR COMPLETED)
40. Illinois 2015 – Macon County Soil and Water Conservation District, tick awareness program (COMPLETED)
41. Iowa 2014 – Lyme Disease United Coalition, Education grant (COMPLETED)
42. California 2014 – LymeDisease.org, Education grant (COMPLETED)
43. Connecticut 2014 – Lyme Connections, formerly Ridgefield LD Task Force, Education grant (COMPLETED)
44. Illinois 2014 – Macon County Soil and Water Conservation District, Education Grant (COMPLETED)
45. Kansas 2014 – Lyme Association of Greater Kansas City. Educational projects in the schools in Kansas and Missouri (COMPLETED)
46. Maryland 2014 – Harford County Lyme Disease Support Group, Education grant (COMPLETED)
47. Massachusetts 2014 – Patricia McCleary, SLAM, Education grant (COMPLETED, BILLBOARD)
48. New York 2014 – LDA Dr. Referral grant (COMPLETED)
49. New York 2014 – LDA Dr. Referral and Website grant (COMPLETED)
50. New York 2014 – LDA Dr. Referral and Website grant (COMPLETED)
51. Virginia 2014 – Western Tidewater Medical Reserve Group, Educational material grant (COMPLETED)
52. Maryland 2014 – Lucy Barnes, Maryland Lyme Information and Support Group for Education purposes (COMPLETED)
53. California 2013 – LymeDisease.org, formerly CALDA, Education grant (COMPLETED, PUBLISHED)
54. Kansas 2013 – Lyme Association of Greater Kansas City, Educational grant
55. Maine 2013 – Maine Lyme, Educational grant (COMPLETED)
56. Maryland 2013 – Maryland Lyme Information and Support Group, Education grant (COMPLETED)
57. Massachusetts 2013 – Patricia McCleary, Sturbridge Lyme Awareness Education (SLAM), Education (COMPLETED)
58. Minnesota 2013 – Minnesota Lyme Association, Education grant (COMPLETED)
59. New York 2013 – Columbia University, Educational grant for Lyme & Tick-Borne Diseases Research Center (ONGOING)
60. New York 2013 – LDA Dr. Referral grant (COMPLETED)
61. Pennsylvania 2013 – H. Holtry, Education grant (COMPLETED)
62. Texas 2013 – Texas Lyme Disease Association, Education grant (COMPLETED)
63. Virginia 2013 – Western Tidewater Medical Reserve, Education grant (COMPLETED)
64. Connecticut 2013 – Jennifer Reid, Poster presentation on research at the International Lyme Conference in Boston (COMPLETED, POSTER PRESENTED)
65. California 2012 – LymeDisease.org, formerly CALDA, Education grant (COMPLETED, PUBLISHED)
66. California 2012 – S.W. Barthold, Education Hearing (COMPLETED)
67. Florida 2012 – Clinic of Angels, Adult patient support (COMPLETED)
68. Kansas & Missouri 2012 – Lyme Association of Greater Kansas City, Educational projects in the schools in Kansas and Missouri (COMPLETED)
69. Maryland 2012 – Lyme Information and Support Group, Education (COMPLETED)
70. Massachusetts 2012 – Sturbridge Lyme Awareness Education (SLAM), Education billboard grant (COMPLETED)
71. Massachusetts 2012 – Sturbridge Lyme Awareness Education (SLAM), Education (COMPLETED)
72. Minnesota 2012 – Minnesota Lyme Association (formerly MLAS) Education grant (COMPLETED)
73. New Jersey 2012 – Wendy Inglis PT, Lyme Disease Educational Awareness Forum grant Holmdel High School (COMPLETED)
74. New York 2012 Spring – LDA Dr. Referral grant (COMPLETED)
75. New York 2012 Fall – LDA Dr. Referral grant (COMPLETED)
76. Pennsylvania 2012 – Lyme Disease Association of Southeastern Pennsylvania, Inc., Education/Publication grant (COMPLETED, TEXTBOOK PUBLISHED)
77. Pennsylvania 2012 – H. Holtry, Education grant (COMPLETED)
78. Texas 2012 – North Texas Lyme Group, Lyme Education Seminar (COMPLETED)
79. Virginia 2012 – Western Tidewater Medical Reserve Group, Lyme Information Packet (COMPLETED)
80. California 2011 – California Lyme Disease Association, Education grant (COMPLETED)
81. Georgia 2011 – Georgia Lyme Disease Association, Educational grant (MONIES RETURNED)
82. Missouri 2011 – Mineral Area College, Cross-Disciplinary Vector-Borne Diseases Symposium Tick-Sampling Workshop, Education grant (COMPLETED)
83. New York 2011 Spring – LDA Dr. Referral grant (COMPLETED)
84. New York 2011 Fall – LDA Dr. Referral grant (COMPLETED)
85. Minnesota 2011 – Minnesota Lyme Association (formerly MLAS) Education grant (COMPLETED)
86. Massachusetts 2011 – Sturbridge Lyme Awareness Education (SLAM) (COMPLETED)
87. Kansas & Missouri 2011 – Lyme Association of Greater Kansas City. Educational projects in the schools in Kansas and Missouri (COMPLETED)
88. Maryland 2010 (& Jan 2011) – Maryland Lyme Information and Support Group Education grant (COMPLETED)
89. Connecticut 2010 – Friends of Ridgefield Community Programs (Education grant Returned by grantee)
91. Minnesota 2010 – Minnesota Lyme Action Support, Education grant (COMPLETED)
92. Kansas & Missouri 2010 – Lyme Association of Greater Kansas City. Educational projects in the schools in Kansas and Missouri (COMPLETED)
93. Pennsylvania 2010 – Lyme Disease Association of Southeastern Pennsylvania, Inc., Education grant (COMPLETED)
94. California 2010 – California Lyme Disease Association, Education grant (COMPLETED)
95. Massachusetts 2010 – Sturbridge Lyme Awareness Education (SLAM), Educational grant (COMPLETED)
96. Connecticut 2009 – Sandy Berenbaum, CSW-R, BCD, Judith Leventhal, PhD, Pat Exman, Education seminar presentations (COMPLETED)
97. Georgia 2009 – Georgia Lyme Disease Association, Education (COMPLETED)
99. California 2009 – California Lyme Disease Association, Educational
100. **Louisiana 2009** – Karan Arrant, MSN, University of LA Monroe, *Lyme Disease and Other Tick-Borne Diseases in the South*, Education (COMPLETED)


103. **California 2008** – California Lyme Disease Association. Educational projects and sponsorships (Lyme Times). (COMPLETED)

104. **Florida 2008** – Florida Lyme Advocacy, Inc., Education website. (COMPLETED)

105. **New York 2008** – Lyme Rights. (COMPLETED)

106. **Kansas 2008** Lyme Association of Greater Kansas City. Educational projects in the schools in Kansas and Missouri (COMPLETED)


108. **Maryland 2008** – Harford County LDSG, Inc. Education grant. (COMPLETED)

109. **Pennsylvania 2007** – Lynn Seybold BSN, RN: University of Pittsburg School of Nursing, Materials grant (COMPLETED)

110. **Oregon 2007** – Oregon Lyme Disease Network, Website upkeep (COMPLETED)

111. **North Carolina 2007** – North Carolina Lyme Disease Foundation. Educational projects (COMPLETED)

112. **Kansas 2007** – Lyme Association of Greater Kansas City. Educational projects in the schools in Kansas and Missouri. (COMPLETED)

113. **California 2007** – California Lyme Disease Association. Educational projects and sponsorships (Lyme Times). (COMPLETED)


117. **New York 2007** – David Younger, MD, NYU Neuromuscular Center. Lyme Disease educational coordinator. (COMPLETED)

118. **New Jersey 2006** – Lyme Disease Network of NJ, East Brunswick. For continued upkeep of the Lymenet.org and LymeDiseaseAssociation.org websites
119. **Maryland 2006** – International Lyme & Associated Diseases Society, Bethesda. For CME scientific meeting in Philadelphia. (COMPLETED)

120. **Maryland 2006** – Mid-Shore Lyme Disease Association – for an education symposium. (COMPLETED)

121. **Connecticut 2006** – Time for Lyme (TFL), Greenwich. Education/curriculum project. (COMPLETED)

122. **California 2006** – California Lyme Disease Association, Inc. (CALDA), Ukiah. Educational grant. (COMPLETED)

123. **California 2006** – California Lyme Disease Association, Inc. (CALDA), Ukiah. Educational grant for Lyme Times Children’s Education issue. (COMPLETED)

124. **California 2006** – California Lyme Disease Association, Inc. (CALDA), Ukiah. Educational grant. (COMPLETED)

125. **Florida 2005** – Florida Lyme Advocacy Network for expenses relating to educational meetings. (COMPLETED)

126. **Kansas (and Missouri) 2005** – Lyme Association of Greater Kansas City (LAGKC), Overland Park. To continue to prepare educational packets including *Handbook for Prevention of Lyme & Other Tick-Borne Diseases* to school nurses in the Kansas and Missouri schools. (COMPLETED)


131. **New Jersey 2005** – Harjit Singh, MD, FAAP, Hackettstown Regional Medical Center to support Grand Rounds: Update on Lyme Disease with Special Reference to “Chronic Lyme Disease. 1 category 1 AMA-PRA CME (COMPLETED)


138. **Kansas 2003** – Lyme Association of Greater Kansas City, packets for school nurses; LDA provided grant for material and additional printed LDA materials. (COMPLETED – DISTRIBUTED)

139. **Maryland 2003** – ILADS, Education grant (COMPLETED)


141. **Maryland 2003** – International Lyme & Associated Diseases Society (ILADS), Education. (COMPLETED)


143. **New York 1999** – Armand Manasar, DDS Lyme Disease & Other Spirochetal and Tick-borne Disease: A Two Day Discussion of the Most Recent Developments in Research and Clinical Management. Bard/LDA Conference (COMPLETED)
**Recipients per State:**

**2019** – 30 Lyme Conference Educational Grants (States TBA)
Total $ TBA

**2018** NH (4), MA (2) ME, AZ, FL (2), VT (2), OH, NY GA, CO, ME
Total $12, 217

**2017** NY (4), OH, NJ (2), MA (2), ME, PA, CO, VT, MD, CA
Total $11,372.32

**2016** CA, CO, ME, MD, MN (2), MO, NJ (2), NY (3), OH, VT, WA (2), WI
Total: $18,141.19

**2015** NC, AZ, PA (2), MD, OH, CA, NJ (3), NY (3), MA (3)
Total: $10,712.98

---

**History of Lyme Disease Association name changes**

Lyme Disease Association of Central Jersey, Inc. (LDACJ) 1992
Lyme Disease Association of New Jersey, Inc. (LDANJ) 1993
Lyme Disease Association, Inc. (LDA) 2000

**NOTE:** This document is a work in progress. Grants are awarded based on application submission, process of expert review when required, & subject to LDA Board of Directors’ approval (all grants may not be listed).

**Click here for Education Grant Application**
LDA Grants Resulting in Publications/Conferences

The LDA annually awards a number of small education grants. Sometimes they are restricted to publications or conferences. Below is a sample of those grants.

**New York 1999** – Arman Manasar, DDS, Bard College: 2 Day Discussion of Most Recent Developments in Research & Clinical Management; CME, CDE, CEU credits offered

**Maryland 2001** – International Lyme & Associated Diseases Society, ILADS Scientific Meeting, CME credits offered

**England 2003** – Lyme Society, United Kingdom; Scientific conference, PGEA approved (Medical credits offered) June 20 & 21, 2003, York St. John College, York, UK

**Maryland 2003** – International Lyme & Associated Diseases Society, ILADS Scientific Meeting, CME credits offered

**Pennsylvania 2003** – Lyme Disease Association of Southeastern Pennsylvania, Basics booklet

**California 2004** – CALDA, Ray Stricker, MD and Lorraine Johnson, MD, “The Treatment of Lyme Disease: A Medicolegal Assessment,” Expert Reviews in Anti-Infective Therapy

**Maryland 2005** – International Lyme & Associated Diseases Society, ILADS Scientific Meeting, CME credits offered

**California 2005** – CALDA, Lyme Action Program, San Francisco, CA (CONFERENCE COMPLETED)

**Maryland 2006** – International Lyme & Associated Diseases Society, ILADS Scientific Meeting, CME credits offered

**New Jersey 2006** – Hackettstown Community Hospital (HCH), “Lyme
Disease in New Jersey;” ground rounds, 1 Category 1 Credit

**Pennsylvania 2007** – Lyme Disease Association of Southeastern Pennsylvania, *Basics* booklet

**Texas 2007** – Texas Lyme Disease Association, Lyme awareness brochures

**California 2008** – CALDA, *Lyme Times*

**Pennsylvania 2008** – Lyme Disease Association of Southeastern Pennsylvania, *Basics* booklet

**California 2009** – CALDA, *Lyme Times*

**Pennsylvania 2009** – Lyme Disease Association of Southeastern Pennsylvania, *Basics* booklet

**Missouri 2011** – Mineral Area College, *Cross-Disciplinary Vector-Borne Diseases Symposium Tick-Sampling Workshop*, continuing education credits offered

**Pennsylvania 2012** – Lyme Disease Association of Southeastern Pennsylvania, Tick-Borne disease textbook

**Connecticut 2013** – Jennifer Reid, Poster presentation on research at the International Lyme Conference in Boston

**Maine 2015** – (April, May) (Midcoast Lyme Disease Education & Support (MLDSE) 1st Annual MLDSE Conference (CONFERENCE COMPLETED)

**Maine 2016** – Midcoast Lyme Disease Support & Education (MLDSE), 2nd Annual MLDSE Conference, April 30, 2016 (CONFERENCE COMPLETED)

**Colorado 2016** – Colorado Tick-Borne Disease Awareness Association, 1st Rocky Mountain Lyme & Other Tick-Borne Diseases Forum, May 7, 2016 (CONFERENCE COMPLETED)

**Pennsylvania 2017** – Allegheny Health CME conference
New York 2017 – Lyme Society conference (CONFERENCE COMPLETED)

Maine 2017 – Midcoast Lyme Disease Education & Support (MLDSE) 2nd Annual MLDSE Conference (CONFERENCE COMPLETED)

Colorado 2017 – Colorado Tick-Borne Disease Awareness Association, 2nd Rocky Mountain Forum, June 3, 2017 (CONFERENCE COMPLETED)

Maine 2017 – Midcoast Lyme Disease Education & Support (MLDSE) 3rd Annual MLDSE Conference (CONFERENCE COMPLETED)

Colorado 2018 – Colorado Tick-Borne Disease Awareness Association, 3rd Rocky Mountain Forum, May 19, 2018 & publication (CONFERENCE COMPLETED)

Ohio 2018 – NE Ohio Lyme Foundation, 3rd Annual Lyme Disease Symposium, May 11, 2019 (CONFERENCE COMPLETED)

Maine 2018 – Midcoast Lyme Disease Education & Support (MLDSE) 4th Annual MLDSE Conference (CONFERENCE COMPLETED)

Maine 2019 – Midcoast Lyme Disease Education & Support (MLDSE) 5th Annual MLDSE Conference (CONFERENCE COMPLETED)