economics, and history in specific universities in the five countries. These "views from below" not only illustrate how the organizational arrangements and pressures affect the working of professors and students in local settings but also bring to the fore the importance of interpersonal arrangements, cooperation, and support within such local groups.

The juxtaposition of the "macro" and "micro" analyses presented in the individual essays allows the editor in his conclusions to identify what he sees as the central problem facing graduate education: How can apprenticeship in research embodying the Humboldtian ideal of the unity of teaching, learning, and research be pursued effectively in the face of the increasing size, formalization, and bureaucratization of research and education and the increasing external pressures on the universities to become more efficient, relevant, and accountable?

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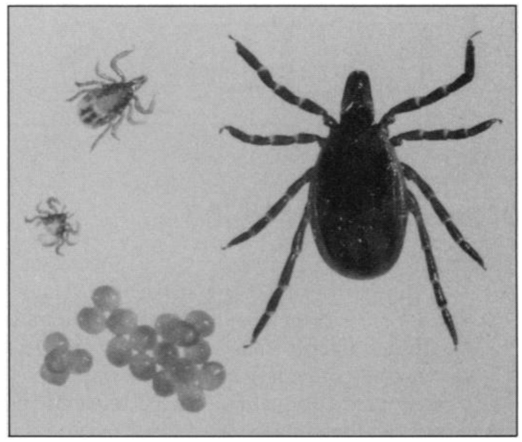
Acaropathology

Ecology and Environmental Management of Lyme Disease. HOWARD S. GINSBERG, Ed. Rutgers University Press, New Brunswick, NJ, 1993. viii, 224 pp., illus. $37.

Just when it seemed that infectious diseases in the United States had been nearly conquered, along came AIDS, Lyme disease, and Legionnaires' disease. Even that old nemesis tuberculosis came roaring back. Infectious and parasitic diseases continue to wreak havoc on humans globally. Indeed, today malaria is estimated to affect approximately 300 million people and accounts for 1.5 million deaths annually. Fortunately, mosquito-transmitted malaria is rare in the United States, but tick-borne Lyme disease is prevalent both here and abroad, affecting western and central Europe, the former Soviet Union, and China and Japan as well as the rest of North America. It accounts for more than 90 percent of all reported vector-borne illnesses in the United States. More than 9600 cases of Lyme disease from 45 states were reported to the Centers for Disease Control and Prevention in 1992. This represents a 19-fold increase over the 497 cases reported from 11 states in 1982. Most cases were reported from the northeastern, mid-Atlantic, north central, and northern Pacific coastal regions.

There is controversy regarding whether the number of reported Lyme disease cases is accurate. Moreover, it is unclear whether the 19-fold increase in reported cases since 1982 is due to heightened awareness of Lyme disease, increased use of laboratory testing for diagnosis, increased surveillance and requirements for reporting, or a true increase in the number of cases. Perhaps all of these factors are involved.



Life stages of *Ixodes scapularis*. Clockwise from bottom: eggs, larva, nymph, adult (female). [From Fish's chapter in *Ecology and Environmental Management of Lyme Disease*; courtesy M. Bechtel and D. Fish]

Lyme disease is caused by a spirochete, *Borrelia burgdorferi*, which is transmitted primarily by ticks of the genus *Ixodes*. Transmission to humans is accomplished mainly by ticks in the *I. ricinus–I. persulcatus* species complex, and the global distribution of the disease parallels that of *I. ricinus*, *I. persulcatus*, *I. scapularis*, and *I. pacificus*. In the United States, the principal vector in the West is *I. pacificus* (the western black-legged tick) and in the East is *I. scapularis* (the black-legged tick). The northern form of *I. scapularis* was for a short time (1979 to 1992) known as *I. dammini* (the "deer" tick), but recent studies have convincingly shown that *I. dammini* is actually the same species as the southern *I. scapularis*; thus the correct name for northern and southern populations of this species is *I. scapularis*. (A note added in proof to the book under review here indicates this fact and reminds readers that the name *I. scapularis* now applies to the species that is called both *I. dammini* and *I. scapularis* in the book and in scientific papers from 1979 to 1992.)

In addition to *I. scapularis* and *I. pacificus*, there are at least three other *Ixodes* species (*I. dentatus*, *I. neotomae*, *I. spinipalpis*) that transmit *B. burgdorferi* in the United States. These species usually do not bite humans but maintain the spirochete enzootically by transmitting it to cottontail rabbits and wood rats. The enzootic cycles are important because they provide a source of infected hosts for *I. pacificus* and *I. scapularis*, which in turn bite humans and other animals. However, the most common and important hosts of *B. burgdorferi* in the United States, from which most human cases are derived, are various species of *Peromyscus* mice, especially *P. leucopus* (the white-footed mouse).

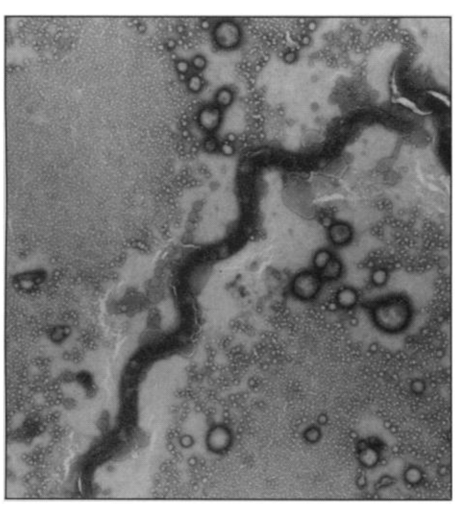
The unraveling of the mysteries of Lyme disease has been and continues to be a good biomedical detective story. Initially, epidemiologic evidence suggested a tick as the vector of an arthritic disease of unknown etiology in Old Lyme, Connecticut. Associations of similar arthritic symptoms with a distinctive "bull's-eye" erythematous skin rash in the early stages of the disease and certain neurologic and cardiac sequelae were subsequently made. The discovery of a new species of spirochete in *I. scapularis* (at that time called *I. dammini*) ticks in New York that was later isolated from patients suffering from these clinical symptoms was a landmark achievement. These discoveries laid the foundation for the recognition and characterization of Lyme disease.

As new information is uncovered, concepts of Lyme disease are changing. For example, it is now clear that *B. burgdorferi* is not limited to the northeastern, north central, and northern Pacific coastal regions; it is increasingly being isolated in the southern United States, where it is cycling enzootically. These recent discoveries—many not yet published—and the realization that northern and southern populations of the primary tick vector, *I. scapularis*, occur over large geographic areas, raise the question of why larger numbers of human cases of Lyme disease are not reported from the South. Lack of adequate surveillance of the disease and misinformation among physicians concerning the distribution of *B. burgdorferi*, plus the misconception that a competent tick vector was not present in the South, are part of the answer. However, another likely contributing factor—among others that are yet to be fully investigated—is the difference in ecologic conditions between the North and the South. Realization of the importance of ecology and environmental management in reducing the number of new cases of Lyme disease prompted Howard S. Ginsberg to compile this book, which contains contributions by him and 17 other experts, all of whom have conducted original research on some aspect of Lyme disease. The book is well done, although some text is apparently missing between pages 92 and 93.

Although a considerable amount of information is available on the ecology of Lyme disease in the western United

States, the book deals overwhelmingly with the disease in the northeastern states, where in fact most of the ecologic research has been conducted. In a brief overview of Lyme disease ecology in his introduction to the book Ginsberg does devote a small amount of space to the situation in the western and southeastern states (one page) and in Europe and Asia (one paragraph). The thorough chapter on the natural history of *B. burgdorferi* in vectors and vertebrate hosts also transcends the Northeast, discussing some of the ecologic differences among the major vectors of *B. burgdorferi* worldwide. This chapter also contains a brief discussion of reservoir hosts; a useful table of other species of *Borrelia*, their vectors, and their associated diseases; and a table listing wild and domestic animal hosts for *B. burgdorferi*.

Two intriguing questions associated with Lyme disease have to do with the antiquity of *B. burgdorferi* and its tick vectors and their distribution and spread in the United States. Ginsberg clearly lists the evidence and correctly notes where evidence ceases and speculation begins. For example, he points to the difficulty of establishing the historical distribution of *I. scapularis* on the basis of scattered indirect sources. Given the available evidence, he notes, the most likely hypotheses for historical trends in the distribution of northern populations of *I. scapularis* are (i) recent geographical spread from a few coastal New England islands and (ii) local spread coupled with population increases of a widespread, but formerly rare, species. He comments, "The published records and the collections found in museums, on which these hypotheses are based, are each generally the result of the efforts of a few collectors who went into an area with a specific set of interests. A diminutive species that is spottily distributed at low population levels could easily have been missed in the few surveys that have been taken. Therefore, these alternative scenarios must remain speculative at present." This objective analysis is especially refreshing given that the first hypothesis has often been assumed to be correct in the absence of sufficient evidence. The same objective approach is taken toward such topics as the antiquity of Lyme disease in North America, historical changes in vegetation and host populations, and current tick distribution and spread.



"Unfixed, negatively stained micrograph of *Borrelia burgdorferi*." [From Anderson and Magnarelli's chapter in *Ecology and Environmental Management of Lyme Disease*; courtesy Connecticut Agricultural Experiment Station]

The second half of the book is devoted to Lyme disease surveillance, personal protection against ticks, and vector management and offers useful practical information for researchers as well as for the general public. The final chapter, devoted to ecologic principles that should underlie environmental management of ticks and Lyme disease, contains discussions of such strategies as habitat modification (including burning, mowing, and other procedures); removal or reduction of tick hosts (especially deer); application of acaricides to hosts and habitats; use of predators, parasitoids, and pathogens of ticks; disruption of tick reproduction via pheromone manipulation; and release of sterile male ticks. This chapter sets the stage for a "forum" in which eight Lyme disease researchers comment on the subject of environmental management, providing additional information and perspectives. There seems to be general agreement among all the contributors that everyone who is exposed to ticks should employ personal protection methods to avoid tick attachment. Opinions differ regarding the effectiveness of various other methods of tick control.

It is clear from this book that no single intervention technique will work in all situations. Indeed, even a combination of techniques does not always produce the desired results. Intraspecific tick populations usually vary in different ecologic areas. Nevertheless, integrated pest management is the most logical, effective approach to managing tick populations, just as it is in the management of agricultural pests. Similarly, attempts to manage ticks or any other kind of pest should be based on an understanding of the fundamental ecology of the offending pest or vector. Ecologic relations are complex, interdependent, and variable. Clearly, caution must be exercised and management techniques tailored to fit the particular situation.

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Photosynthesis

The Photosynthetic Reaction Center. JOHANN DEISENHOFER and JAMES R. NORRIS [Eds.]. Academic Press, San Diego, 1993. In two volumes. Vol. 1, xiv, 432 pp., illus. Vol. 2, xviii, 574 pp., illus. $129 or £99 each.

Through x-ray crystallography and nuclear magnetic resonance studies, a wealth of information has been obtained on the three-dimensional structure of a number of soluble proteins, including a bacteriochlorophyll-binding protein. However, it is a major challenge to have membrane-protein complexes form sizable, stable crystals that diffract x-rays to high resolution and that can be used to determine the atomic structure of the protein complex. The first example of a membrane-protein complex for which a high-resolution (3 Å) crystal structure could be obtained was the photosynthetic reaction center complex from a purple bacterium. This work, carried out by Hartmut Michel, Johann Deisenhofer, and their colleagues in the mid-1980s, represented a milestone in the structural analysis of membrane-protein complexes. Since then, similarly detailed information has been obtained on homologous reaction center protein complexes from purple bacteria and, recently, on a light-harvesting chlorophyll protein from plants.

The detailed structural information provided by the crystal structure of the bacterial reaction center has triggered an avalanche of investigations targeting a functional understanding of the properties and mechanisms of energy and electron transfer events in photosynthetic reaction centers. A significant part of this research is reviewed in *The Photosynthetic Reaction Center*, which includes coverage of a number of different techniques and approaches used in the analysis of photosynthetic reaction centers from purple bacteria (ranging from crystallization of an antenna complex to sophisticated absorption and magnetic resonance spectroscopy) as well as discussions of related reaction centers, such as photosystem II from plants. In addition to material on the structure and function of the bacterial reaction center, the first volume includes informative contributions on light-harvesting antenna systems, biochemical replacement of pigments in reaction centers, biogenesis of the photosynthetic apparatus in purple bacteria, and parallels with the photosystem II complex from plants; because the purple bacterial and photosystem II reaction center complexes appear to be related evolutionarily, the determination of the structure of the purple bacterial reaction center has had a significant impact