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Bacterial Biogeochemistry. The Ecophysiology of Mineral Cycling

T. FENCHEL, G. H. KING, T. H. BLACKBURN

1998. Academic Press, San Diego (2nd ed.)

307 pp. 23.5 × 16 cm.
Price: $ 65
ISBN 0-12-103455-0

The influence of bacterial activity on the chemical composition of the biosphere has been recognized and gradually developed as a research topic throughout this century. Before the turning of the 20th century, Sergei N. Winogradsky discovered chemolithotrophy, a process which he described as "contradictory to that fundamental doctrine of physiology which states that a complete synthesis of organic matter cannot take place in nature except through chlorophyll-containing plants by the action of light". Martinus W. Beijerinck, founder of the Delft School of microbiology, among his many other discoveries, described nitrogen fixation by bacteria. Later, Vladimir I. Vernadsky related biogeochemistry to the concept of biosphere in his book *La Géochimie* (Paris, 1924), an essay based on a series of lectures he gave at La Sorbonne in 1922 and 1923 (see the article "Meeting the Biospheres" on the translations of Vernardsky's work, by M. Piqueras on INTERNATL MICROBIOL [1998] 1:165–170). Although bacteria are not the only microorganisms to effect decomposition of organic matter into mineral nutrients available to plants, they play the major role in such transformation. Several steps in the C and N geochemical cycles are carried out exclusively by bacteria.

Twenty years have passed since the publication of *Bacteria and Mineral Cycles* (Academic Press, 1979) by T. Fenchel and T. H. Blackburn, which the authors wish to consider the first edition of the book reviewed here. At that time, Fenchel and Blackburn were at the Institute of Ecology and Genetics, Aarhus, Denmark, one of the earliest centers of European microbial ecology. Many discoveries and new concepts have been developed since then as microbial ecology has become a thriving interdisciplinary field of science.

The same authors, along with G. M. King, have published this work with a new title, *Bacterial Biogeochemistry*, and have added a subtitle: *The Ecophysiology of Mineral Cycling*, which is the real leitmotiv of the book. *Bacterial Biogeochemistry*, which deals with 3,800 million years of cycling by prokaryotic life, is a book about the history of the Earth itself. Our planet's present physiology has derived from eons of prokaryotic activity, which have enormously changed the Earth's environment. Life, as it is now in the biosphere, evolved through prokaryotic processes that have effected the chemical environment since the origin of life itself. This issue, not yet acknowledged by the entire scientific community, is a central point in the understanding of the cycles of matter that profoundly influence environmental conditions. The book also provides clues to the solution of some current environmental problems. With an approach based primarily on the physiology of prokaryotes, the book, which takes all these matters into consideration, may be regarded as a "physiology of the Earth".

The book's 10 chapters are all related to global environmental science. Chapter 1 (General considerations) sets up the background of knowledge for all the subsequent chapters. A general view of bacterial metabolism, bioenergetics, transport mechanisms, and functional and spatial structure of microbial communities provides the basis for understanding patterns of natural microbial processes. Chapter 2 (Mineral cycles) deals with the breakdown of organic matter to the major elements (C, N, S, P, etc.). It must be noted here that the word "mineralization" is polysemic, because it is used for different meanings: microbiologists, for instance, as in Fenchel's book, mean the conversion of organic matter into different inorganic compounds (CO_2, NH_3, H_2S, PO_4^{3-}, etc.), whereas geologists mean the formation of minerals (such as calcite, magnetite, greigite) by the activities of organisms. Chapters 3 to 8 describe microbial processes in particular habitats (water column, soil, sediment, mats, animal and plant tissue, and extreme environments, respectively). Chapter 9 focuses mainly on the role of microbial processes in the distribution and abundance of gaseous phases of C, N and S in the atmosphere. Chapter 10 is devoted to the early evolution of both life and biogeochemical cycles. Appendix 1 presents the major ideas needed for thermodynamic analysis of metabolic processes. For most environmental scientists, thermodynamics is just an irrelevant subfield of theoretical physics. Not so. The principles of equilibrium thermodynamics can be applied readily to understand the energetics of metabolic processes and the biogeochemical outcome of the behavior of microorganisms. The origins of life, metabolic diversity, microbial competition and mass and energy cycles can, and in principle should be, explained in the context of thermodynamics.

Bacterial Biogeochemistry, an excellent book, deserves to be used as a major text in microbial ecology courses for university students. But deficiencies in academia may preclude its acceptance. A broader view in education programs imparted by instructors, eager to understand the innermost processes of life will be well served by this text which is also useful as a

treatment of short advanced microbiology subjects such as ecology, limnology, soil science, geochemistry, bioremediation and environmental science. The book can also serve as an essential reference book for professionals in these fields. Lost among many unimaginative, tedious, encyclopedic biology textbooks—sold by the many thousands—one occasionally finds rare jewels, seminal books on biological thought, such as these three Fenchel (et al.) works: the two aforementioned ones (*Bacterial Biogeochemistry* and *Bacteria and Mineral Cycles*) and *Ecology and Evolution in Anoxic Worlds* (with B. J. Finlay; Oxford Univ. Press, 1995). Sadly enough, such jewels probably sell only a few thousand copies. Scientific and intellectual concern leads us to wish that the invalue be more greatly appreciated, and the information in them widely disseminated.

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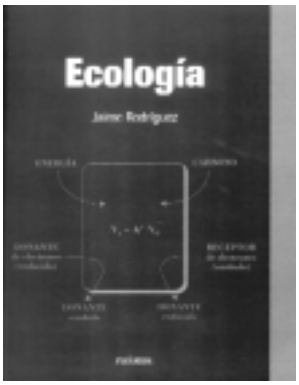

Ecología

JAIME RODRÍGUEZ

1999. Ediciones Pirámide, Madrid.

411 pp. 19 × 24 cm.
Price: 3500 PTA
ISBN 84-368-1302-2

Perhaps in an involuntary way, one can find a sort of reconciliation among ecology and microbiology in the approach of the book. Until recently, ecology had developed paying little attention, if any, to microorganisms. The question whether ecological theory was applicable to microorganisms had not been even considered. On the other hand, microbiologists had entirely ignored the methods, concepts and careful reasoning and planning that characterize ecological research. We must therefore thank the author because, in such a concise, brief text, he has extensively considered the role of microorganisms in ecology. Despite the extraordinary relevance of microorganisms, their contribution to the ecological theory has been traditionally overlooked. Usually, their only role in ecosystems that was taken into account were those of mineralizers of organic matter and intermediates in some cycles of nutrients, no matter the different guilds of bacterioplankton carry out a wide range of functions in aquatic environments. For ecology to be universally valid, its principles should apply also to microorganisms. Limiting the objects of ecological studies to animals and plants means to ignore most of the history of life on Earth. (In fact, microorganisms have been the only inhabitants of our planet for about 85% of the history of life on it.) It seems that one of the main purposes of microbial ecology should be to test whether general ecological principles apply to microorganism, so that microorganisms were integrated in the current ecological paradigms.

Communities exist because different populations interact. If species or populations simply coexisted, without establishing any sort of interactions, a community would have a random structure, which would be independent of the number, of species present. The first problem when dealing with relationships among different kinds of organisms is classifying the relationships themselves. The major properties used to classify relationships are duration, relative size of the organisms, physical contact, specificity, nutrition, interdependence and integration in the community. Each of these criteria is actually a continuum between two extremes.

Surely it was not the intention of the author to publish a book that replaced the classical textbooks of ecology, but—as he states in the foreword—to provide the students of biology, ecology, environmental sciences and marine sciences with the fundamental concepts and tools of ecology. The author is a university instructor who must be acquainted with the difficulties to fit in the curriculum the elements that the student should acquire at this stage. Perhaps—one never knows—it would be useful that the academic authorities responsible for our educational systems had a small idea of the balancing acts that an instructor has to do for students to get a comprehensive knowledge of the subjects they have to study. The current distribution—both in time-length and in the curriculum—of subjects is very often against common sense and hardly contributes to the professional training of the students.

The book starts with an excellent conceptual introduction that offers a critical discussion of the different approaches of such a complex discipline. Classical topics of ecology such as biomes and production of the ecosystems, the concept of ecosystems itself and populations theory are discussed under the same critical point of view. For a better understanding, the author suggests that both evolutive and thermodynamics point of view should be taken into account. It would be necessary to have an idea of the ecosystem as an interactive complex of populations in a physical medium and in a specific space. The book discusses the temporal evolution of some populations and the properties of ecosystems that, as open systems, are continuously changing and exchanging matter and energy. The contents, distributed in 19 chapters deals with models (Chapter 2), physics (Chapter 3), metabolic diversity (Chapter 4) , oxygen, carbon and nitrogen (Chapters 5, 6, 7), sulfur, iron and phosphorus (Chapters 8, 9), energy fluxes and primary production (Chapters 10, 11), growth, interspecific competence, predation, parasitism and epidemiology (Chapters 13, 14, 15), colonization and extinction, abundance and diversity of species (Chapters 16, 17), size structure of communities (Chapter 18) and succession and stability (Chapter 19).

An appendix provides information on several simulation programs which are a complement to some chapters of the book and can be unloaded from a website of the University of Málaga. The pages of the book have wide margins with annotations which can be definitions of terms found in the text, brief explanations or complementary information on the topic discussed. Boxes dealing with different subjects, and simple, yet quite informative, Figures and Tables are useful tools for the students to understand the extreme complexity of ecology. Major classic—but also modern—topics are discussed in an introductory way. This approach will prepare the readers to look for further exhaustive, deep discussion of the subjects in other specialized well known textbooks. Instructors of ecology in the different university schools will also find the book a useful tool to prepare their lectures in both theoretical and practical aspects of ecology.

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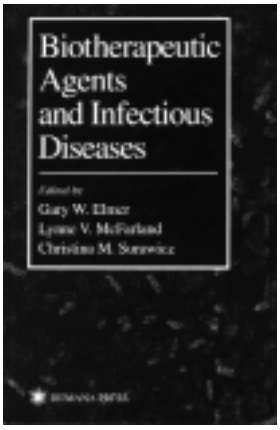


Biotherapeutic Agents and Infectious Diseases

GARY W. ELMER,
LYNNE V. MCFARLAND,
CHRISTINA M. SURAWICZ (eds)

1999. Humana Press, Totowa, New Jersey.

336 pp. 16 × 23.5 cm.
Price: $ 125.00 (hardcover)
ISBN 0-89603-647-2

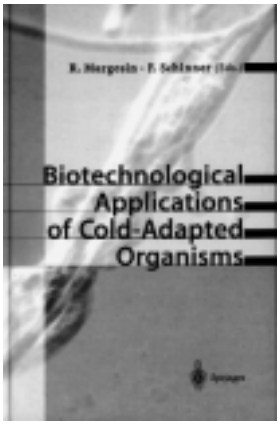
It is well known that there is a long way until a biological product becomes a biotherapeutic agent. In the United States, it takes a minimum lapse of time research of 10 years for a product to be approved by the FDA (if this is the case).

In *Biotherapeutic Agents and Infectious Diseases*, sixteen authors, actively involved in the discovery, development and application of biotherapics, have contributed with an updated review of their expertise. While concentrated on application in human and animal therapy, they discuss the use of whole, living microorganisms with in vivo antagonistic activities against specific pathogens. Authors and editors consider this a third way to elucidate the body defense mechanisms in the fight against infectious diseases. The first way are vaccines, the second, endogenous antimicrobial peptides.

There are three main approaches in the book. Those dealing with fundamental research that discuss the mechanisms of action of biotherapeutic agents (chapter 2), their influences on the normal microflora (chapter 4) and their immunological effects (chapter 5). Clinical applications (the second approach) of biotherapeutic agents constitute the most extensive part of the book and include pharmacokinetics (chapter 3), prevention and management of diarrhea, both in adult and children and in the case of association to antibiotics (chapters 6, 8, 9); and specific woman diseases, such as vaginitis and cystitis (chapters 10, 11). There is a third aspect of the book that concerns both fundamental and applied approach. It is related to the necessary control and thinking about benefits and risks of the new discoveries and tendencies. In this sense, the first chapter, devoted to the quality control and regulatory issues for biotherapeutic agents is welcome for the comprehensive way in which the procedures are showed. The risks are briefly treated in chapter 12 and, as reported, it seems that until now they are extremely rare. Nevertheless, it would be important to search and study any emergence in this sense. Finally, the last chapter (13) offers a complete overview about the contribution of genetic approaches on the studies of lactic acid bacteria. The authors of this chapter present a methodology to assess the bacterial physiology in the digestive tract, which will help to know the metabolism of the lactic acid bacteria.

Biotherapeutic Agents and Infectious Diseases deals to a large extent with microbiology, infectious diseases, gastroenterology, molecular biology and pharmacology. The scope focuses on the applications to humans of the agents that have been tested in controlled clinical studies. The book addresses to specialists in infectious diseases, gynecologists, medicinal chemists, microbiologists and clinical pharmacologists. It is also recommended to students of those specialities. Besides the contents, the bibliography of each chapter has been accurately selected.

Carmen Chica
INTERNATIONAL MICROBIOLOGY



Biotechnological Applications of Cold-Adapted Organisms

R. MARGESIN,
F. SCHINNER (eds)

1999. Springer-Verlag, Berlin.

338 pp. 24 × 16 cm.
Price: DM 298
ISBN 3-540-64972-7 (hardcover)

Would you ever have imagined that digestive enzymes in shrimp-like crustaceans would prevent periodontitis and caries, improve impaired digestion caused by the presence of particular

strong food ingredients, or treat injured vetebral discs? These unique digestive enzymes come from krill, the planctonic crustaceans—*Euphausia superba* being the predominant species—that constitute the main food of some whales, and live at ambient temperatures which seldom exceed +2°C. Other medical applications of these enzymes are the non-invasive removal of necrotic tissues in wounds, the control of chronic pancreatic insufficiency, and the management of stroke and myocardial infarction.

Over the last decade, much attention has been devoted to thermophylic organisms, especially to thermophylic prokaryotes, and to their biotechnological applications. A few heat-stable enzymes from microorganisms growing at high temperatures have become the stars of biotechnology, due to their use to automate the repetitive steps of the polymerase chain reaction (PCR) technique. They have even aroused much controversy when a company patented the *Taq* polymerase, obtained from an organism—*Thermus aquaticus*—which its discoverer—Thomas D. Brock—had freely deposited in the American Type Culture Collection. Little attention has been devoted, however, to other organisms considered also extremophiles, such as those adapted to grow at temperatures around zero degrees Celsius. Yet, some metabolic features of cold-adapted organisms—which comprise not only prokaryotes but also eukaryotes, even macroscopic metazoa—offer a great potential for application in various fields of biotechnology. Psycrotrophs ('cold-tolerant') and especially psychrophiles ('cold-loving') have an advantage over termophiles. Many microorganisms which can grow around 0°C have optimum growth temperatures higher than 20°C. In fact, some soil bacteria which had been considered to be mesophiles should more appropriately be named psychrotrophic.

The pages of *Biotechnological Applications of Cold-Adapted Organisms* disclose a wide range of biotechnological activities in which cold-tolerant organisms can be involved. An Introduction on "Genetic Tools" deals with the development of regulatable expression systems for cloned genes in cold-adapted bacteria. The general topics in which the book is divided are: "Enzyme Biotechnology" (five chapters), "Health Biotechnology" (one chapter), "Food Biotechnology" (two chapters), "Agricultural Biotechnology" (four chapters), "Environmental Biotechnology" (five chapters), "Bio-Mining" (one chapter) and "Multidisciplinary Applications" (two chapters).

Biotransformations which take place in the natural environment proceed mostly at low temperatures. Most industrial processes, however, run at high temperatures, either because the environment is heated to accelerate the process or because the processes themselves are exothermic. Psycrotrophic microbiota is a potential source of enzymes which could be used in biotechnological processes which usually need high temperatures. This would be an advantage both in cold climate countries and in developing countries not able to afford expensive or sophisticated heating facilities. *Biotechnological Applications of Cold-Adapted Organisms* makes the reader acquainted with processes such as waste water treatment and biodegradation of pollutants (swine manure, petroleum hydrocarbons, non-halogenated aromatic compounds, chlorinated aromatic compounds, surfactants. et cetera) at ambient temperatures in cold regions; wine and beer production using psychrophilic yeasts; low temperature fermentation and ripening of foods (their taste and flavor are improved regarding those fermented at high temperatures); processing of fruit juice; degradation of hydrogen peroxide in milk (if it were added as a preservative) and in waste water tanks; improvement of the efficiency of detergents at low temperatures; cryopreservation of food; chemical synthesis of volatile compounds (in perfumery); construction of biosensors that can function at low temperatures; production of attenuated vaccines from viruses adapted at low temperatures; plant protection against pathogens and insect pests by cold-adapted fungi; improvement of symbiotic nitrogen fixation by rhizobia isolated from temperate legumes (clover, alfalfa, soybean) or from alpine or arctic legumes; and bioleaching of metal sulfides. Enzymes from cold-adapted microorganisms can be even useful in PCR techniques—which currently use thermoresitant enzymes for the process itself. In fact, uracil-DNA glycosylase can be applied to control contamination of PCR samples by products from previous amplifications. (Nevertheless, it must be inactivated after use since the residual active enzyme would degrade DNA produced by the subsequent PCR.)

The book will be of great interest to microbiologists that work in environmental microbiology, in agriculture, in the food industry and in other biotechnological specialities. Instructors and advanced students of microbial ecology, environmental sciences and applied microbiology can find the book useful to improve their knowledge of the capabilities of cold-tolerant organisms. To the curious reader, the book will disclose a new, unsuspected world worthwhile exploring.

Mercè Piqueras