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EDITORIAL

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Microbial ecology comes of age

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Origins of microbial ecology

Microbial ecology is a scientific field that developed during the second half of the twentieth century. As a cohesive branch of the microbiological sciences, it blossomed in the 1960s during an era of public concern with environmental issues [1]. The publication, in 1962, of *Silent Spring* by Rachel Carson brought about changes in the perception of nature. The concepts which microbial ecology represents, however, were not new; they were already evident in the pioneering microbiological research of Beijerinck, Winogradsky and others in the late nineteenth century. As a scientific discipline with its own identity, microbial ecology arose from the integration of microbiology and ecology. The principles of general ecology, so brilliantly developed throughout the twentieth century, were based mainly on studies of animals and plants. Ecological studies, however, rarely considered the role of microorganisms in ecosystems, or whether ecological theory could also be applied to those tiny creatures. Nevertheless, only when the principles of ecology can be applied to all living things will they gain universal validity. Overlooking microorganisms in ecological studies means disregarding "the unseen majority" [7], as microorganisms make up most of the biomass on Earth. Furthermore, since they were the only inhabitants of the planet for more than three quarters of life's history, microorganisms play unique roles in ecosystems. The inclusion of prokaryotes in global ecological studies would almost double estimates of carbon stored in living organisms, not to mention those of nitrogen and phosphorous. In fact, prokaryotes comprise the largest pool of those elements in the biota [7].

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The first textbook with the words "microbial ecology" in the title, authored by Thomas D. Brock, was published in 1966 [3]. It was followed by Sheldon Aaronson's *Experimental Microbial Ecology*, in 1970, and Martin Alexander's *Microbial Ecology*, in 1971. Since then, many other scientists have contributed – either directly or indirectly – to the development of the subject to its current status. The journal *Microbial Ecology* (Springer Verlag) has been published since 1974. (See comprehensive lists of books and periodicals on microbial ecology in [1].) The relatively newness of microbial ecology accounts for the lack of definition of its tremendous complexity and for the multiple approaches necessary for its development. Microbial ecology deals with natural processes, with interactions between microorganisms, and between microorganisms and other species and the environment. It also offers new clues to solve problems that modern human societies face. The breadth of subjects that make up microbial ecology include autoecology, or ecology of genetically related populations; ecology of specific ecosystems such as lakes or the rumen; biogeochemical ecology, which studies biogeochemical cycles; ecology of relationships between associated micro- and "macroorganisms"; and applied microbial ecology [4].

The ISMEs (meetings) and the ISME (society)

Researchers who through microbial ecology found new approaches to their studies felt the need to meet and share their experiences and knowledge. In 1972, Thomas Rosswall, from the University of Uppsala, Sweden, chaired a meeting that was the cradle of future regular symposia on microbial ecology, and which has become known as the "Zero meeting" – as it was presented in the 1992 meeting by the author of this introduction (RG, in ISME-6) and confirmed by Tiedje in a more recent publication [6]. The first formal International Symposium on Microbial Ecology (ISME-1) took place in Dunedin, New Zealand, in 1977, and was chaired by Margaret Loutit. Since then the ISMEs have been held every 3 years. The

ISMEs' Proceedings have kept researchers up to date on advancements, trends, and prospects in the field. Their successive titles are listed in Table 1.

The ISMEs (meetings) were first organized under the auspices of the International Committee on Microbial Ecology (ICOME) of the International Union of Microbiological Societies (IUMS). At the ISME-8 meeting in Halifax, Canada, ICOME founded the International Society of Microbial Ecology (ISME), which has since become the official organizer of the ISMEs. The first president of the society was James M. Tiedje (Michigan State University, USA), who was followed by the current president, Yehuda Cohen (Hebrew University of Jerusalem, Israel). ISME (society) has adopted the journal *Microbial Ecology* as its official publication. The main objective of the ISME is to promote the exchange of scientific information on microbial ecology, which includes organizing meetings, sponsoring publications, promoting education and research activities, and facilitating interactions between workers in microbial ecology and other disciplines [see the ISME website: www.microbes.org].

New frontiers in microbial ecology

On December 11–13, 2001, a special meeting on microbial ecology, ''New Frontiers in Microbial Ecology'', was held in Barcelona, Spain. It was organized under the auspices of Fundación Ramón Areces, Spain, and was not intended as a conventional specialized meeting. On the contrary, its primary aim was to present recent advances in microbial ecology to both microbiologists not working in the field of microbial ecology and to researchers in other fields. Prof. Julio R. Villanueva, Vice-president of the Scientific Council of Fundación Ramón Areces, and a distinguished microbial biochemist himself, was aware of the need for microbiologists to see microbes from an ecological perspective and for ecologists to realize the role of microbes in ecosystems. He therefore invited the author of this introduction (RG) to organize a Symposium on current topics in microbial ecology. A 3-day symposium consisting of plenary lectures could not deal with all topics included in such a wide branch of the microbiological sciences. Regardless, ''New Frontiers in Microbial Ecology'' provided a suitable framework to present the state of the art in this burgeoning scientific field: new prospects and approaches based on novel techniques, along with the results of their applications. The last day of the Symposium, a meeting took place between representatives of Spanish and Latin American microbiological societies and the American Society for Microbiology (ASM). From the meeting, possible collaborations between ASM and microbiological societies in Latin America and Spain were discussed. This special issue of International Microbiology includes nine reviews that reflect topics that were discussed at the meeting, and a Perspectives article, by Daniel O. Sordelli and Lily Schuermann, on the international activities of ASM.

Contents of this issue

Even though the program and titles for the Symposium had been agreed to well before September 11, 2001, the first talk turned out to be of utmost interest after the events of that date: Ronald M. Atlas, from the University of Louisville, KY, USA – who at the time of the Symposium was the ASM Elected President – , discussed the threat of bioterrorism from a microbial ecology

Table 1 Dates, locations and Proceedings of the International Symposia on Microbial Ecology (1972–2001)

Meeting	Year	Place	Proceedings
''ISME-0''	1972	Uppsala, Sweden	Rosswall T (ed) (1973) Modern methods in the study of microbial ecology. Swedish Natural Science Research Council. Uppsala, Sweden
ISME-1	1977	Dunedin, New Zealand	Loutit MW, Miles JAR (eds) (1978) Microbial ecology. Springer, Berlin, Germany
ISME-2	1980	Warwick, UK	Ellwood DC, Latham MJ, Hedger JN, Lynch JM, Slater JH (eds.) (1980) Contemporary microbial ecology. Academic, London, UK
ISME-3	1983	East Lansing, USA	Klug MJ, Reddy CA (eds) (1984) Current perspectives in microbial ecology. American Society for Microbiology, Washington DC, USA
ISME-4	1986	Ljubljana, Slovenia	Megusar F, Gantar M (eds) (1986) Perspectives in microbial ecology. Slovene Society for Microbiology, Ljubljana, Slovenia
ISME-5	1989	Kyoto, Japan	Hattori T, Ishida Y, Maruyama Y, Morita RY, Uchida A, (eds) (1989) Recent advances in microbial ecology. Japan Scientific Societies Press, Tokyo, Japan
ISME-6	1992	Barcelona, Spain	Guerrero R, Pedrós-Alió C (eds.) (1993) Trends in microbial ecology. Spanish Society for Microbiology, Barcelona, Spain
ISME-7	1995	Santos, Brazil	Martins MT, Sato M, Tiedje JM, Mendonça-Hagler LC, Döbereiner J, Sanchez P (eds) (1997) Progress in microbial ecology. Sociedade Brasileira de Microbiologia, São Paulo, Brazil
ISME-8	1998	Halifax, Canada	Bell CR, Brilinsky M, Johnson-Green P (eds.) (2000) Microbial biosystems: New frontiers. Atlantic Canada Society for Microbial Ecology, Halifax, Canada
ISME-9	2001	Amsterdam, The Netherlands	

perspective. As was the focus of his talk, his contribution here is on anthrax, conveying the opinion that, although *Bacillus anthracis* is a potential weapon of mass destruction, physicians and public health workers can provide an adequate protective response. Emilio Montesinos and coworkers, from the University of Girona, Spain, describe interactions between microorganisms and plants. At the Symposium, Montesinos discussed a selected series of topics in microbial ecology dealing with plant-associated bacteria, mostly in the context of plant pathology. The prospects for plant-beneficial bacteria to control plant diseases (biopesticides) and to promote plant growth (biofertilizers) in the context of sustainable agriculture are of great interest. Ricardo Guerrero and coworkers, from the University of Barcelona, Spain, approach the study of microbial mats from an ecological perspective, to show that mats are an example of a minimal ecosystem. Yehuda Cohen, from the Hebrew University of Jerusalem, Israel, presents another approach to the study of microbial mats; in this case, as potential agents of bioremediation in oil spills. Carlos Pedrós-Alió and Rafael Simó, from the Institute for Marine Sciences, Barcelona, Spain, discuss a few examples of how microorganisms can be studied from satellites when present in huge amounts, as is the case for plankton, and what effects they may have on global ecology. John F. Stolz et al., from Duquesne University, Pittsburgh, PA, USA, write about arsenic and selenium, whose roles in microbial ecology have only recently been recognized. These two elements, toxic at high concentrations, can be required in trace amounts for growth and metabolism. Dirk Schüler, from the Max-Planck-Institute for Marine Microbiology, Bremen, Germany, reviews the ecology, physiology and molecular biology of magnetotactic bacteria. These unique microorganisms are able to precipitate iron as magnetite, enabling them to sense and orient to magnetic fields. Carmen Ascaso, from the Center for Environmental Sciences, Madrid, Spain, and Jacek Wierzchos, from the University of Lleida, Spain, present a new approach to study lithobiontic microorganisms and their inorganic traces, and their application in astrobiology for the detection of life in Martian rocks. Related to this topic is the review by Kenneth H. Nealson et al., from the Jet Propulsion Lab at the California Institute of Technology and the University of Southern California, USA. They discuss the methods and approaches needed in the search for extraterrestrial life. As life beyond Earth might be different in its composition, generals properties related to physics and chemistry, rather than to biology, which is more familiar to us, must be considered first.

Concluding remarks

In 1956, Albert J. Kluyver (1888–1956) and his former student, Cornelis B. van Niel (1897–1985), published *The Microbe's Contribution to Biology*, the printed version of the John M. Prather Lectures that the authors had delivered at Harvard University in April 1954 [5]. Kluyver is considered to be the father of comparative biochemistry. He spread the idea of the unity of life and promulgated the use of microorganisms to elucidate biochemical pathways and energy transformations, as well as their application as aids in biochemical technology [2]. In Chapter 2 of *Microbe's Contribution* he writes: "[...] the biochemist who examines extracts of crushed cell suspensions from the most different sources will have the greatest difficulty in identifying the source of the materials; they may as well originate from sulfur bacteria as from some pigeon's organ ". All life is connected by the cycling of matter and all organisms are connected through the web of ecosystems. Microbial ecology provides a most useful approach to understand the inherent unity in the apparent diversity of life. As Tiedje wisely forecasts: "[...] the state of our discipline has never been stronger, our future is bright because many major challenges of society over the next decades have their root in microbial ecology." [6] The editors of this issue hope that this work will contribute somewhat to the brilliant future of microbial ecology.

Finally, I wish to thank the efficient work of the two co-editors of this issue, John F. Stolz and Mercedes Berlanga, who have made possible the publication of the monograph so accurately prepared and always in time. It has been a pleasure to collaborate with them – they are good scientists and excellent friends. I also wish to acknowledge the many students, both in my laboratory and from the School of Biology of the University of Barcelona, who helped us to organize and develop the Symposium. I want to thank especially three of them who transcribed and prepared the text of some of the lectures: Laura Llacuna, Helena Martínez López-Amor, and Héctor Ruiz. Lastly, I wish to thank the the Hanse Wissenschaftskolleg (Delmenhorst, Germany) for the generous fellowship from from January to June 2002, which allowed me to prepare the final version of this issue.

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