INTERNATIONAL MICROBIOLOGY (2006) 9:151-154
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INTERNATIONAL MICROBIOLOGY

International Symposium "The Microbe's Contribution to Biology", Fundación Ramon Areces Barcelona, April 27–28, 2006

The Microbe's Contribution to Biology was the title of a series of lectures that Albert J. Kluyver (1888–1956) and Cornelis B. van Niel (1897–1985) delivered at Harvard University in April 1954. Two years later, Harvard University Press published a book [Kluyver AJ, van Niel CB (1956) *The microbe's contribution to biology*. Harvard University Press, Cambridge, MA] consisting of the expanded texts of those lectures. Kluyver and van Niel offered a new perspective of the microbial world; they highlighted the biochemical uniformity of living beings and proposed the use of microorganisms as models for studies in genetics and metabolism. Some features of microbial cultures, including their rapid growth and the possibility of selecting mutants easily, made microorganisms ideal systems for molecular biology studies. In April of this year, the Fundación Ramón Areces, Madrid, Spain, in collaboration with the Institute for Catalan Studies (IEC, the Academy of Sciences and Humanities of the Catalan territories), celebrated the fiftieth anniversary of the book with an international symposium entitled "The Microbe's Contribution to Biology" (Barcelona, April 27–28, 2006). Ricardo Guerrero, Professor of Microbiology at the University of Barcelona and IEC Scientific Secretary, coordinated the symposium. The meeting provided a forum to discuss the changes that microbiology has undergone since the publication of Kluyver and van Niel's book, as well as the current status and future prospects of the microbiological sciences. The lecturers, experts in different areas of the field, combined historical perspectives with a review of their own contributions to recent developments in microbiology.

Moselio Schaechter, currently Professor Emeritus at Tufts University, Boston was a young brilliant researcher in microbiology when he attended a summer course on microbial diversity given by van Niel at Woods Hole Marine Biological Laboratory in 1959. The summer course kept the spirit of the 1956 book, and exerted on Schaechter a lasting influence. Despite his retirement from teaching, Schaechter remains very active and collaborates with researchers at the University of California-San Diego and San Diego State University. He had been asked to deliver the opening lecture of the symposium, but was unable to come to Barcelona. Nonetheless, technology allowed the attendants to see and listen to him by video. Schaechter defined systems biology as an extension of the study of the physiology of growth, and described the origins of that approach. Growth rate is understood to be the unitary manifestation of response of microorganisms to nutritional conditions and the control condition for studies on the effect of environmental stresses. For a culture to be readily reproducible, it must be in the steady state known as balanced growth. However, many researchers who study growth in culture are unaware of this prerequisite and do not establish the conditions necessary to ensure the balanced growth.

Jan Sapp, from York University, Toronto, Canada, discussed the historical aspects leading to the basic classification of organisms as prokaryotes or eukaryotes. In 1962, Roger Y. Stanier (1916–1982) and van Niel formulated that the main biological feature separating organisms from one another was their basic structure, either prokaryotic or eukaryotic, as proposed by Edouard Chatton (1883–1947) in the late 1930s. The use of these two concepts—prokaryote and eukaryote—meant a change of paradigm in the study of biology and had an impact on both classification and phylogeny. Traditionally, an organism was assigned to one of the two great kingdoms of living things: plants or animals. There had been some attempts to create new kingdoms and taxonomical groups, but they had failed. The 'prokaryote' concept allowed the proper classification of many organisms, including those that until then had been called "blue-green algae", despite the fact that their structure was similar to that of bacteria. It also resolved the differences between bacteria, viruses, and the cells of protists, fungi, plants, and animals. In 1977, however, Carl Woese, based on a comparison of 16S ribosomal RNA, proposed a new classification that comprised three groups: archaebacteria, eubacteria, and eukaryotes. In the 1990s, he reconsidered this classification and proposed three Domains: Archaea, Bacteria and Eukarya.

Fernando Baquero, from the Ramón y Cajal Hospital in Madrid, discussed the evolution of the concept of bacterial pathogenesis and the influence that van Niel exerted on Spanish clinical microbiologists, especially through the biochemist Carlos Asensio (1925–1982), an outstanding student in van Niel's famous summer course at Woods Hole. Baquero, a clinical microbiologist with strong interests in microbial ecology, population biology and bacterial evolution, had frequently collaborated with Asensio. The ecological approach to clinical microbiology has provided new insights into the infectious process. Thus, pathogenic bacteria are no longer considered to be intrinsically harmful; instead, bacterial pathogenesis can be considered to be the

result of interactions among bacteria, the host, and the environment.

Ignacio Moriyón, from the University of Navarra, Pamplona, proposed that endosymbiosis offers an explanation for the kind of bacterial pathogenesis that eludes innate immunity. The mechanisms of innate immunity are strongly rooted in evolution and they allow pathogen-associated molecular patterns to be recognized by receptors that have developed throughout the evolutionary process. Harmless bacterial strains can become virulent through the acquisition—by horizontal transfer—of certain genes that are usually found in plasmids and lysogenic phages or that can assemble in pathogenicity islands. Some bacteria that are intracellular parasites, however, lack most of those factors. Given the similarities between mitochondria and pathogenic bacteria that can surpass their host's innate immunity, it can be assumed that the late common ancestor of mitochondria must have overcome any potential predatory/non-self recognizing system.

Marie-Odile Soyer-Gobillard, from the Oceanographic Observatory "Laboratoire Arago", in Banyuls-sur-mer, France, presented a biographical outline of the aforementioned Edouard Chatton, a great protistologist of the first half of the twentieth century. Chatton anticipated some of the fundamental concepts of cellular biology, which would be corroborated decades later. Even before the development of the transmission electron microscope, he noted fundamental differences between bacteria and protists as well as between prokaryotic and eukaryotic organisms. He also observed the reproductive ability of the kinetosome-centriole system, the homology between the kinetosome and the mitotic centriole of animal cells, and the existence of different types of mitotic systems.

Milton S. da Costa, from the University of Coimbra, Portugal, talked about a group of microorganisms whose study is relatively recent: extremophiles. These are bacteria that live in environments subject to extreme conditions of temperature, acidity, hydrostatic pressure, saline concentrations, or to high doses of gamma radiation. The concept of an "extreme" condition is relative and arises in comparison to the conditions in which most studied bacteria usually live. Extremophiles were initially recognized because of their role in food spoilage (e.g., of canned food subject to high temperatures for sterilization and of salted fish). With time, however, researchers found that these microorganisms also reside in certain natural, "extreme" environments. Over the last few decades, extremophiles have been the focus of great interest due to their many biotechnological applications.

Ricardo Guerrero talked about the unity and flexibility of life, and of ecology as a link between those two concepts. Kluyver, the father of comparative biochemistry, postulated the concept of life's unity and proposed the study of microorganisms to elucidate the biochemical pathways and energy transformations that take place in living beings. Guerrero has studied stromatolites and stratified aquatic ecosystems, which in many ways resemble the ecosystems that existed in early Earth, when microorganisms were the only inhabitants. He described what must have happened in the early stages of biological evolution, especially the need for the establishment of ecosystems (ecopoiesis), in which some organisms must have fed on the metabolic products of others and differentiation allowed for growth under a wide range of environmental conditions. Microorganisms' ubiquity, after billions of years of evolution, is based on their small size, their metabolic versatility, and their genetic plasticity. With modern molecular techniques, which offer a new approach to diversity studies and to the analysis of microbial communities in natural environments, microbial ecology has entered a new and exciting era.

José A. Gil, from the University of León, discussed the importance of some species of bacteria in the process of bioremediation due to their ability to accumulate metals. The accumulation of metals and toxic metalloids in soils and waters has caused serious environmental concern. In fact, unlike organic contaminants, metals and metalloids cannot be degraded into innocuous forms. Gil described the case of arsenic and how the effects of that metal can be lessened by eliminating it from the environment through the actions of certain types of bacteria.

Stanley Maloy, from San Diego State University, California, described how a technique that was initially developed to study the pathogenesis of *Salmonella* led to the discovery of the phenomenon called transduction. *Salmonella* became a model in the studies of bacterial genetics, facilitated the discovery of some mechanisms of bacterial biosynthesis, and provided insight into the regulation of gene expression in response to environmental changes. The need for an ecological vision of microbiology was once again made clear. At the same time, a more thorough understanding of *Salmonella* infection has demonstrated its potential role in human chronic diseases. Genome sequencing of various strains of *Salmonella* has provided a detailed snapshot of the evolutionary changes that distinguish closely related bacteria. Thus, from the initial interest in *Salmonella* as a dangerous pathogen, studies on this bacterium over the last fifty years have yielded key insights into bacterial physiology, genetics, cell biology, and evolution.

Rubén López, from the Center for Biological Research of the CSIC, in Madrid, retired recently after a brilliant research career focused on the study of a pathogen that has played a major role in the history of microbiology: *Streptococcus pneumoniae*, the fearsome pneumococcus. The study of this

bacterium contributed to the development of immunology through the discovery that its antigens were not proteins but polysaccharides. In addition, the revolutionary research showing that genes were fragments of DNA was carried out on *S. pneumoniae*. Nowadays, pneumococcus research addresses the growing concern over the evolution of multidrug-resistant strains, and the attempts to find alternatives, such as phages and phage products, to currently available antibiotics.

Esteban Domingo, from the Severo Ochoa Center for Molecular Biology, in Madrid, talked about viruses as biological entities that have also contributed to expanding our knowledge of microbiology. They have allowed the development of vaccines and the elucidation of the basic principles of immunology. Bacteriophages have been used as experimental systems to study the replication of genetic material as well as the mechanisms of transcription and translation. In addition, the discovery of viral reverse transcriptase put an end to the "central dogma of molecular biology", which asserted that the flow of genetic information went from DNA to RNA to protein. Currently, virus research focuses mainly on the development of gene therapy, in which viral vectors deliver the gene of interest to target cells.

Enrique Herrero, from the University of Lleida, discussed yeasts, a group of eukaryotic microorganisms that humans have "tamed" since ancient times and which are currently also used in numerous biotechnological processes. Beginning in the late eighteenth century, yeasts contributed significantly to progress in chemistry and biology and to establishing the foundations of biochemistry as a scientific discipline *Saccharomyces cerevisiae* was the first eukaryotic genome to be completely sequenced, in 1997. Knowledge of its biology, furthered by the genetic data, has made this yeast a model for the study of other yeasts, including pathogens such as *Candida albicans*.

Thomas M. Schmidt, from Michigan State University, talked about the role of Kluyver and van Niel's book in the development of microbial ecology. He emphasized the metabolic unity of microorganisms and their exceptional versatility in adapting to a wide range of environmental changes. The impossibility to grow most microorganisms found in nature has been a hindrance for many ecological studies. However, modern molecular biology techniques have allowed the study of natural communities as reflected by their metabolic activities.

Carles Pedrós-Alió, from the Marine Sciences Institute, in Barcelona, described the changing perspective regarding the metabolic contributions of marine bacteria. Marine microbial ecology started in the 1970s, when a great abundance of marine bacteria was discovered. It was subsequently shown that marine bacteria were responsible for most of the respiration in the oceans, and later studies revealed that they are responsible for approximately half of the planet's primary production. Moreover, the study of marine microbial ecology by a genomic approach led to the discovery of new metabolic functions, providing further proof of the great diversity of microorganisms living in the sea and generating renewed controversy about the significance of terms such as species, genome, and niche.

Emilio Montesinos, from the University of Girona, discussed those microorganisms that inhabit plants, anywhere from the aerial parts to the root system. Plants and microbes have co-evolved, developing strategies that allow them to live together through commensalistic, beneficial, or detrimental interactions. Throughout history, plant-pathogenic microorganisms have had profound effects on human society, ones that go beyond the economics of crop losses Currently, the study of microorganism-plant interactions focuses on several aspects of their relationships, including beneficial effects, how to overcome pathogen actions, the promotion of antagonism through the production of antimicrobial substances, and the development of hyperparasitism or direct interference with pathogens.

Finally, Gary J. Olsen, from the University of Illinois, Urbana, dealt with the present-day difficulties in establishing a natural system for the classification of organisms. Molecular biology allowed Woese to realize that prokaryotes did not form a monophyletic group. He therefore divided bacteria into two groups, Archaea and Bacteria, and considered Bacteria to be as far off from Archaea as it was from Eukarya. Many microbiologists have objected to Woese's classification, since prokaryotic species may have obtained many of their genes through horizontal transfer. Olsen's view is that horizontal transfer does not override the tree of life, although it encumbers its drawing and comprehension.

The symposium was not only a means of remembering *The microbe's contribution to biology*, a milestone of modern microbiology; it also provided a framework to discuss many issues of great relevance to the microbiological sciences. In addition, it allowed the young researchers that attended the lectures to witness and participate in the process of scientific debate and the development of ideas, through which, from experimental data and personal opinions new scientific approaches, paradigms, and a collective and integrated view can ultimately be reached.

MERCÈ PIQUERAS
INTERNATIONAL MICROBIOLOGY
int.microbiol@telefonica.net

The Third European Symposium on Biopolymers (ESBP05) Madrid, November 24–25, 2005

The Spanish Society of Biotechnology (SEBIOT) and a group of microbiologists of the Biological Research Center, as part of the Spanish Higher Council for Scientific Research (CIB-CSIC), organized the 3rd edition of the European Symposium on Biopolymers (ESBP05) on November 24-25, 2005. The first edition was held at the UFZ-Centre for Environmental Research, Leipzig-Halle, Germany, and the second at Materials Science and Technology, EMPA, in St. Gallen, Switzerland. The ESBP was established as a bi-annual European meeting to bring together experts from academia and industry to discuss their contributions in the field, as well as to establish collaborations for new projects with the aim of maintaining close contact among the European groups working on biopolymers in the field of environmental biotechnology and biomedicine.

The main subject of ESBP05 was the "Molecular Bases and Biotechnological Applications of Biopolymers Based on Renewable Resources". Nowadays, biopolymers such as polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and polyisoprene are the subject of great interest as environmentally friendly materials because, in addition to their biodegradability, their production is based on renewable resources, such as agricultural feedstock, instead of on diminishing stockpiles of fossil fuels. When sustainable processes must substitute for non-sustainable conventional ones, the conversion of raw material into bioplastics, biomaterials, or biopolymer derivatives with added value is an important input in terms of eco-effective applications. The topics addressed in the meeting were organized into six sessions: biopolymers based on renewable resources; the biochemical and molecular basis of biopolymer synthesis; biochemical and molecular basis of biopolymer degradation; resources for biopolymer production; tailor-made biopolymers; and medical and other advanced applications of biopolymers.

ESBP05 brought together 68 participants from 15 countries: Spain, Germany, Switzerland, Italy, Ukraine, Netherlands, France, Belgium, Russia, Ireland, Portugal, Turkey, Great Britain, Latvia, and Finland. Conference participation was well-balanced among academia, research institutions, and Spanish and European companies, such as Biomedal S.L. (Spain), Biopolis S.L. (Spain), The Centre for Process Innovation (CPI) (Great Britain), BASF (Germany), Produkt Design & Consulting (Germany), Anteis S.A (Switzerland), Hycail (Finland), and Coca-Cola (Belgium). The meeting featured a plenary lecture, 12 lectures by invited speakers, 17 oral presentations, and 18 poster communications. B. Witholt opened the symposium with the plenary lecture "White biotechnology and biomaterials: meeting future needs". He discussed long-term sustainability and how to maintain and further develop an acceptable world for a growing population. Later, selected leaders from the most active research groups in Europe lectured in the symposium. First, A. Steinbüchel reviewed recent findings concerning biopolymers based on renewable resources. M. Vert gave an interesting lecture about routes to artificial polymers based on glycolic, lactic, malic, citric, and gluconic acids and on serine and lysine amino acids. H.R. Kricheldorf discussed the important role played by cyclic polypeptides as products in the polymerization of a-amino acids *N*-carboxyanhydrides. D. Jendrossek reported the latest findings on the enzymatic biodegradation of natural rubber (polyisoprene), and K. O'Connor described the conversion of aromatic hydrocarbons, such as styrene, into PHA. M. Zinn talked about the tailored synthesis of polyhydroxy-alkenoate (PHAE) by chemical engineering and the importance of functional biopolymers in the biopolymer field. J. San Román described several polymeric systems based on chitosan that are of biomedical interest, and R. Reis enlightened us on the basic principles of tissue engineering, from the properties of available biodegradable polymers, to scaffold-processing issues, and, finally, to information on the available cellular sources and required biological studies. V. Hasirci revealed that, in addition to the chemistry and morphology of biomaterial surfaces, the cell type is also of prime importance in biomaterial–cell interactions. C. Migliaresi discussed the preparation and properties of silk-fibroin-derived scaffolds suitable for various applications in tissue engineering. Finally, our group described the latest findings regarding PHA mobilization in *Pseudomonas putida* and the molecular characterization of PhaZ depolymerase.

The overwhelming positive response by the participants to the symposium confirmed the successful establishment of the meeting as a bi-annual event. The 4th edition of ESBP will be held in Turkey in 2007. V. Hasirci, from the Middle East Technical University of Ankara, Turkey, has kindly agreed to organize the next meeting.

M. AUXILIO PRIETO
Biological Research Center, CSIC, Madrid
auxi@cib.csic.es