LIFE IN THE UNIVERSE

Cellular Origin and Life in Extreme Habitats and Astrobiology

Volume 7

Series Editor:

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Hebrew University of Jerusalem, Israel

Life in the Universe

From the Miller Experiment to the
Search for Life on other Worlds

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DEDICATION

This book is dedicated to **Professor Stanley L. Miller** in honor of his 50th jubilee experiments in the prebiotic origin of life.

Professor Stanley Miller with the editor **Joseph Seckbach** during the **Trieste-2003** conference on *Life in the Universe*.

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Biodata of **Stanley Miller**, dedicatee of the volume “*Life in the Universe*”

Professor Stanley Miller, an American chemist and biologist was born in Oakland, California. He was educated at University of California (B.Sc. in 1951), and then at University of Chicago (where he was a student of Nobelist Harold Urey, and received his Ph.D. in chemistry in 1954). He was an assistant professor (1958–1960), associate professor (1960–1968), and then full professor of chemistry at the University of California, San Diego (from 1968). His research deals primarily with the origin of life and he is considered a pioneer in the field of exobiology. He has also studied the natural occurrence of clathrate hydrates and the use of hydrogen as a commercial fuel. In the 1950's, Urey theorized that the early atmosphere of the Earth was probably like the atmosphere now present on Jupiter—i.e., rich in ammonia, methane, and hydrogen. Miller, working in his laboratory at the University of Chicago, demonstrated in 1953 that when exposed to an energy source such as spark discharges these compounds and water can react to produce amino acids essential for the formation of living matter. This watershed experiment gave the first demonstration that the building blocks of life could be produced spontaneously from a planetary environment. The current consensus is that the Earth never had an atmosphere that was so reducing, but similar results have been obtained with less reducing gas mixtures. Indeed, this experiment has been repeated tens of thousands of times with different mixtures of gases, and the basic results have been spectacularly confirmed by the discovery of amino acids in meteorites. Professor Miller is a member of the National Academy of Science and has received numerous honors and medals, including the Oparin Medal of the International Society for the Study of the Origin of Life (1983). He served as the President of the above society (ISSOL) from 1986 to 1989.

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Biodata of **Joseph Seckbach**, author of the chapter “*Diversity of Microbial Life on Earth and Beyond*” and editor (with co-editors Julian Chela-Flores, Tobias Owen and Francois Raulin) of this book (*Life in the Universe* (2004)).

Professor Joseph Seckbach is the initiator and chief editor of *Cellular Origins, Life in Extreme Habitats and Astrobiology (COLE)* book series, and author of several chapters in this series. He earned his Ph.D. from the University of Chicago, Chicago, IL (1965) and spent his postdoctoral years in the Division of Biology at Caltech (Pasadena, CA). Then he headed at the University of California at Los Angeles (UCLA) a team for searching of extraterrestrial life. Dr. Seckbach has been appointed to the faculty of the Hebrew University (Jerusalem, Israel) performed algal research and taught Biological courses. He spent his sabbatical periods in Tübingen (Germany), UCLA and Harvard University and served at Louisiana State University (LSU), (1997/1998) as the first selected occupant of the John P. Laborde endowed Chair for the Louisiana Sea Grant and Technology transfer, and as a visiting Professor in the Department of Life Sciences at LSU (Baton Rouge, LA).

Among his publications are books, scientific articles concerning plant ferritin (phyto-ferritin), cellular evolution, acidothermophilic algae, and life in extreme environments. He also edited and translated several popular books. Dr. Seckbach is the co-author (with R. Ikan) of the *Chemistry Lexicon* (1991, 1999) and other volumes, such as the Proceeding of *Endocytobiology VII* Conference (Freiburg, Germany, 1998) and the Proceedings of *Algae and Extreme Environments meeting (Trebon, Czech Republic, 2000)*. His recent interest is in Life origins and extremophilic environments of microorganisms.

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Professor **Chela-Flores** current positions are: Staff Associate of the Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Research Associate, Dublin Institute for Advanced Studies (DIAS) and *Professor Titular*, Institute of Advanced Studies (IDEA), Caracas. He is a Fellow of: The Latin American Academy of Sciences, The Third World Academy of Sciences, the Academy of Creative Endeavors (Moscow, Russia) and a Corresponding Member of the Academia de Fisica Matematicas y Ciencias Naturales (Caracas). Professor Julian Chela-Flores studied in the University of London, England, where he obtained his Ph.D. (1969) in quantum mechanics. He was a researcher at the Venezuelan Institute for Scientific Research (IVIC) and Professor at Simon Bolivar University (USB, Caracas) until his retirement in 1990. His particular area of expertise is astrobiology, in which he is the author of numerous publications in this new science, including some in the frontier between astrobiology and the humanities (philosophy and theology). Professor Chela-Flores has been the organizer of a series of Conferences on Chemical Evolution and the Origin of Life from 1992 till 2003 (and was the co-director from 1995 till 2003). From 1992 till 1994 he worked in collaboration with Cyril Ponnampерuma. This series continued Ponnampерuma's *College Park Colloquia on Chemical Evolution*, which had started in Maryland, USA in the 1970s. All the proceedings of the present series of conferences have been published. In 1999 Professor Chela-Flores co-directed and edited the proceedings of an Iberoamerican School of Astrobiology in Caracas at the IDEA Convention Center.

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Tobias Owen is a Professor of astronomy at the Institute for Astronomy of the University of Hawaii. He studies the Planets, satellites and comets of our solar system using the giant telescopes on Mauna Kea and by means of deep-space missions. He has participated in the Viking Lander on Mars, the Voyager, Galileo, Deep Space 1, Nozomi and Contour Missions. He is currently an Interdisciplinary Scientist and member of several experiment teams on the ESA-NASA Cassini-Huygens Mission to the Saturn System, an Associate Scientist on the Rosina team for the Rosetta Mission to Comet Churyumov-Gerasimenko, and a Science team member of the Kepler Mission to search for terrestrial planets. Professor Owen received his Ph.D. in astronomy from the University of Arizona in 1965. He has published over 250 scientific articles and has co-authored two textbooks: “The Search for Life in the Universe” (with Donald Goldsmith) and “The Planetary System” (with David Morrison). He was awarded the NASA Medal for Exceptional Scientific Achievement for his Viking study of the Martian atmosphere.

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François Raulin is Full Professor at University Paris 12, and head of PCOS (Space Organic Physical Chemistry) group of LISA, Laboratoire Interuniversitaire des Systèmes Atmosphériques a joint University Paris 7, University Paris 12 and CNRS laboratory of more than 80 persons, working on terrestrial troposphere in relation to environmental problems and on extraterrestrial environments, in relation to exobiology (<http://www.lisa.univ-paris12.fr/>). He is Director of LISA since 1995 and , since 1999, of CNRS “Groupement de Recherche” in Exobiology (GDR Exobio), federation of laboratories working on Exobiology, affiliated to NAI (<http://www.lisa.univ-paris12.fr/GDRexobio/exobio.html>)

He got a diploma of Engineer from the Ecole Supérieure de Physique et Chimie Industrielles de la Ville de Paris in 1969, and a Doctorat d’Etat ès Sciences Physiques (on the role of sulphur in prebiotic chemistry) from the Université Paris 6 in 1976. He).

His research fields are related to planetology and exo/astrobiology: organic chemistry in extraterrestrial environments (Titan, giant planets, comets and Mars) using laboratory experiments (experimental simulations, spectroscopy, GC techniques), theoretical modeling and observation (remote sensing and *in situ* space exploration).

F. Raulin is IDS (InterDisciplinary Scientist) of the Cassini-Huygens mission (Titan’s Chemistry and Exobiology program). He is also Co-I (Co-Investigator) of the CIRS (Cassini), ACP and GC-MS (Huygens) experiments. He is Co.I of the COSAC and COSIMA experiments of the Rosetta European cometary mission. He is Chair of COSPAR Commission F (Life Sciences), Vice Chair of COSPAR Planetary Protection Panel and Irst Vice-President of ISSOL. He has been member of the Microgravity Advisory Committee of the European space Agency and of ESA Exobiology Science Group. He is currently member of the Planetary Protection Working Group of ESA.

He is the author or co-author of more than 200 scientific papers, and 9 books related to the field of the origins of Life and Exobiology. He likes classical music, swimming, tennis and mountain climbing by foot in summer and by skis in winter and spring, with his wife Florence and his three children Antoine, Stella and Nicolas.

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EDITORS' PREFACE: *LIFE IN THE UNIVERSE*

This volume is a collection of chapters that have been presented as oral presentations or posters during the Seventh Trieste Conference on Chemical Evolution and the Origin of Life: Life in the Universe—"From Miller Experiments to the Search for Life on Other Worlds." This conference took place at the International Center for Theoretical Physics (ICTP), Trieste, Italy on 15–19 September 2003 in Trieste, Italy.

We were particularly delighted that Professor Miller himself was able to be with us for this singular occasion. We all greatly appreciated his retrospective and forward-looking lecture.

The ICTP Center in collaboration with many other institutions has sponsored the previous six conferences, since we first started planning the series with Professors Abdus Salam and Cyril Ponnampерuma. We were deeply honored, privileged and grateful to have had the following 10 sponsors: on this occasion:

The Abdus Salam International ICTP, Trieste, Italy
Scuola Internazionale Superiore di Studi Avanzati (SISSA), Trieste, Italy
Consiglio Nazionale delle Ricerche (CNR), Rome, Italy
NASA Institute of Astrobiology (NAI), USA
European Space Agency (ESA), France
National Aeronautics and Space Administration (NASA) Washington, USA
University of Paris 12, France
Osservatorio Astronomico di Trieste, Italy
Laboratorio dell'Immaginario Scientifico,
and
with the collaboration of the book series of
Kluwer Academic Publishers:
"Cellular Origin, Life in Extreme Habitats and Astrobiology"

Among the many presentations that we enjoyed during the conference we had contributions from experts on questions related to the origin, evolution and cosmic distribution of life, as well as talks on cosmology and the origin of biogenic elements and even two talks about the destiny of life in the universe from the perspectives of philosophy and epistemology.

Aspects of space exploration played a prominent part in our discussions, including the Galileo, Cassini-Huygens, Mars Express and Rosetta Missions, as well as proposed missions that are currently in the planning stage for Mars and, the Jovian satellite Europa. Two additional topics were included to round out our coverage of life in the universe: The search for planets outside the solar system, and the closely related subject of the possible manifestation of intelligence in potential galactic environments.

Finally, we continued to dedicate lectures to commemorate Cyril Ponnampерuma and Abdus Salam, the two distinguished scientists who initiated this series of conferences.

We would like to express our pleasure with the wide interest that this conference attracted. We had worldwide representation from 28 nations, with attendees from: Algeria, Argentina, Austria, Brazil, Cameroon, Chile, China, Colombia, Cuba, France, Germany, Hungary, India, Iran, Israel, Italy, Mexico, Morocco, Netherlands, Nigeria, Russia, Spain, Sweden, Switzerland, Turkey, UK, USA and Venezuela,

With this conference the **Chemical Evolution and the Origin of Life** series has now brought together well over 500 scientists, philosophers and theologians, since the series began in October 1992. It seemed appropriate to remember in particular two members of our advisory board, who unfortunately were no longer with us, and whom we remember with particular affection for their many solid contributions to the previous meetings: The astrophysicist Professor **Mayo Greenberg** and the biologist Professor **Martino Rizzotti**. They shall remain perennially in our memory.

February 2004

Joseph Seckbach
Julian Chela-Flores
Tobias Owen
François Raulin

ACKNOWLEDGEMENTS

We thank all colleagues who assisted us in finishing this volume and made every effort to move things along as smoothly as possible. We acknowledge the assistance of Professor Mauro Messerotti (Trieste, Italy) for supplying a scientific document, Professor A. Lazcano (Mexico City) for assisting with some manuscripts, and Professor Andre Brack (Orleans, France) who recommended the source for the book's cover. We express our gratitude to Malte Reimold from the laboratory of Professor von Kiedrowski, Ruhr-University, Bochum, Germany, for contributing her artwork to the cover. Last but not least, we appreciate very much the great and constant interest of Ms. Claire van Heukelom and Dr. Frans van Dunne (Kluwer Academic Publishers) in the series of "Cellular Origins, Life in Extreme Habitats and Astrobiology (COLE)" books. Their faithful investment in this book is very noticeable.

February 2004

Joseph Seckbach
Julian Chela-Flores
Tobias Owen
François Raulin

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“Young Miller” in University of Chicago (1953)

Photos by NINA ALEXANDRINA (BRAZIL) from “Life in The Universe-2003” Meeting

PHOTOS BY **JOSEPH SECKBACH** FROM THE LIFE IN THE UNIVERSE (2003) MEETING