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Astrobiology:
The Quest for the
Conditions of Life

Preface

This book guides the reader into the fascinating world of the newly emerging science of astrobiology. Its central focus is directed towards questions that have intrigued humans for a long time: Where do we come from? What is life? Are we alone in the Universe? They are jointly tackled by scientists converging from widely different fields, reaching from astrophysics to molecular biology and from planetology to ecology, among others. This spilling beyond the boundaries of classical sciences opens completely new opportunities for research, a state described by some contemporaries as the “Astrobiology Revolution of the Sciences”. The book is written in such a way that on the one hand it provides the latest knowledge in this rapidly evolving field of astrobiology for the educated expert, while on the other hand describing most phenomena in a general and understandable way; it is thus also intended for interested laymen who are attracted to this new discipline.

In the first section on “Organic Material in Space and Habitable Zones” we invite the reader to explore the vast realms of the Universe for signatures of life beyond the Earth. In the interstellar medium, as well as in comets and meteorites, complex organics teem in huge reservoirs that eventually may provide the chemical ingredients for life. Astronomers are rapidly acquiring data on the existence of more and more planetary systems in our Galaxy, which supports the assumption that habitable zones are frequent and are not restricted to our own solar system. Within such a habitable zone, life may not be confined to its planet of origin: the impact scenario describes a natural mechanism of expulsion and transport of microbial communities through space.

In the following three sections, the physical and chemical conditions for life are discussed, the environmental requirements and boundaries for life on Earth, and the extraordinary capabilities of life to adapt to environmental extremes. These data are used to assess the habitability of other bodies within our solar system, especially Mars and Europa which are located within habitable zones. Among the wide field of environmental conditions life has to cope with, the most essential ones are discussed in detail. These are: water, one of the prerequisites for life; stresses associated with low levels of water; temperature extremes; electromagnetic fields and radiation, with an emphasis on environmental UV radiation and ionizing radiation; and gravity as a constant source of stress for life on planets.

Contemplating life, its origin, evolution and distribution, within the context of cosmic evolution, shows that it is the same principle that drives evolution towards increasing complexity, from the formation of the first elements to the self-organization of life and the appearance of consciousness. The section “Complexity and Life” presents examples of the emergence of complexity in astrobiological issues in general. A prominent example of this phenomenon is provided by molecular self-assembly in the context of the origin of life.

The book concludes with a description of ongoing or planned space missions from which we expect answers to the burning questions in astrobiology. Examples are astronomical missions which search for “biomarkers” in our Galaxy, planetary missions with targets of astrobiological interest, such as Mars, Saturn’s moon Titan, the comet Wirtanen, and Jupiter’s moon Europa, as well as experiments in Earth orbit on the likelihood of interplanetary transfer of life and the resistance of life to environmental extremes.

Most authors of this book were recruited from the participants of the 1st Symposium on Exo/Astrobiology in Germany, that took place on 22 March 2000 in Bremen, during the Annual Meeting of the Deutsche Physikalische Gesellschaft. We are grateful to the German Aerospace Center DLR for their support of this symposium. When, after the meeting, Christian Caron from the Astronomy and Space Sciences Editorial Department of Springer encouraged us to edit a book on Astrobiology, we realized that most of the areas that should be represented in one of the first books in astrobiology could be competently covered by the participants of the symposium. Where necessary, the authorship was complemented by colleagues and experts in astrobiology from other countries in Europe and from the US. Our special thanks go to Christian Caron, who invested so much interest in discussions on the structure and content of the book, in finding the right balance between exact and popular science and we thank him also for his patience during the finalization of the book. We appreciate the assistance of Lisa Steimel, our former secretary at DLR, for her invaluable help during the finalization of the manuscripts, including careful proofreading.

Köln, Germany
August 2001

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