Life Beyond Earth

The Search for Habitable Worlds in the Universe

With current missions to Mars and the Earth-like moon Titan, and many more missions planned, humankind stands on the verge of exciting progress and possible major discoveries in our quest for life in space.

What is life and where can it exist? What searches are being made to identify conditions for life on other worlds? If extraterrestrial inhabited worlds are found, how can we explore them? Could humans survive beyond the Earth?

In this book, two leading astrophysicists provide an engaging account of where we stand in our quest for habitable environments, in the Solar System and beyond. Starting from basic concepts, the narrative builds scientifically, including more in-depth material as boxed additions to the main text. The authors recount fascinating recent discoveries, from space missions and observations using ground-based telescopes, of possible life-related artefacts in Martian meteorites, of extrasolar planets, and of subsurface oceans on Europa, Titan and Enceladus. They also provide a forward look to exciting future missions, including the return to Venus, Mars and the Moon; further explorations of Pluto and Jupiter's icy moons; and placing giant planet-seeking telescopes in orbit beyond Jupiter, showing how we approach the question of finding out whether the life that teems on our own planet is unique.

This is an exciting, informative read for anyone interested in the search for habitable and inhabited planets, and makes an excellent primer for students keen to learn about astrobiology, habitability, planetary science and astronomy.

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Preface

Life in space, whether strange beings on distant worlds, or an expansion of our own species into the Solar System and beyond, is a very exciting idea. Humankind may currently stand on the verge of major discoveries and exciting progress in both areas. The discoveries of possibly life-related artefacts in a Martian meteorite, in a subsurface ocean on Europa, Titan or Enceladus, and in the atmospheres of extrasolar planets, for example, show how close we are to finding out at last whether the life that teems on our own planet is unique. Some increasingly sophisticated space missions are currently under way, such as Cassini, which has been exploring the Saturnian system and Titan, the Earth-like moon, since 2004; others are in preparation, such as the Mars Sample Return and the Jupiter Icy Moons Explorer missions. Plans to return to Venus, Mars, the Moon and Titan, to orbit Europa and to place giant planet-seeking telescopes in space are thus on the table. These and other advances promise rapid progress in the coming years.

This is a book that deals with possible habitats in our Solar System and beyond. We will define which places might be harbouring past, present or future life, or can be considered as 'habitable' in the sense that human life could survive, adapt or continue to evolve therein. The book will include a necessarily brief but pertinent definition of life as we know it on Earth and review it as a phenomenon, considering its origins, properties and potential; we will combine a discussion of present knowledge with informed speculation, bounded by scientific realism but using non-technical language. We will briefly review the origin of life in the Universe, the reasons for thinking it may be unique and reasons, in contrast, for believing it could be commonplace. We will also offer some thoughts on its destiny and

on scientific discoveries yet to be made in areas we can barely apprehend at present. The main goal is to update the reader on the current situation in our Solar System and beyond, in terms of exploration for traces of past or present life and of the existence of conditions for habitable worlds. We also aim to provide and provoke thoughts about our distant horizons in this respect.

The format of the book is such as to address a large audience (lay persons, students and others). The purpose is not to give an exhaustive description from the biological, geological or philosophical point of view, but rather to excite the imagination of the reader, by including up-to-date illustrations and clear, relevant and accurate text that only astrophysicists can provide on recent discoveries and future projects. As astronomers, we will offer a personal, inside view of space exploration, using our own knowledge and interests to describe the most interesting places outside Earth, as well as the vanguard techniques that we use to investigate them. We would like to thank here all of our colleagues (experts in various fields of astronomy) who assisted us with information, discussions and re-reading, and the artists who gracefully provided us with figures and photographs.