# Astrobiology studies of microbes in simulated interplanetary space

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**Abstract**

For laboratory studies on the responses of resistant life forms to simulated interplanetary space conditions, testbeds are available that simulate the parameters of space, such as vacuum, solar electromagnetic and cosmic ionizing radiation, temperature extremes and reduced gravity that can be applied separately, or in selected combinations. Appropriate biological test systems are extremophiles, i.e. microorganisms that are adapted to grow, or survive in extreme conditions of our biosphere. Examples are airborne microbes, endolithic or endoevaporitic microbial communities, or bacterial endospores. Such studies contribute to answer several questions pertinent to astrobiology, such as (i) the role of solar UV radiation in genetic stability, (ii) the role of gravity in basic biological functions, (iii) the probability and limits for interplanetary transfer of life, (iv) strategies of adaptation to environmental extremes, and (v) the needs for planetary protection.

## 1. Introduction

The primary goal of astrobiological research is to reach a better understanding of the processes leading to the origin, evolution and distribution of life on Earth or elsewhere in the universe. In this endeavor, scientists from a wide variety of disciplines are involved, such as astronomy, planetary science, organic chemistry, paleontology and the various sub-disciplines of biology. Space technology plays an important role by providing planetary probes to explore our solar system, and Earth orbiting satellites for astronomical observations, for collecting extraterrestrial samples and for utilizing the peculiar environment of space as a tool. However, such astrobiology studies in space are limited by the scarcity of flight opportunities, in Earth orbit as well as to other bodies of our solar system.



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To overcome this lack of flight opportunities, simulator testbeds for planetary and space environments have been constructed in laboratories on the ground. These simulators provide the opportunity to study interactions between terrestrial organisms or ecosystems and selected extraterrestrial conditions. These facilities allow more sophisticated experimentation to be conducted than can be accomplished in most space experiments. Therefore, such laboratory studies are complementary to the *in situ* studies in space. They contribute to define the final layout of space experiments and to clarify phenomena observed in space experiments. In addition, they can help to determine the underlying mechanisms of these phenomena.

Studies conducted in facilities simulating the surface conditions of other bodies in our solar system, such as Mars, comets or other icy bodies will be discussed in the chapter by H. Kochan, this chapter will mainly cover the aspects of astrobiology which can be investigated in simulated interplanetary space.

## 2. Research Topics in Laboratory Astrobiology

### 2.1. ROLE OF SOLAR UV RADIATION IN GENETIC STABILITY

Solar UV radiation is a dynamic driving force of organic chemical evolution, yet it may have set severe constraints in biological evolution. Especially in the early history of life, before the evolution of a protective ozone layer in the atmosphere, the highly mutagenic UV bands, UVC (190 - 280 nm) and short wavelength UVB (280 - 315 nm), reached the surface of Earth. Although life has invented several adaptive strategies to cope with environmental UV radiation stress, such as DNA repair pathways and inducible pigmentation, potential evolutionary pathways under a UV radiation environment different from the terrestrial one are difficult to assess. Studies on ecosystems in a UV radiation climate, simulating the radiation conditions of the early Earth, or the early or present-day Mars can help to understand which strategies life may develop for UV tolerance.

### 2.2. ROLE OF GRAVITY IN BASIC BIOLOGICAL FUNCTIONS

Terrestrial life developed under a continuous stimulation of 1 *g*. Gravity is likely to have influenced the structure and function of life during its evolution, that of individual organisms as well as that of whole ecosystems. Little is known how life would develop under gravity regimes different from the terrestrial one, as they are encountered on other planets. Ground-based studies on individual cells, microorganisms or microbial ecosystems under simulated 0 *g* conditions or in hypergravity can help to find out whether single cells dispose already of a gravity sensing mechanism or whether gravity sensing is restricted to multicellular organisms. Studies in simulated 0 *g* conditions are also required in connection with microgravity experiments in space, in the definition phase before the mission and as ground-control during the mission.