“Bacterial micronauts”- insights in the space resistance of Bacillus subtilis

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Abstract:

The vast, cold, and radiation-filled conditions of outer space present an environmental challenge for any form of life. The majority of experiments on microorganisms in space were performed using Earth orbiting robotic spacecraft, or human-tended spacecraft, and space stations, e.g. the International Space Station (ISS). The responses of microorganisms to selected factors of space (microgravity, galactic cosmic radiation, solar UV radiation, and space vacuum) were determined in space and laboratory simulation experiments. Spores of the Gram-positive bacterium *B. subtilis* are highly resistant to inactivation by environmental stresses, such as biocidal agents and toxic chemicals, desiccation, pressure and temperature extremes, and high fluences of UV radiation and are a powerful biodosimetric system for terrestrial environmental monitoring and astrobiological studies. Onboard several spacecraft, e.g. Apollo 16, spores of *B. subtilis* were exposed to selected parameters of space, such as space vacuum and different spectral ranges of solar UV-radiation and cosmic rays, applied separately or in combination (Horneck et al. [2010]).

Spores have since been recognized as the hardiest known form of life on Earth, and considerable effort has been invested in understanding the molecular mechanisms responsible for the almost unbelievable resistance of spores to environments which exist at (and beyond) the physical extremes which can support terrestrial life (Nicholson [2009]). Because of their high resistance to environmental extremes and their reported longevity spores have also been suggested as ideal test system for studying the “*Lithopanspermia*” theory, the hypothetical transfer of (microbial) life between the planets of our Solar System via meteorites (Mileikowsky et al. [2000]).

Spore-forming bacteria are of particular concern in the context of planetary protection because their tough endospores are capable of withstanding certain sterilization procedures as well as harsh environments. Microbial contamination arising from spacecraft exploration harbors the distinct potential to impact the development and integrity of life-detection missions on planetary bodies such as Mars and Europa. Those missions going into space are subjected to strict regulations. In the context of the planetary protection guidelines, established by the Committee of Space Research (COSPAR) in 1967, it is essential to reduce or eliminate the biological burden on flight hardware prior to launch in order to prevent cross contamination of celestial bodies with environmental or human-associated microorganisms. For several years a number of activities in the field of sterilization of heat sensitive materials by means of non-thermal plasmas are known. Plasma sterilization methods are characterized by the use of gas or gas mixtures that are partially excited by an applied electric field. Accordingly, multiple plasma components are individually bactericidal and make plasma suitable as a new method for decontamination and sterilization even against highly resistant spores or complex biofilm structures of *Bacillus* sp. for spaceflight purposes.

In this seminar talk, I will present data and information on the molecular mechanisms of *B. subtilis* (as spore or biofilm) allowing it to survive or (re-)grow in environmental extremes or disinfection methods, and give an outlook of the ongoing and future activities of DLR’s Astrobiology and Space Microbiology research groups.

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