LIVING INTERPLANETARY FLIGHT EXPERIMENT (LIFE): AN EXPERIMENT ON THE SURVIVABILITY OF MICROORGANISMS DURING INTERPLANETARY TRANSFER.

David Warmflash[1], Neva Ciftcioglu[2], George Fox[1]; David S. McKay[3], Louis Friedman[4], Bruce Betts[4], Joseph Kirschvink[5], [1]University of Houston Dept. of Biology and Biochemistry (david.m.warmflash@nasa.gov), [2]Nanobac Inc. [3]NASA Johnson Space Center, [4]The Planetary Society, [5]California Institute of Technology

Introduction: The possibility that transpermia, the interplanetary transfer of microorganisms, may have played a role in the origins of terrestrial life depends on the ability of microorganisms to survive the voyage. While it is unlikely that loose microbes could escape a planet's gravity well or survive radiation and vacuum or entry through a planetary atmosphere, approximately one ton of Martian rock ejected via major impact events arrives on Earth each year in the form of meteorites (8). Some thirty meteorites have now been identified as having originated in the Martian crust (13,14), and these represent only a small sampling of transferred Martian rocks. Although most of the interplanetary material that arrives on Earth has spent several million years in space, it is estimated that one out of 10^7 Earth-impacting Mars rocks has made the interplanetary journey in less than a year (8) and that every million years, approximately ten rocks larger than 100g are transferred from Mars to Earth in only two to three years (8). It is known that major impact events are able to move rocks from the surface of a planet such as Mars to the surface of a planet such as Earth without heating their interiors to temperatures high enough to kill prokaryotic or eukaryotic microorganisms, either during impact/ejection on Mars or during entry through Earth's atmosphere (18). Alternatively, dust particles can be decelerated gently in the upper atmosphere of a planet such as Earth, thus reaching the surface without excessive heating of the dust's contents (1). Whether survival of active microbes or spores during the interplanetary transfer phase itself would be sufficient to allow for transpermia is unknown. Previously, microbial survival in space has been investigated, for periods of up to six years, though in low Earth orbit (LEO) (11,12,16) where radiation exposure is relatively low, and outside the Earth's geomagnetosphere, thus in the interplanetary radiation environment, but for relatively short durations (several days) (3,4,5,6,7,9,11,15,16). The afformentioned studies demonstrated survivability of sporulating microbes as well as plant seeds. To advance survivability knowledge to the level of 34 months in the interplanetary space environment, and thus in time range appropriate to the transpermia hypothesis, the Planetary Society is preparing an experiment known as LIFE (Living Interplanetary Flight Experiment), which would fly on the Russian Phobos Soil mission. The Planetary Society has flown hardware on numerous planetary missions. In addition, The Planetary Society flew a test of microbial life in space [give acronym and what it stands for) on the Space Shuttle and add a numerical reference]. LIFE is being done in collaboration with the Space Research Institute and the Institute of Microbiology of the Russian Academy of Sciences. Currently, the experiment is under formal consideration by NPO Lavochkin, the engineering organization building the spacecraft. The experiment is being done in collaboration with Alexander Zakharov, Space Research Institute, Elena Vorobyova, Moscow State University, and Valery Galchenko, Inst of Microbiology. LIFE would test the survival of approximately ten species selected from among bacterial, archaeal, and eukariotic domains. Organism selection is ongoing, but species will be selected based on two general criteria: 1) baseline data which exist for the organism based on previous survivability experiments in space; 2) organism survivability in "extreme" or Mars-analog environments. The latter includes strains with radiation resistance and/or the ability to metabolize lithotrophically. The samples will be carried throughout all mission phases, from the launch until the Phobos sample return landing. The experiment is passive, with no active control nor actuators. The experiment container will be integrated inside the sample entry vehicle, in spare volume between the aeroshell heatshield substrate and internal avionics(Svitek and Fraze).

References: (1) Anders, E. 1989. Pre-biotic organic matter from comets and asteroids. Nature 342:255-257. (2) Bucker H, et al. Results of the Bacillus subtilis unit of the Biostack II experiment: physical characteristics and biological effects of individual cosmic HZE particles. Life Sci Space Res. 1975; 13: 161-6. (3) Bucker H, et al. The Biostack experiment on Apollo 16. Life Sci Space Res. 1973; 11: 295-305. (4) Bucker H, Horneck G. The biological effectiveness of HZE-particles of cosmic radiation studied in the Apollo 16 and 17 Biostack experiments. Acta Astronaut. 1975 Mar-Apr; 2(3-4): 247-64. (5) Bucker H. The Biostack Experiments I and II aboard Apollo 16 and 17. Life Sci Space Res. 1974; 12: 43-50. (6) Facius R, et al. Radiobiological results from the Bacillus subtilis Biostack experiments within the Apollo and the ASTP space flights. Life Sci Space Res. 1978; 16: 151-6. (7) Facius R, et al. Dosimetric and biological results from the Bacillus subtilis Biostack experiment with the Apollo-Soyuz Test Project. Life Sci Space Res. 1979; 17: 123-8. (8) Gladman. B. (1997). Destination Earth: Martian meteorite delivery. Icarus, 130, 228-246. (9) Graul EH, et al. Radiobiological results of the Biostack experiment on board Apollo 16 and 17. Life Sci Space Res. 1975; 13: 153-9. (10) Horneck G, et al. Long-term survival of bacterial spores in space. Adv Space Res. 1994 Oct; 14(10): 41-5. (11) Horneck G, et al. Microbial studies in the Biostack experiment of the Apollo 16 mission: germination and outgrowth of single Bacillus subtilis spores hit by cosmic HZE particles. Life Sci Space Res. 1974; 12: 75-83. (12) Horneck G. Responses of Bacillus subtilis spores to space environment: results from experiments in space. Orig Life Evol Biosph. 1993 Feb; 23(1): 37-52. (13) Meyer, C. 2002 Mars Meteorite Compendium. NASA, Houston. (14) Nyquist, et al. Ages and geologic histories of Martian meteorites. Space Science Reviews 96, 105-164. (15) Reitz G, et al. Results of space experiments. Radiat Environ Biophys. 1995 Aug; 34(3): 139-44. (review of entire Biostack program) (16) Rettberg P, et al. Survival of microorganisms in space protected by meteorite material: results of the experiment 'EXOBIOLOGIE' of the PERSEUS mission. Adv Space Res. 2002; 30(6): 1539-45. (17) Svitek T and Fraze B 2007 Phobos Deimos conference. (18) Weiss, B. P., et al. (2000) A low temperature transfer of ALH84001 from Mars to Earth. Science, 290, 791-795.