Space Flight Conditions designed to Model a Round-trip to Mars and Back
- Bacillus pumilus chosen as a model organism as Bacillus spores are notably resistant to challenging environmental conditions, including UV radiation, γ-radiation, H2O2, desiccation and chemical disinfections. Specifically, Bacillus pumilus surivives standard decontamination procedures of the Jet Propulsion Laboratory.
- Conditions modeled to simulate 550 days in flight to Mars or 500 days on Mars
- Survivability challenges include microgravity, extreme variation in temperatures, galactic and solar radiation, and high vacuum
- Space – Dark (0% T)
  - cosmic radiation; UV=110 nm: 8 x 10-16 kJ/m²; vacuum environment
  - Space – UV (0.5 T)
  - cosmic radiation; UV=110 nm: 6 x 10-16 kJ/m²; vacuum environment
  - Micro-Dark (0.005 T)
  - cosmic radiation; UV=110 nm: 5 x 10-16 kJ/m²; 600 Pa CO2 (4.5 Torr)
  - Mars – UV (0.2 T)
  - cosmic radiation; UV=110 nm: 4 x 10-16 kJ/m²; 600 Pa CO2 (4.5 Torr)
- Temperature cycled from -12°C to 60°C on each of ~9,000 orbits

Sample Preparation
- Bacillus pumilus spores coated onto aluminum plates
- Coated plates placed in 2D arrays on European Technology Exposure Facility (EuTEF)
- EuTEF carried to International Space Station
- EuTEF returned to earth on STS-122

Stressful Exposure Conditions
- Exposure to simulated Mars conditions: UV > 110 nm ~ 22 kJ/m² U > Space
- Exposure to high vacuum (2.2 kPa)
- Exposure to γ radiation: 107 rad
- Exposure to cosmic radiation: ~ 18 months on each of ~ 9,000 orbits
- Exposure to reduced oxygen levels: ~ 9,000 orbit
- Exposure to desiccation and chemical disinfections. Specifically, Bacillus pumilus survives standard decontamination procedures of the Jet Propulsion Laboratory.

Project Launch
STS-122 (Atlantis) take-off from Launch Pad 39A on Friday, July 3, 2008

Eutef Returns to Earth on STS-128 (Discovery) September 2009

Results of Analysis
- Qualitative identifications
  - All peptide identifications scored at ~ 1% FDR using forward database
  - 358 proteins identified using 1,649 peptides
  - 215 proteins with > 1 peptide

Quantitative Analysis
- Space-dark sample was an analytical outlier and was removed from analysis
- Accurate Mass and Time Tag Alignment data map (Space-UV sample)

Sample Viability Study
- Initial spore-viability determination based on number of Colony Forming Units
  - Viability ranking
    - Mars-Dark > Space-Dark > Mars-UV > Space-UV

Enhanced Survivability of Spores – UV Resistance of Survivor Spores
- Evaluated UV resistance found in both UV exposed spore groups or ground control
- UV survivors exhibit growth even after exposure to exposure to 4,000 mJ/m² UV, whereas all ground control spores die at exposures > 1,500 mJ/m²

NASA's Planetary Protection Mandate
- Protect other solar system bodies for life, remnants of past life, and the precursors to challenging environmental conditions, including UV radiation, γ-radiation, H2O2, desiccation and chemical disinfections. Specifically, Bacillus pumilus survives standard decontamination procedures of the Jet Propulsion Laboratory.
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Sample Preparation
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- Spores recovered by application and peeling of polyester alcohol films
- 10% dilution of recovered spore solutions were plated and Colony Forming Units were counted after incubation
- Five Generation Colonies used for all subsequent studies

2D Agglomerative Cluster Analysis of ANOVA Significant Proteins (2-score corrected)
- Error weighted ANOVA analysis with a Bonferroni correction (p<10⁻⁵)
- Each column is a 2-score protein-level expression measurement