Microbial Monitoring of Spacecraft and Associated Environments

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The search for evidence of life on other planets, either by *in situ* exploration or sample return missions, will likely involve ultra-sensitive detection of biomarkers. Accurately assessing the microbial burden requires effective sampling of cells or biomolecules. As structure and chemistry are integral parts of biology, utilization of various modern molecular methods, including microscopic techniques coupled with in situ chemical analyses, is obligatory in assessing microbial contamination. Real time microbial detection methods based on enzymatic activity (for general cleanliness; viable microbes), molecular presence (dipicolonic acid for spores), several gene markers (ribosomal and spore-specific), and DNA-microarray techniques are under evaluation.

A detailed understanding of the microbial species associated with the surfaces of spacecraft hardware would provide an understanding of the terrestrial microbes most likely to contaminate extraterrestrial environments, in-situ life detection studies, or, possibly, returned samples. In addition, characterizing the microbial communities aboard the International Space Station (ISS), and on spacecraft is crucial in maintaining cleanliness as well as astronaut health. NASA's culture-based techniques have found species of *Bacillus* to be dominant, while direct DNA isolation, cloning and rDNA sequencing analysis revealed the presence of many Gram-positive and Gram-negative microorganisms, actinomycetes and fungi that are both cultivable and non-cultivable. Several novel bacterial species have been isolated that exhibit elevated resistances to desiccation, H_2O_2, UV, and γ-radiation conditions. H_2O_2 vapor is currently the sterilant-of-choice for flight hardware because it is a low-heat sterilization process that is suitable for various spacecraft components. Preliminary studies, however, have shown that certain strains of cultivable microbes (*Bacillus* species; *Acinetobacter radioresistens*; *Aureobasidium pullulans*) collected from spacecraft and assembly facility surfaces are resistant to H_2O_2. While assessing the cleanliness of several spacecraft assembly facility surface locations, several H_2O_2 resistant *Bacillus pumilus* strains were repeatedly encountered.

Rapid microbial monitoring technologies are invaluable in assessing the contamination events aboard the ISS and thus preventing potential health hazards to astronauts, as well as in the construction of high quality spacecraft for present and future missions.