Team discover how microbes survive clean rooms and contaminate spacecraft

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Engineers work on Opportunity (in its cruise configuration) in a cleanroom at Kennedy Space Center. A very important part of planetary protection is keeping contaminants from humans from riding aboard spacecraft. The pictured engineers are donning "bunny suits" that only allow their eyes to be exposed.

Rakesh Mogul, a Cal Poly Pomona professor of biological chemistry, was the lead author of an article in the journal *Astrobiology* that offers the first biochemical evidence explaining the reason the contamination persists.

Chemistry professor Gregory A. Barding, Jr., was a collaborator and second author on the paper. The remaining 22 coauthors are all Cal Poly Pomona students—14 undergraduates in chemistry, three chemistry graduate students and five undergraduates in biological sciences.

"We designed the project to give students hands-on experience – and to support the learn-by-doing philosophy of Cal Poly Pomona. The students did the research, mostly as thesis projects in the areas of enzymology, molecular microbiology and analytical chemistry," said Mogul.

In the clean room facilities, NASA implements a variety of planetary protection measures to minimize biological contamination of spacecraft. These steps are important because contamination by Earth-based microorganisms could compromise life-detection missions by providing false positive results.

Despite extensive cleaning procedures, however, molecular genetic analyses show that the clean rooms harbor a diverse collection of microorganisms, or a spacecraft microbiome, that includes bacteria, archaea and fungi, explained Mogul. The Acinetobacter, a genus of bacteria, are among the dominant members of the spacecraft microbiome.

To figure out how the spacecraft microbiome survives in the cleanroom facilities, the research team analyzed several Acinetobacter strains that were originally isolated from the Mars Odyssey and Phoenix spacecraft facilities.

They found that under very nutrient-restricted conditions, most of the tested strains grew on and biodegraded the cleaning agents used during spacecraft assembly. The work showed that cultures grew on ethyl alcohol as a sole carbon source while displaying reasonable tolerances towards oxidative stress. This is important since oxidative stress is associated with desiccating and high radiation environments similar to Mars.

The tested strains were also able to biodegrade isopropyl alcohol and Kleenol 30, two other cleaning agents commonly used, with these products potentially serving as energy sources for the microbiome.

"We're giving the planetary protection community a baseline understanding of why these microorganisms remain in the clean rooms," said Mogul. "There's always stuff coming into the clean rooms, but one of the questions has been why do the microbes remain in the clean rooms, and why is there a set of microorganisms that are common to the clean rooms."

For planetary protection, this indicates that more stringent cleaning steps may be needed for missions focused on life detection and highlights the potential need to use differing and rotating cleaning reagents that are compatible with the spacecraft to control the biological burden.

More information: Rakesh Mogul et al. Metabolism and Biodegradation of Spacecraft Cleaning Reagents by Strains of Spacecraft-Associated Acinetobacter, *Astrobiology* (2018). DOI: 10.1089/ast.2017.1814

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