

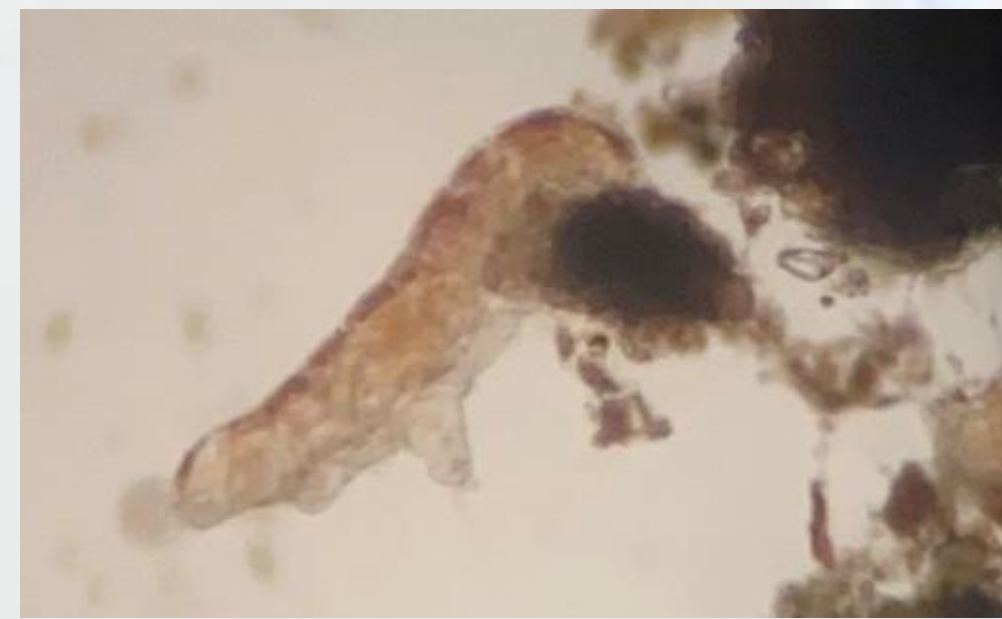


Planetary Protection at Marshall Space Flight Center

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A tardigrade at 100x magnification

Planetary Protection (PP) at NASA aims to 1) protect solar system bodies from contamination by Earth life and 2) protect Earth from possible life forms that may be returned from other solar system bodies. It is particularly relevant for missions focused on life detection. PP specialists at MSFC act as subject matter experts to interpret PP requirements and communicate with other NASA centers and/or vendors to ensure compliance. This includes insight and oversight to help projects consider and plan PP implementation during design phases. It also includes physical implementation during build, assembly, and test operations, (i.e. microbial sampling of environments and spacecraft) to help maintain cleanliness. MSFC has also expanded to include PP research which included standing up a fully functional BSL2 microbiology laboratory.

MSFC's PP lab is primarily concerned with identifying microbial threats and developing novel methods to neutralize those threats. This effort has included development of numerous collaborations with other NASA centers, companies, federal agencies, and academic institutions. The research goals of MSFC's PP Lab are summarized in three main areas:

1. Bioburden of Nonmetallic Spacecraft Materials

The greatest threat to achieving PP requirements is the bioburden encapsulated within nonmetallic spacecraft materials. MSFC's PP lab analyzes the bioburden associated with commonly used nonmetallic materials. This analysis includes both culture-based and molecular methods of analysis. An Example experimental flow for bioburden assessment of nonmetallic materials is displayed below and can be used for almost any nonmetallic material of interest.



Additional work is underway to expand PP approaches to include molecular methods. MSFC's PP lab is working to include direct DNA isolation in the above experimental regime.



These efforts have yielded a collection of over 350 pure bacterial and fungal isolates which are available for collaborative study. A portion of these microbes have been identified using DNA sequencing or mass-spectrometry based approaches. Examples of the impressive variety of these microbes are shown above.

2. Manufacturing and Bioburden Reduction

Some common manufacturing processes, like curing, can be harsh enough that projects may be able to take bioburden reduction "credit." MSFC's PP lab evaluates such processes to determine efficacy against spores. Below, layers of green rubber insulation is inoculated with *B. atrophaeus* spores (left) then laid-up and cured (right) for downstream analysis of microbial survival.



Some materials or chemicals used in spacecraft manufacturing are antimicrobial. For example, many additives used in formulations of insulation are known to be toxic and may have effects on microbial survival, thereby reducing the encapsulated bioburden. MSFC's PP lab assesses such materials for potential bioburden reduction "credit."

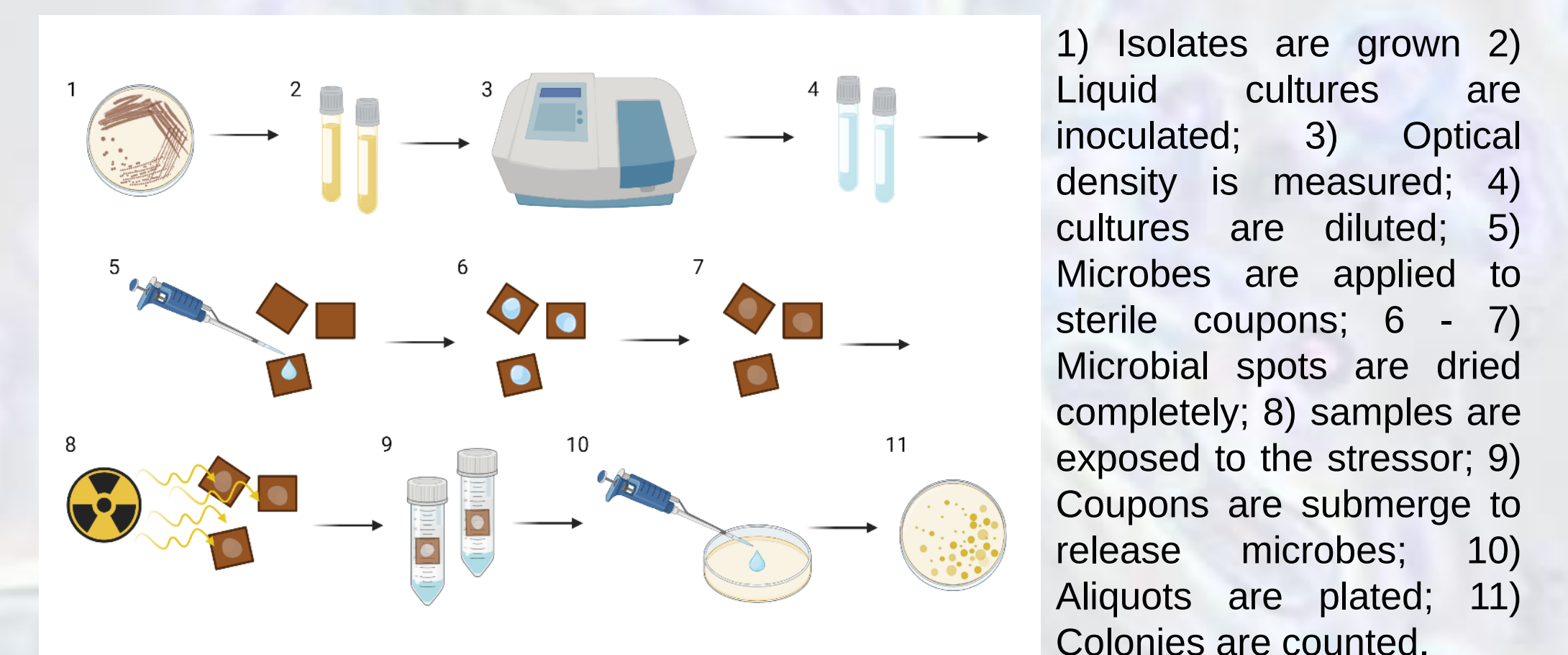
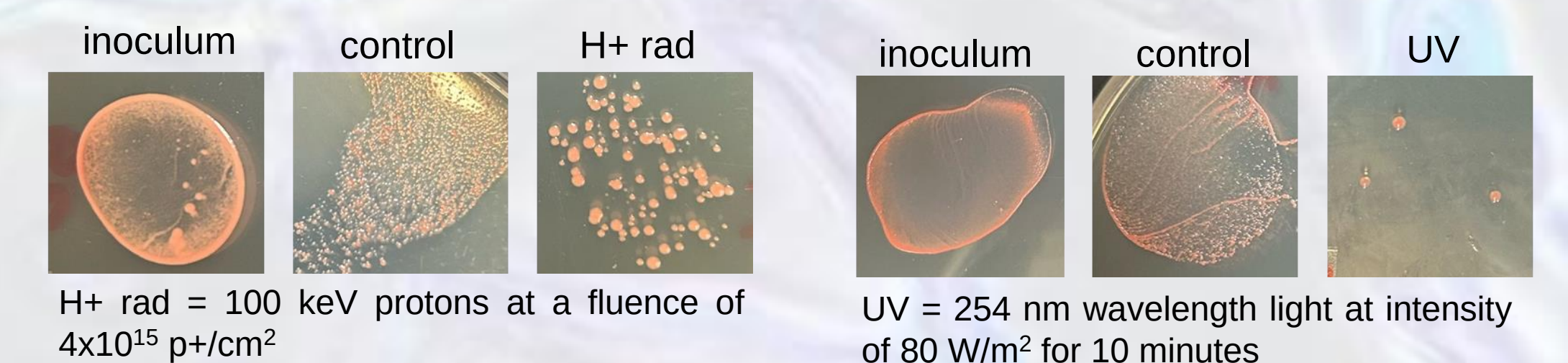


B. atrophaeus zones of inhibition around commonly used powdered rubber additives.



3. Space Environment Effects on Microbial Survival

The space environment consists of many harsh variables, including vacuum, ultraviolet (UV) radiation, ionizing radiation, temperature extremes, etc. which are a potential source of bioburden reduction. MSFC's PP Lab performs exposure studies on microbes isolated from cleanrooms, test facilities, or spacecraft materials. Microbes are dried on sterile coupons, exposed to stressors, then analyzed for downstream survival. A typical experimental flow is shown below:



Above, the insulation-associated microbe *Methylobacterium radiotolerans* demonstrates survival against multiple stressors. Surviving microbes represent the greatest threats to protecting other planets from terrestrial microbial contamination.