



## Post-Fragmentation Whole Genome Amplification-Based Method

**This method has application in hospital cleanliness validation assays, pharmaceutical development, and medical device manufacturing and packaging.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

This innovation is derived from a proprietary amplification scheme that is based upon random fragmentation of the genome into a series of short, overlapping templates. The resulting shorter DNA strands (<400 bp) constitute a library of DNA fragments with defined 3' and 5' termini. Specific primers to these termini are then used to isothermally amplify this library into potentially unlimited quantities that can be used immediately for multiple downstream applications including gel electrophoresis, quantitative polymerase chain reaction (QPCR), comparative genomic hybridization microarray, SNP analysis, and sequencing.

The standard reaction can be performed with minimal hands-on time, and can produce amplified DNA in as little as three hours. Post-fragmentation whole genome amplification-based technology provides a robust and accurate method of amplifying femtogram levels of starting material into microgram yields with no detectable allele bias. The amplified DNA also facilitates the preservation of samples (spacecraft samples) by amplifying scarce amounts of template DNA into microgram concen-

trations in just a few hours. Based on further optimization of this technology, this could be a feasible technology to use in sample preservation for potential future sample return missions.

The research and technology development described here can be pivotal in dealing with backward/forward biological contamination from planetary missions. Such efforts rely heavily on an increasing understanding of the burden and diversity of microorganisms present on spacecraft surfaces throughout assembly and testing.

The development and implementation of these technologies could significantly improve the comprehensiveness and resolving power of spacecraft-associated microbial population censuses, and are important to the continued evolution and advancement of planetary protection capabilities. Current molecular procedures for assaying spacecraft-associated microbial burden and diversity have inherent sample loss issues at practically every step, particularly nucleic acid extraction. In engineering a molecular means of amplifying nucleic acids directly from single cells in their native

state within the sample matrix, this innovation has circumvented entirely the need for DNA extraction regimes in the sample processing scheme.

As typically 90 percent of the biomaterial held within a sample is lost at the extraction step, the absence of DNA extraction in processing a sample of low biomass is quite appealing and seemingly superior, at least in theory. If current understanding of spacecraft-associated microbial burden/diversity is based on a mere 10% of the actual sample collected, then a much broader diversity and elevated bioburden should be able to be resolved upon mitigating this  $\approx$  90% loss of sample biomatter. This innovative process should lend considerable credence to such assays, and ultimately result in a much more comprehensive knowledge base of the abundance and phylogenetic diversity of microbes on and around spacecraft surfaces.

*This work was done by James (Nick) Benardini and Myron T. La Duc of Caltech and John Langmore of Rubicon Genomics for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-47201*

## Microwave Tissue Soldering for Immediate Wound Closure

**Wounds can be closed rapidly, without staples, sutures, or tapes.**

*Lyndon B. Johnson Space Center, Houston, Texas*

A novel approach for the immediate sealing of traumatic wounds is under development. A portable microwave generator and handheld antenna are used to seal wounds, binding the edges of the wound together using a biodegradable protein sealant or "solder." This method could be used for repairing wounds in emergency settings by restoring the wound surface to its original strength within minutes. This technique could also be utilized for surgical purposes involving solid visceral organs

(i.e., liver, spleen, and kidney) that currently do not respond well to ordinary surgical procedures.

A miniaturized microwave generator and a handheld antenna are used to deliver microwave energy to the protein solder, which is applied to the wound. The antenna can be of several alternative designs optimized for placement either in contact with or in proximity to the protein solder covering the wound. In either case, optimization of the de-

sign includes the matching of impedances to maximize the energy delivered to the protein solder and wound at a chosen frequency. For certain applications, an antenna could be designed that would emit power only when it is in direct contact with the wound.

The optimum frequency or frequencies for a specific application would depend on the required depth of penetration of the microwave energy. In fact, a computational simulation for each spe-