National Aeronautics and Space Administration

# PLANETARY PROTECTION
## CENTER OF EXCELLENCE

# BIOINFORMATICS

The Jet Propulsion Laboratory's Biotechnology and Planetary Protection Group is applying bioinformatics to advance understanding in the fields of microbial ecology of extreme environments, space biology, astrobiology and planetary protection.

Recent advances in molecular biology has lead to enhanced "Omics" data for analysis. Omics data can include genomics (the study of genes), proteomics (the study of proteins), and metabolomics (the study of cellular chemistry and metabolism). Analysis can often require dedicated software and application of specific bioinformatic methods. Implementation of advanced bioinformatic approaches can help in understanding a comprehensice microbial census and functional potential of a microbial community present in cleanrooms and on spacecraft hardware. Such knowledge will allow in the future for better ability to gauge the probability of microbial survival and growth in extraterrestrial environments as well as potentially reducing risks to humans on long duration space exploration missions and habitation.

*"A deep understanding of biology is very necessary and a basic computer science working knowledge comes handy."*

## Why Bioinformatics at JPL?

The current NASA Standard Assay utilized to access spacecraft cleanliness is a cultivation-based assay that targets spores, the hardiest but relatively small part of the spectrum of microbial diversity. Understanding their traits responsible for microbial persistence and survival on spacecraft and in cleanrooms remains a significant challenge. NASA also seeks novel approaches to characterize the limits of life on Earth. The ability to analyze genetic sequences, protein structure, cellular chemistry has increased the volume of biological data from samples. The Biotechnology and Planetary Protection Group has pioneered metagenomic approaches (the direct analysis of genomes) to study the microbial diversity and their functional capabilities on spacecraft-related hardware and environments and has developed specialized bioinformatic analysis pipelines to support this research.

## How do we use Bioinformatics to help our research?


*JPL BPPG's five most active research areas in bioinformatics*

Omics studies help in understanding not only which microbes are present on the spacecraft but also what they are capable of doing. This information can provide new insights into genetic variability and functional capabilities of microorganisms.

### 1. Planetary Protection

Planetary protection engineers sample spacecraft for microbial DNA. Using innovative biotechnology methods and bioinformatic tools developed by our group allows JPL to examine the microbial populations associated with the spacecraft and their assembly environments. This research will help planetary protection scientists and engineers develop mitigation approaches for microbial contamination and help ensure accurate life detection investigations on missions.

### 2. Astrobiology

From geothermal hot springs to arid deserts, bioinformatic analyses can help us to understand the extremes of life on Earth. These data provide critical information for astrobiology studies on the origin, evolution and distribution of life in the universe. JPL has applied bioinformatic approaches and omics tools to astrobiology research field work world-wide including Yellowstone, hot springs, deserts, etc.

### 3. Life in Extreme Environments

Biotechnology and Planetary Protection researchers have explored some of the most extreme environments on Earth: deep sea hydrothermal vents, high altitude caves, acidic rivers, etc. to gain further understanding of the limits of life here on Earth. Hot springs at Yellowstone National Park provide an ideal environment for studying microbial ecology because of their high extreme biomass in harsh environmental conditions.

### 4. Space Biology

JPL's bioinformaticians make significant contributions to NASA's Space Biology initiatives including Genelab, translational research and plant biology. GeneLab is a comprehensive space-related omics database. This research helps the scientific community better understand how spaceflight affects living organisms.

### 5. International Space Station (ISS)

JPL research scientists perform comprehensive microbial monitoring of the surfaces, air and water on the ISS using omics techniques. Understanding the effects of microgravity on microorganisms on the ISS as well as astronaut microbiomes is important research in preparation for future human long duration spaceflight.

## Challenges

The primary technical challenge JPL planetary protection scientists and engineers encounter is the extremely clean spacecraft surfaces that are sampled. In order to maintain the spacecraft and the assembly environment clean, JPL has developed unique methods to deal with the very small quantities of sample as well as sensitive DNA extraction techniques to capture the most diversity as possible within the sample for bioinformatic analyses. The bioinformatics tools must be extremely sensitive to detect and accurately analyze these data.

## More about Bioinformatics

JPL is committed to leveraging bioinformatics along with state-of-the-art technology to perform research to better understand the microbiome of space-associated environments. If you would like to learn more about bioinformatics, then visit our website for further information.

Find out more about us!

**NASA Jet Propulsion Laboratory**
**Planetary Protection Center of Excellence**

https://planetaryprotection.jpl.nasa.gov/

*The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.*

© 2020 California Institute of Technology. Government sponsorship acknowledged.