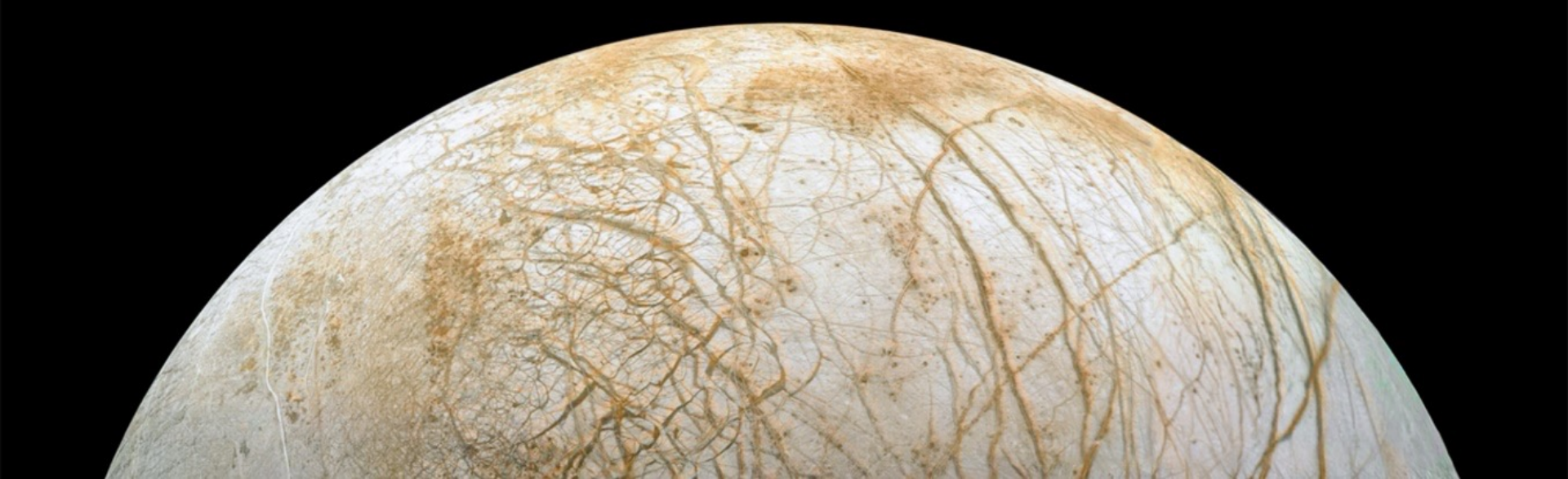
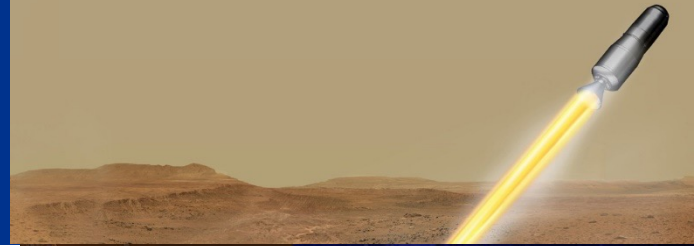




Planetary Protection at Marshall Space Flight Center



Chelsi D. Cassilly, Ph.D.

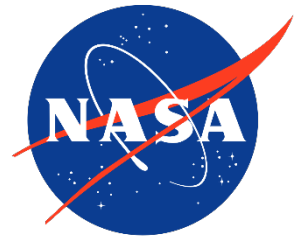
Jacobs Space Exploration Group/ESSCA

Space Environmental Effects Team

Nonmetallic Materials and Space Environmental Effects Branch

NASA/MSFC/EM41

Chelsi.D.Cassilly@nasa.gov



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Who am I?

- Lipscomb University – B.S. in Molecular Biology
 - '08 – '12
- University of Tennessee, Knoxville – Ph.D. in Microbiology
 - '12 – '17
- Harvard Medical School – Postdoctoral Fellow in Chemical Biology
 - '18 – '21
- Jacobs Space Exploration Group – Planetary Protection
 - '21 – present

- Jacobs Engineering Group Inc. is a technical professional services company
- Jacobs Space Exploration Group – subset of Jacobs that supports human spaceflight
 - ESSCA contract with NASA MSFC



What is Planetary Protection?

It's NOT:



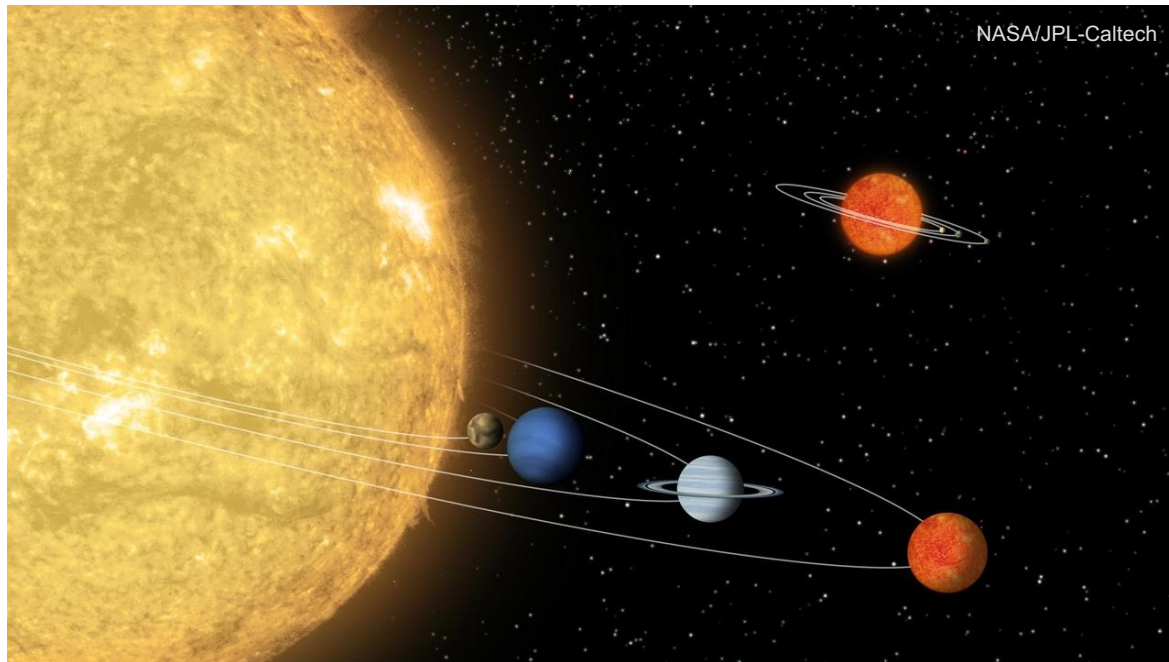
Planetary Defense



Contamination Control

What is Planetary Protection?

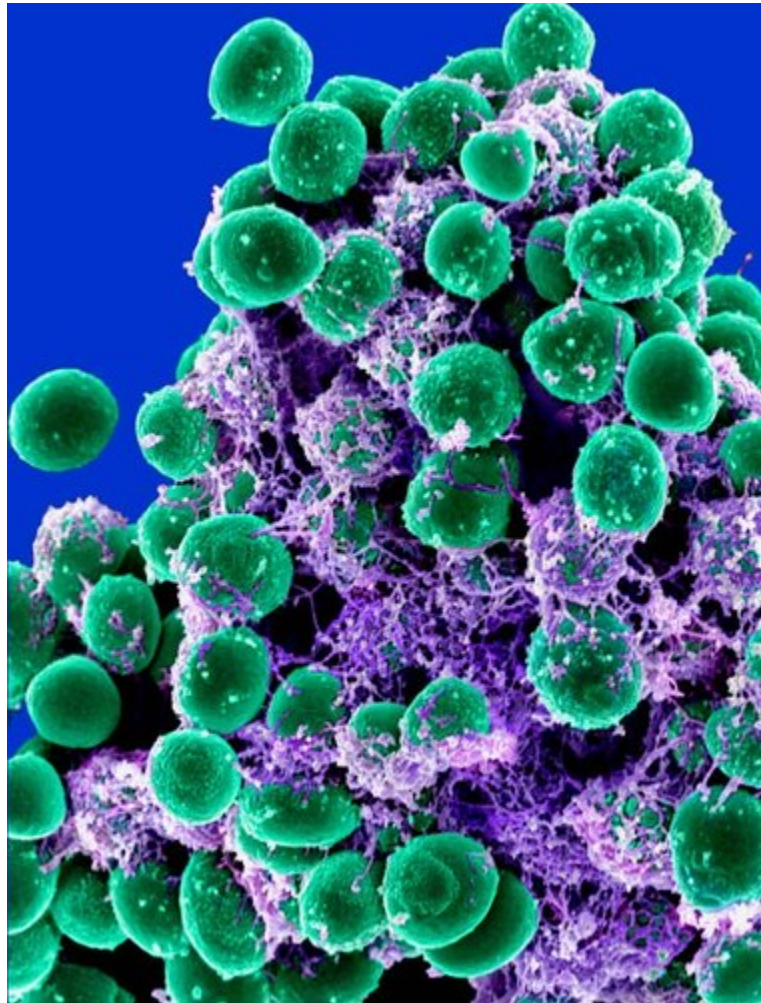
Planetary Protection is the practice of protecting solar system bodies from contamination by Earth life and protecting Earth from possible **life forms** that may be returned from other solar system bodies.



So, what are these “life forms” we care about?



So, what are these “life forms” we care about?



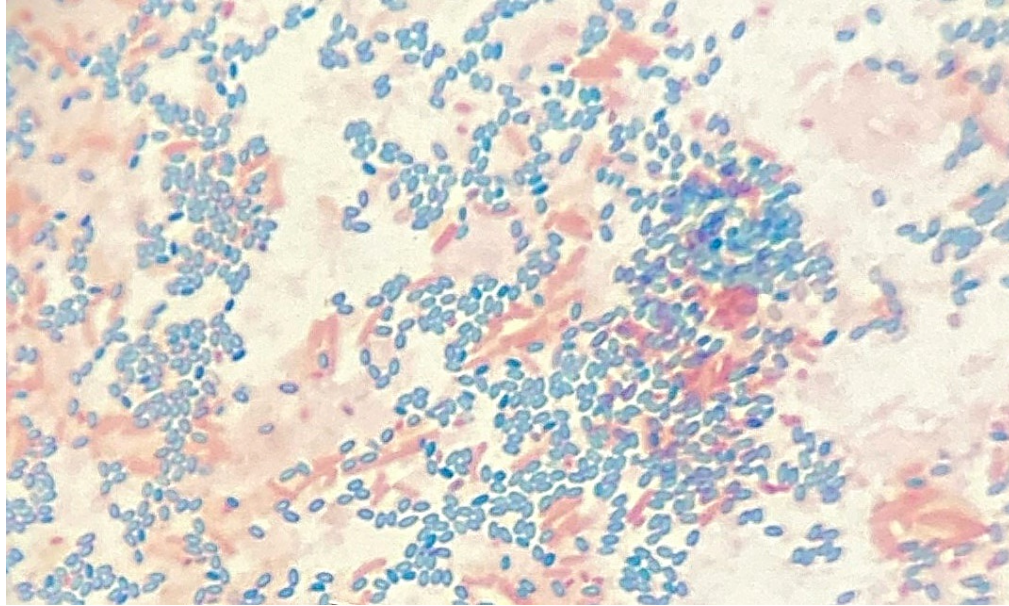
Microbes, Bacteria, Fungi, and Spores

- Microbes are living organisms that are too small to see without the aid of a microscope
- Bacteria, viruses, archaea, protozoa, fungi are subsets of microorganisms
- Spores are hardy, dormant cells that some bacteria produce in order to survive harsh conditions



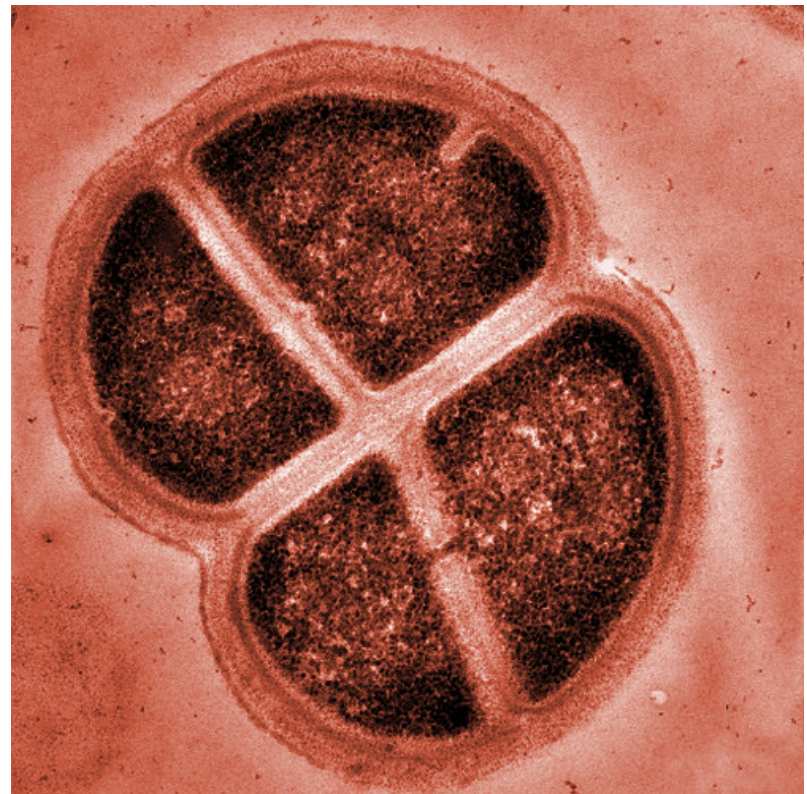
"Microscope at Bioscience Center" by IITA Image Library is licensed under CC BY-NC-SA 2.0

Planetary protection is most concerned with endospores, although some bacteria are very resistant to sterilization, and all microbes can be problematic.



Many microbes can survive harsh conditions:

- Radiation
- Vacuum
- Heat
- Cold
- Dehydration
- Chemicals
- Acid
- Salt
- Impact
- Pressure
- O₂ deprivation
- Starvation
- Time



Why is planetary protection important?

- 1. Ethically, to preserve pristine environments and avoid contamination/seeding with Earth microbes**



Leave No Trace

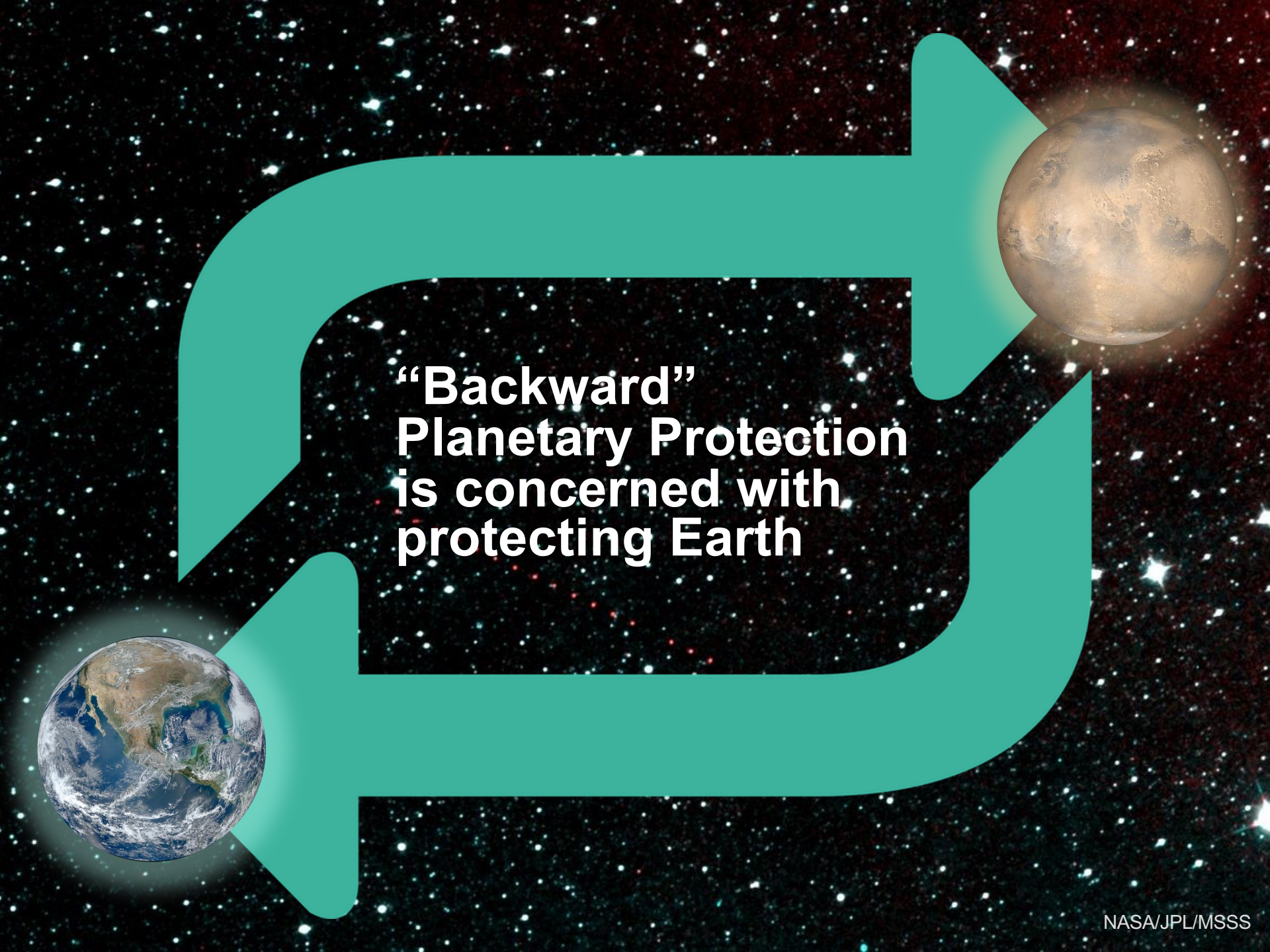
Just as we wish to preserve
certain places on Earth...



...we also wish to preserve other planetary bodies.

Why is planetary protection important?

- 1. Ethically, to preserve pristine environments and avoid contamination/seeding with Earth microbes**
- 2. To protect Earth from possible microbes or bioactive molecules returning in samples or on spacecraft**



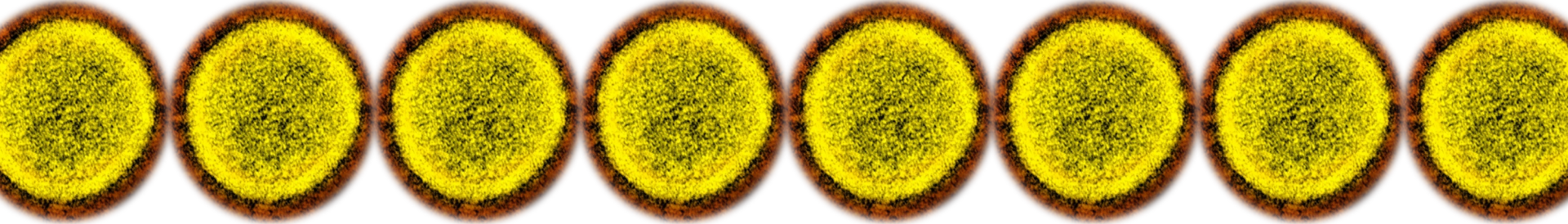
**“Backward”
Planetary Protection
is concerned with
protecting Earth**

Why is planetary protection important?

- 1. Ethically, to preserve pristine environments and avoid contamination/seeding with Earth microbes**
- 2. To protect Earth from possible microbes or bioactive molecules returning in samples or on spacecraft**
- 3. To maintain integrity of science conducted**
 - Hardware functionality
 - Purity of samples collected

How can we search for life if we bring our own?





- 1×10^{31} viruses on earth end to end would stretch for 100 million light years
- 100 million times as many bacteria in the oceans (13×10^{28}) as there are stars in the known universe

Microbiology by numbers. *Nat Rev Microbiol* **9**, 628 (2011). <https://doi.org/10.1038/nrmicro2644>

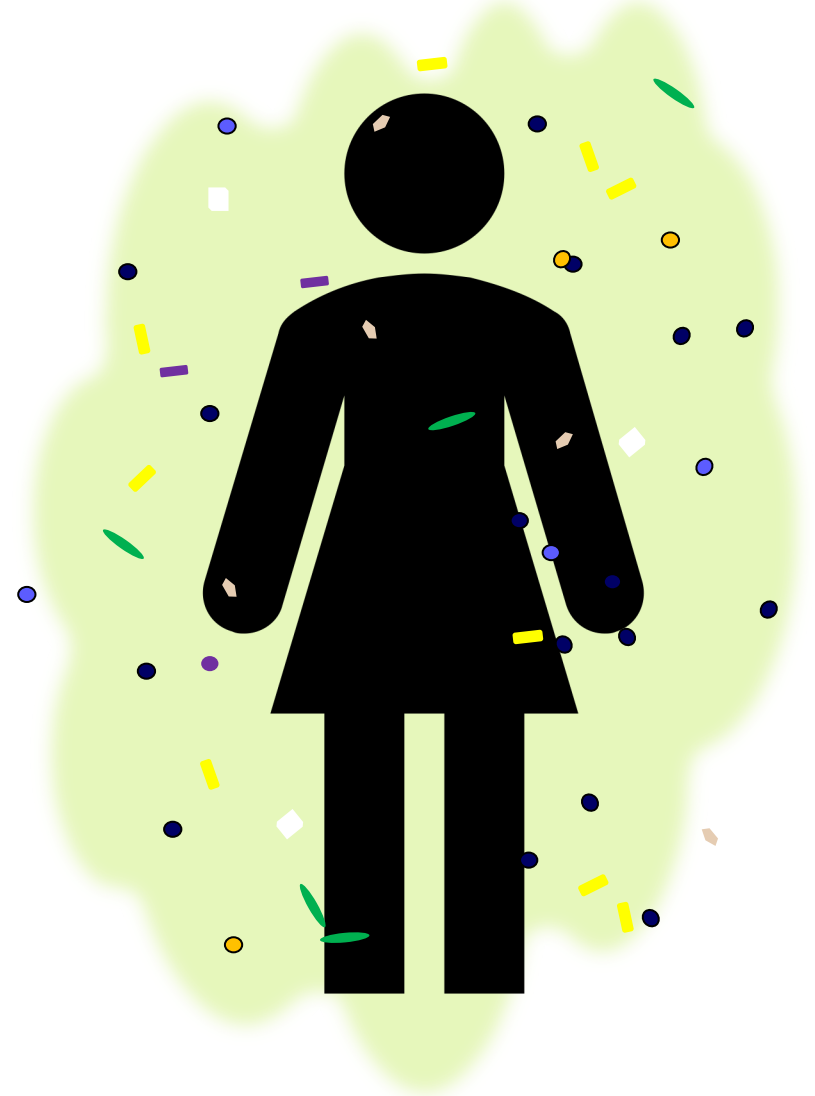


NASA/KSC



We leave a trail of microbes on surfaces and in the air

- Humans give off ~1 million biological particles **every hour** by exhaling, sloughing off skin cells, and radiating hot air from the top of the head



PP Requirements Flow Down from the PPO



NASA Procedural Requirements

COMPLIANCE IS MANDATORY FOR NASA EMPLOYEES

NPR 8715.24

Effective Date: September 24, 2021
Expiration Date: September 24, 2026

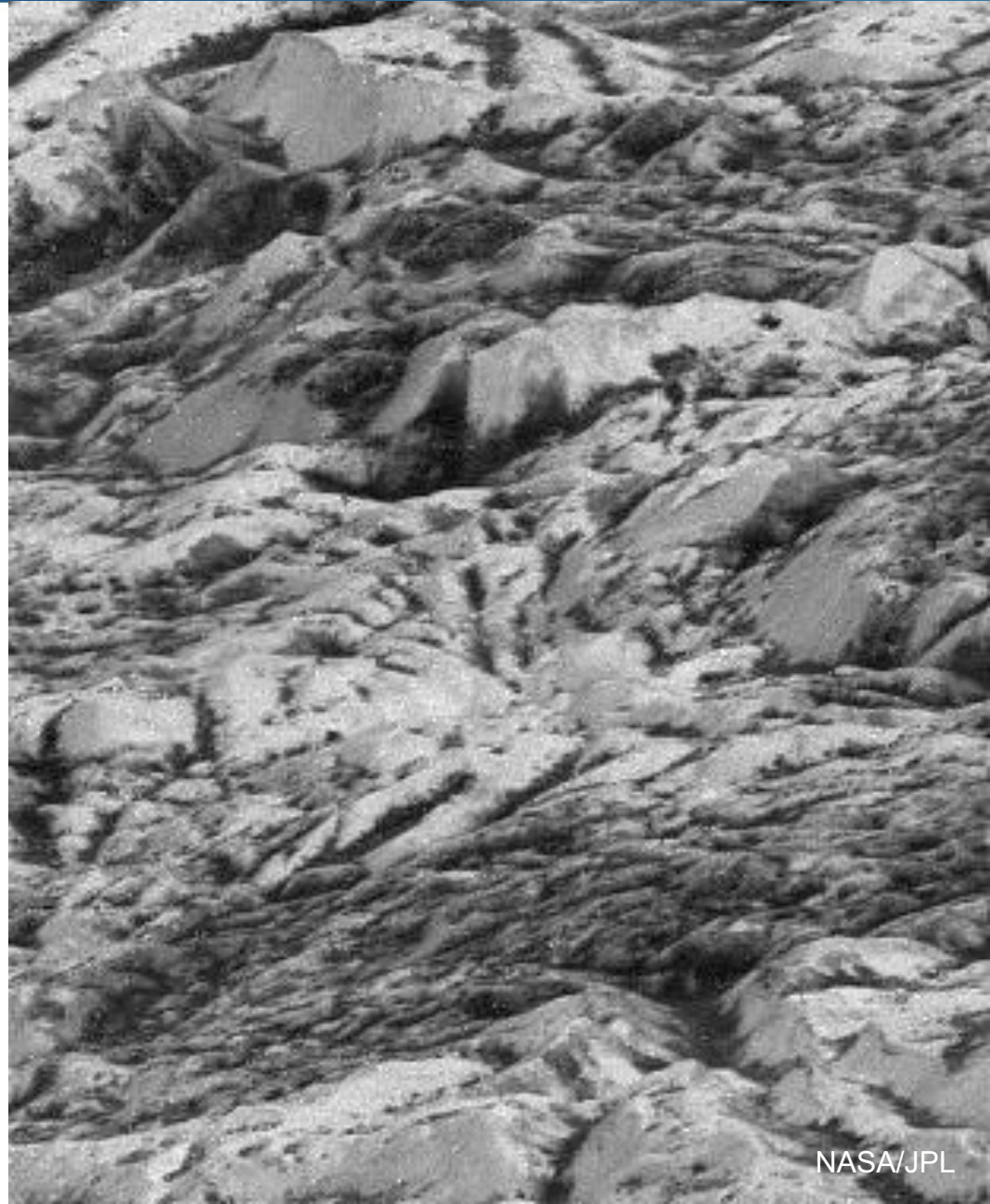
**Subject: Planetary Protection Provisions for Robotic
Extraterrestrial Missions**

Responsible Office: Office of Safety and Mission Assurance



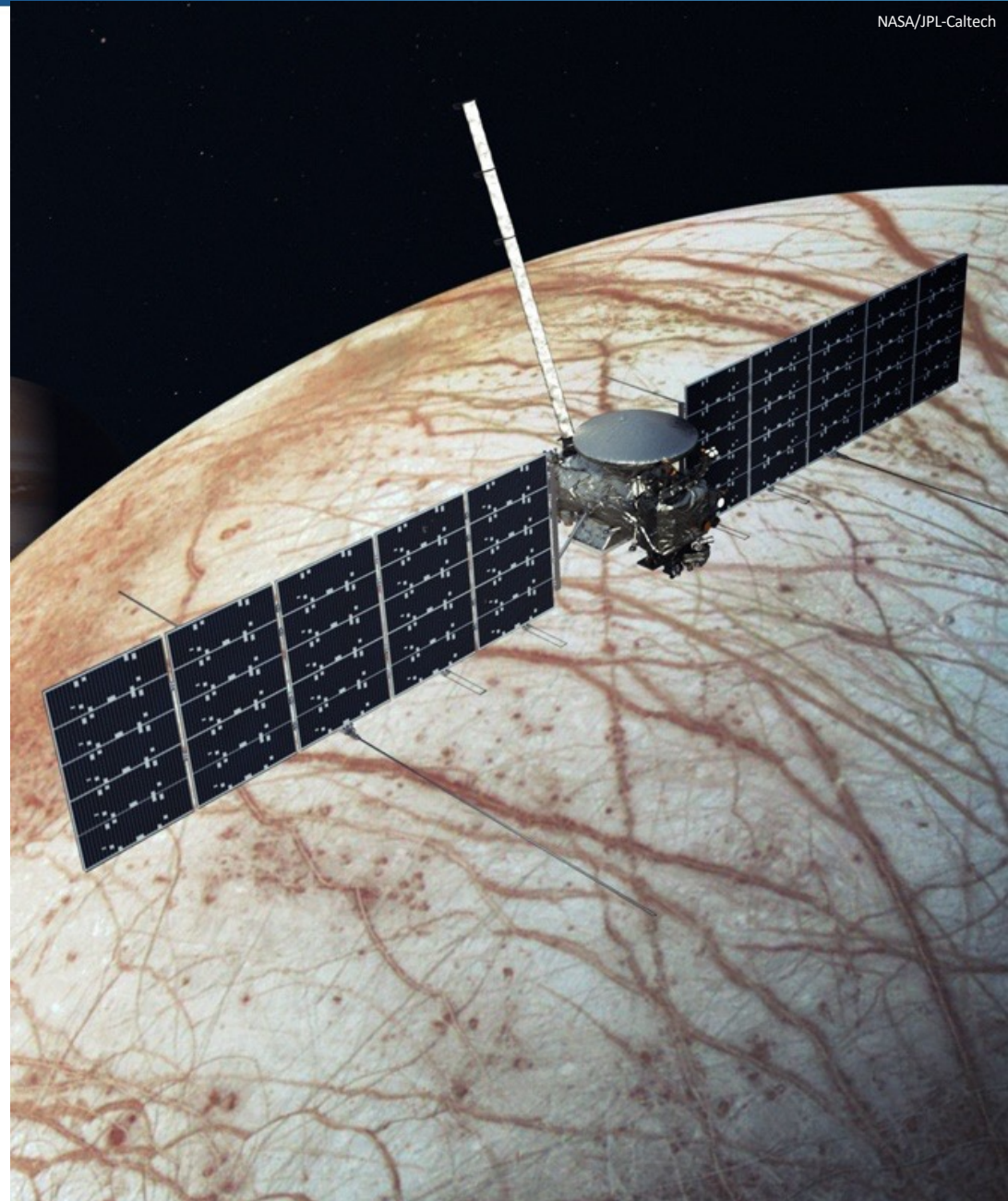
Is there life on EUROPA?

- Europa is an Ocean moon of Jupiter
 - Possible induced magnetic field
 - Thin oxygen atmosphere
 - Possible plumes
 - Ice shell
 - Surface fractures
 - Liquid/slushy salt water ocean
 - Possible deep surface hydrothermal vents
 - Rocky mantel
 - Iron-nickel core



Europa Clipper

- Take measurements to determine if Europa could harbor conditions suitable for life.
- 40 to 50 close passes over Europa
- Expected launch: 2024



Europa Lander

- Concept for a potential future mission that would look for signs of life in the icy surface material of Europa.
- Collect samples from about 4 inches beneath the surface.
- Analyze in miniature laboratory within the robotic lander.

Image credit: NASA / JPL-Caltech / M. C.



Europa Lander

1. Search for evidence of biosignatures on Europa.
2. Assess the habitability of Europa via *in situ* techniques.
3. Characterize the surface and subsurface of Europa.

Image credit: NASA / JPL-Caltech / M. C.





Was there life on Mars?

- Mars is the fourth planet from the sun
 - No structured magnetic field
 - Mostly CO₂ atmosphere
 - Dust storms
 - Terrestrial (soil and rocky surface, rust)
 - Polar ice caps of frozen water
 - No liquid water
 - Volcanoes, craters, mountains, and canyons
 - Rocky mantel
 - Iron rich core



Mars 2020 Mission

Ingenuity
Helicopter

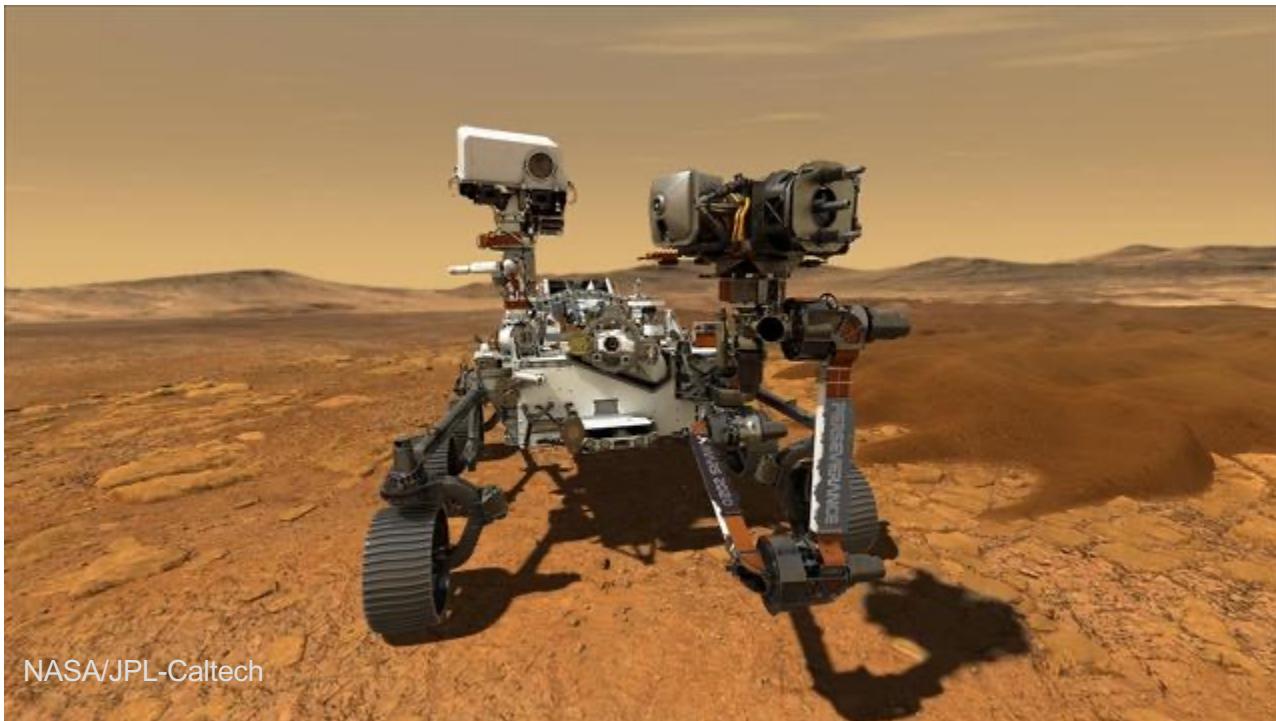


Perseverance
Rover



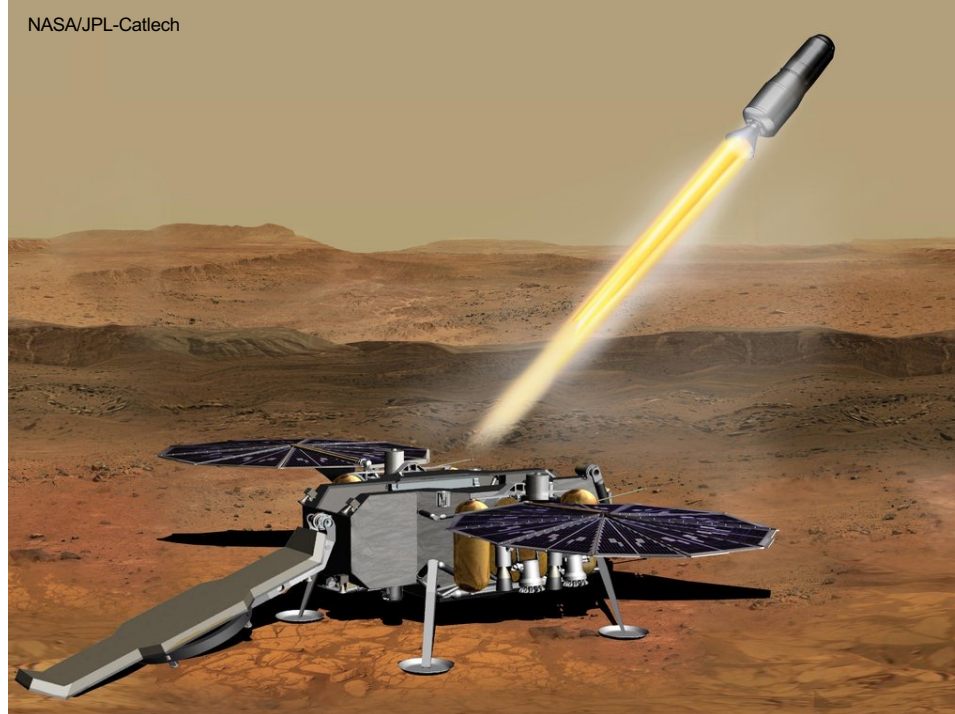
Mars 2020

- Investigate Jezero Crater for evidence of past life
- Collect samples of soil and rock, and cache them for potential return to Earth



Sample Retrieval Lander

- Collects the samples left behind by Perseverance Rover and delivers them to the ascent rocket
- Mars ascent vehicle will launch the sample return canister to a low Mars orbit.



Acceptable Treatment and Cleaning

- Heat microbial reduction (HMR)
- Vapor Hydrogen Peroxide (VHP)



“Clean” is relative

- Strict rules limit the inorganic, organic, and biological contaminants from Earth
- Sample handling hardware must be very clean
 - Sample tubes
 - Sample scoops/drills
 - Anything contacting samples
- Mars 2020 tubes - novel cleaning process



Image Credit: NASA/JPL

JPL and MSFC – Novel Cleaning Methods

- Using new solvents to clean materials
 - Vapor hydrogen peroxide
 - Supercritical carbon dioxide
- Manufacturing credit
 - Can we take credit for reducing microbe numbers if the hardware goes through curing steps?



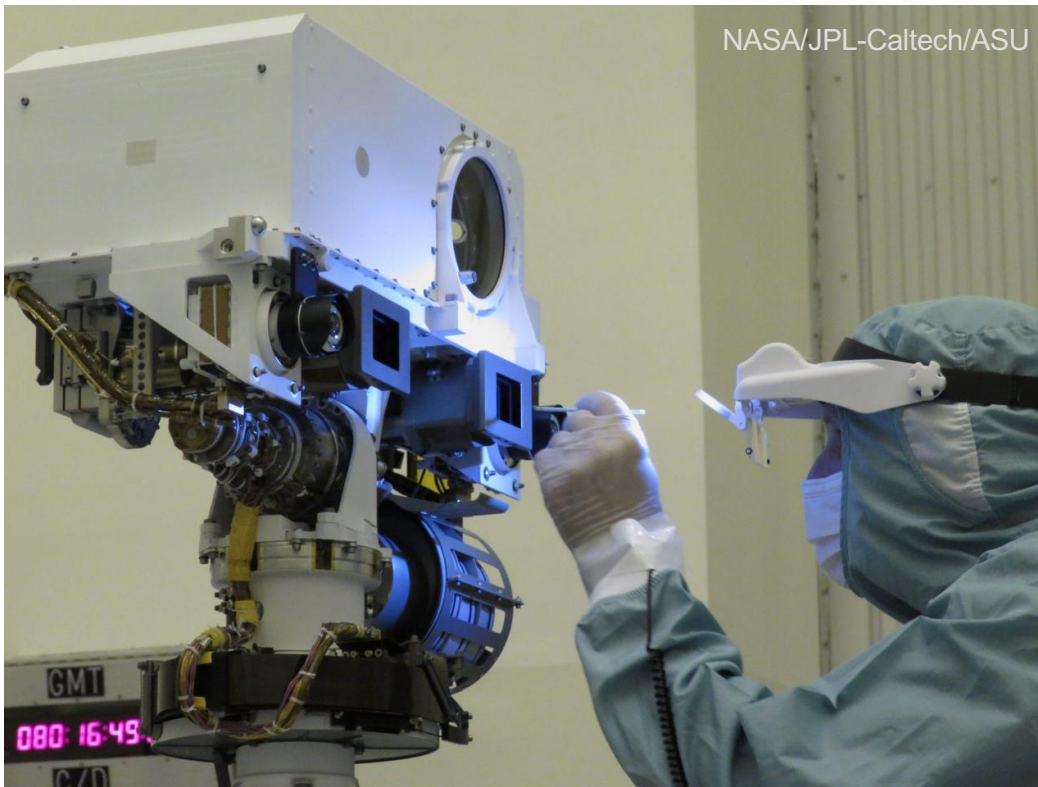
Keep it clean!

- Bio-barriers/ bagging
- Surface wiping with IPA
- HEPA filters



Sampling During Assembly and Integration

To monitor and maintain low bioburden in accordance with NASA requirements



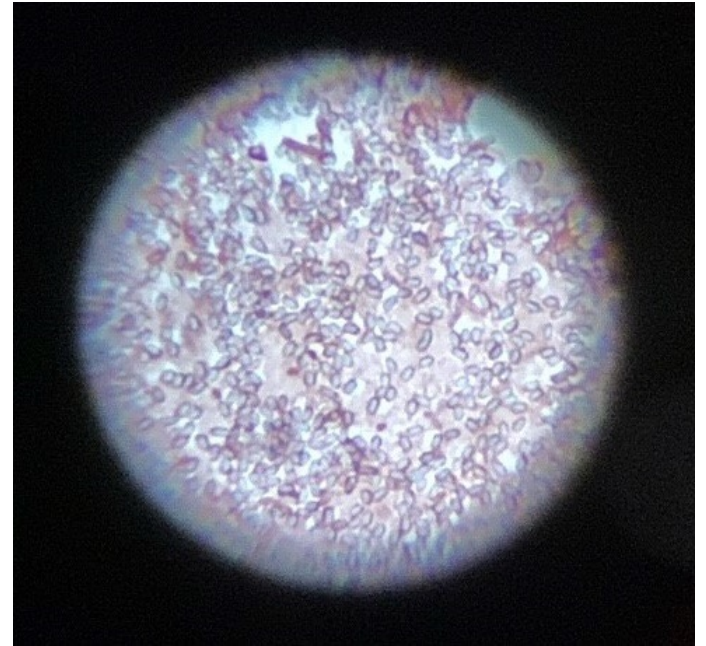
Monitoring cleanroom environment for biological contamination (including air and surfaces)



Image Credit: NASA/JPL-Cattech

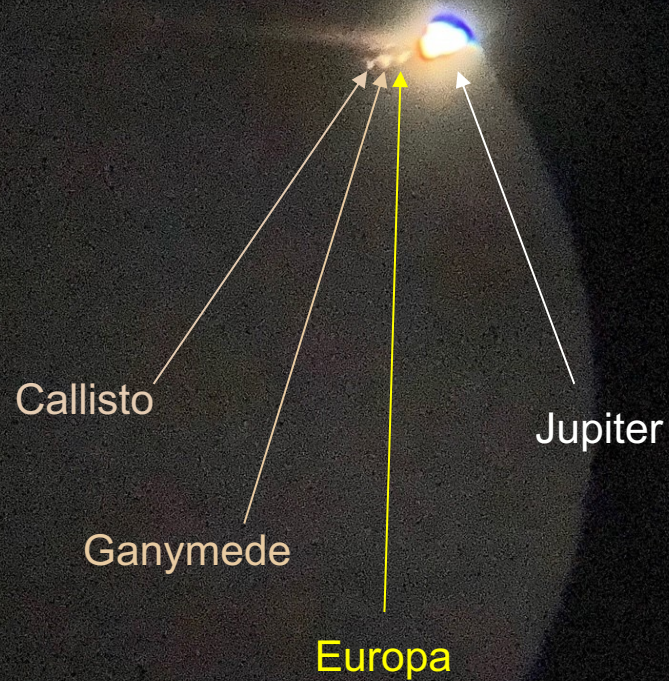
Summary:

- Planetary protection is important, albeit difficult
- MSFC (and NASA as a whole) takes seriously its commitment to meeting PP requirements
- Microbes are amazing!



Bacillus atrophaeus spores at 1000x magnification

Questions?



9.27.2021