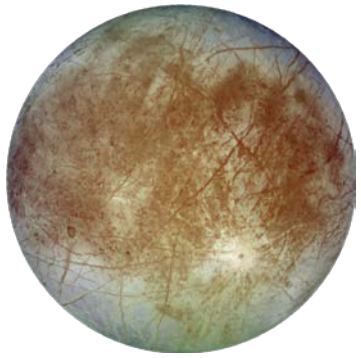
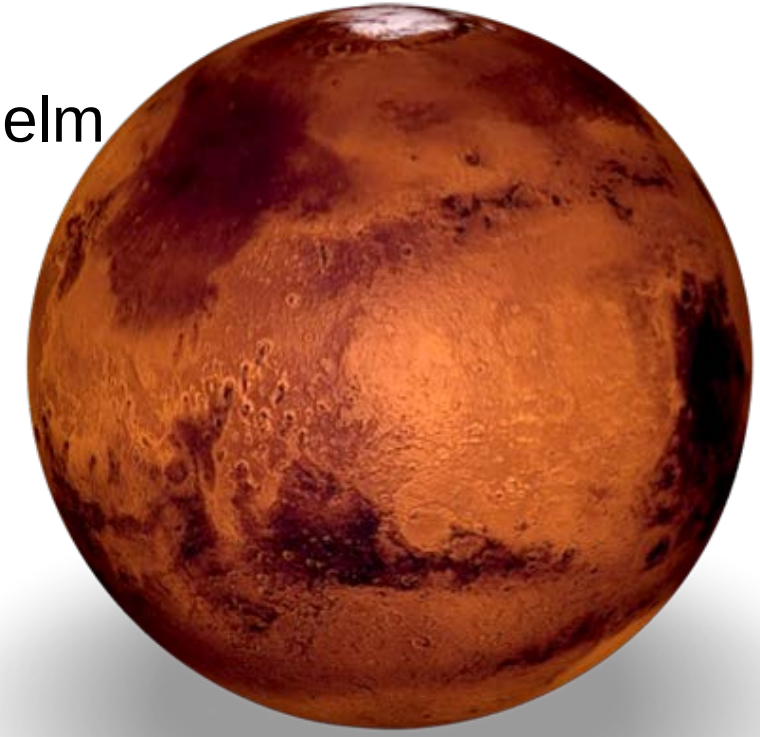


Lipid decontamination procedures for life detection missions

Denise Buckner, Mary Beth Wilhelm

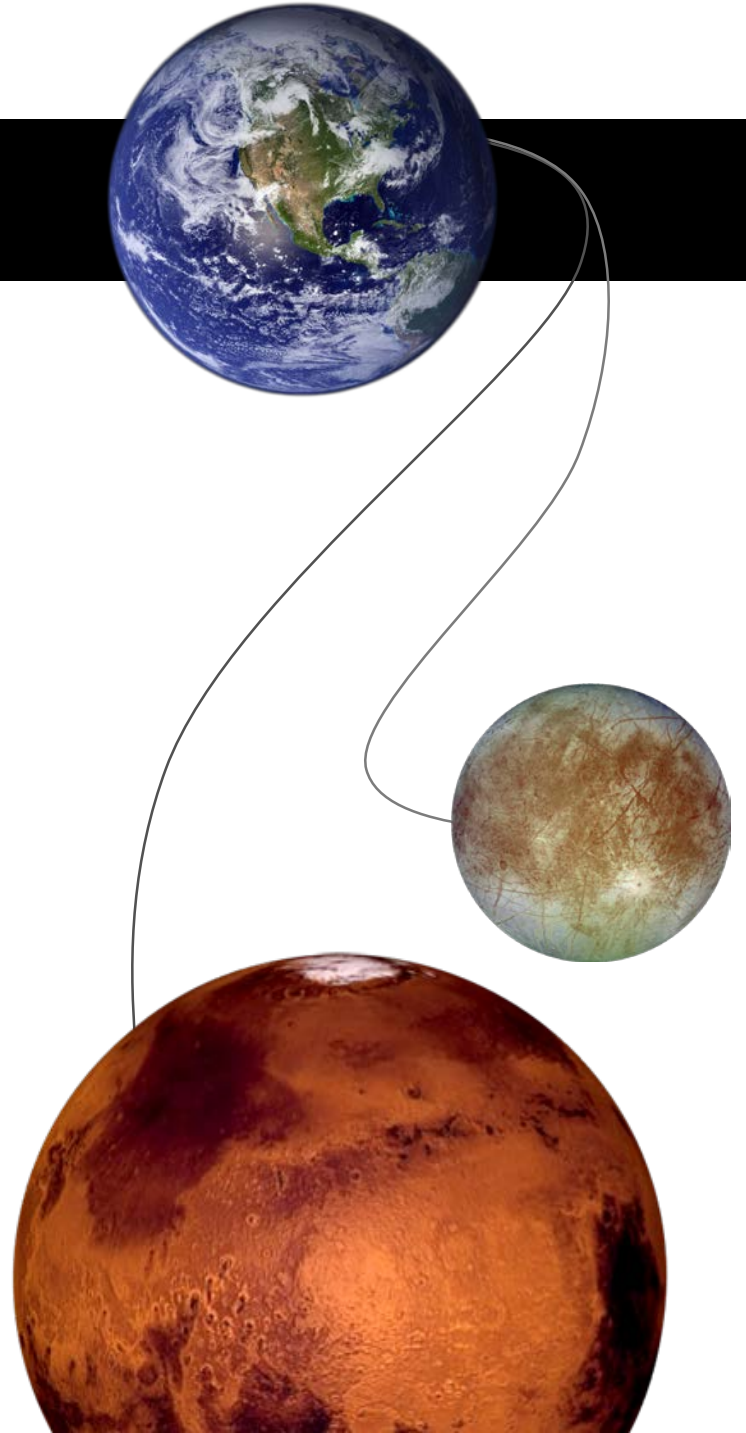


Blue Marble Space
Institute of Science

UND AEROSPACE
UNIVERSITY OF NORTH DAKOTA

Research Overview

1. Life detection search techniques
   - Biomarkers and lipids
   - Analytical instrumentation
2. ExCALiBR instrument concept
3. Contamination control
   - Current techniques
   - Experimental techniques
   - Effect on lipids
   - Instrument compatibility
4. Proposed solutions



Biomarkers

- What are biomarkers?
  - Molecules form **biotically**
  - Precursors can form **abiotically**
  - Chemically unique
  - Essential for life as we know it
  - Possible evidence for extraterrestrial life
- Lipids
  - Universal biomarkers
  - Protect cells from water
  - Can survive for billions of years in rock
  - Found in meteorites, etc

Figure 1: Murchison Meteorite

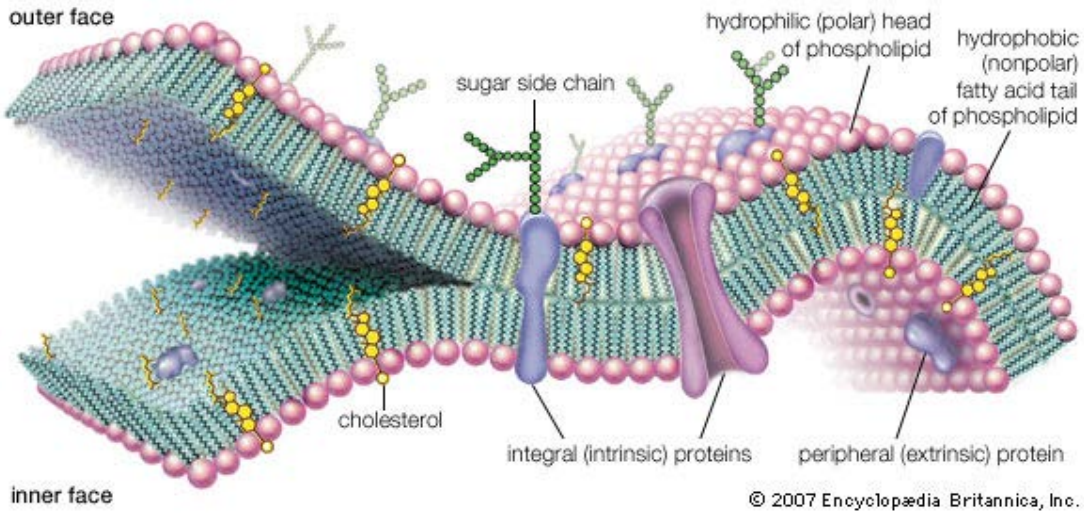
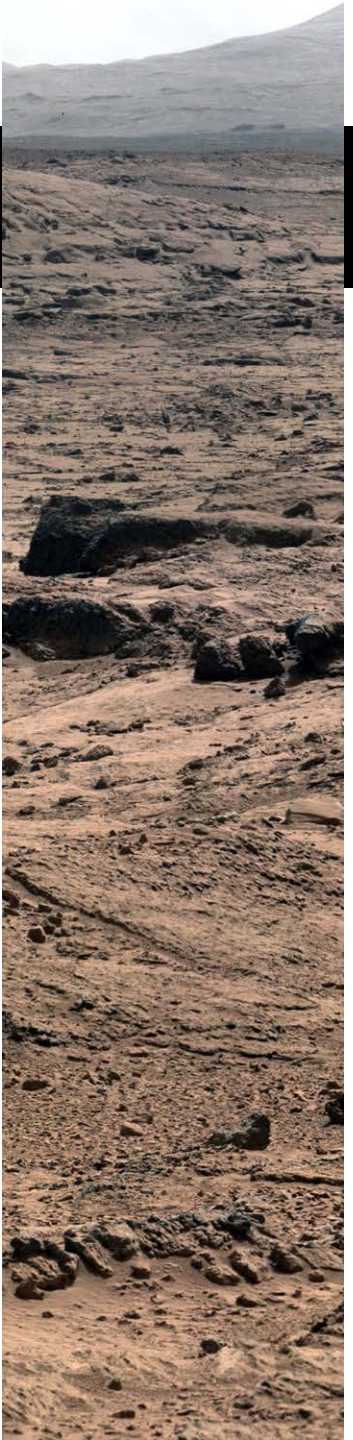


Figure 2: Cell membrane



Searching for biomarkers: ExCALiBR

- Extractor for Chemical Analysis of Lipid Biomarkers in Regolith
- Mars, Titan, Europa, Enceladus, etc
- **<u>Instrument capabilities</u>**
  - *Extracting* lipids
  - *Automating* laboratory processes
  - *Streamlining* sample handling
  - *Detecting* low concentrations
  - *Validating* results
- DECONTAMINATION IS KEY!

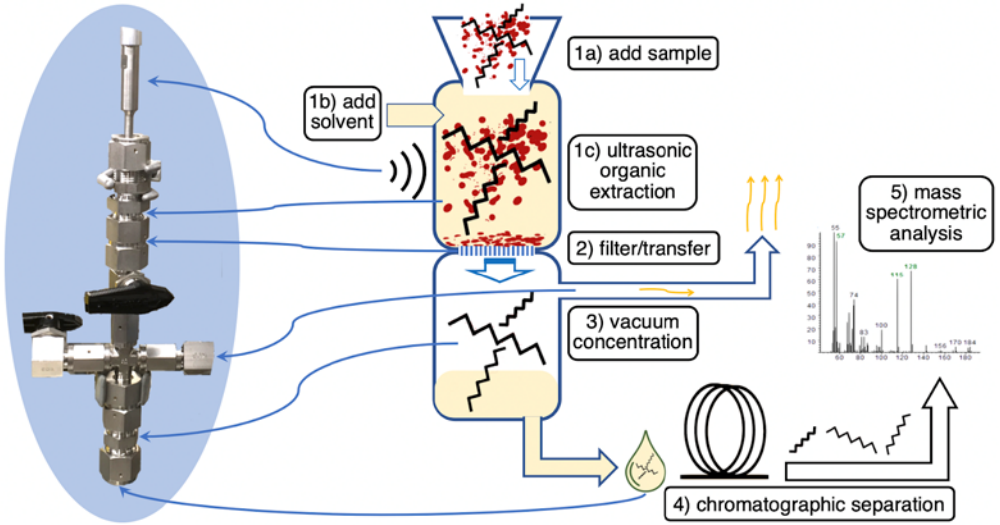


Figure 4: ExCALiBR prototype

Contamination in spacecraft cleanrooms

- Planetary Protection (PP) vs Contamination Control (CC)
  - <30 total surface spores
- Controlled, sterile environment
- Recent research: ***9-70x*** more microbes found
- Measured ***viable*** microbes:
  - 10^6 cells/m^2 (spacecraft surfaces)
  - $4*10^3$ gene copies/5 g (embedded)
- HOWEVER, ***4-8x*** as many dead cells as alive
- *Still meets planetary protection limits, but not clean enough to validate life detection results!*

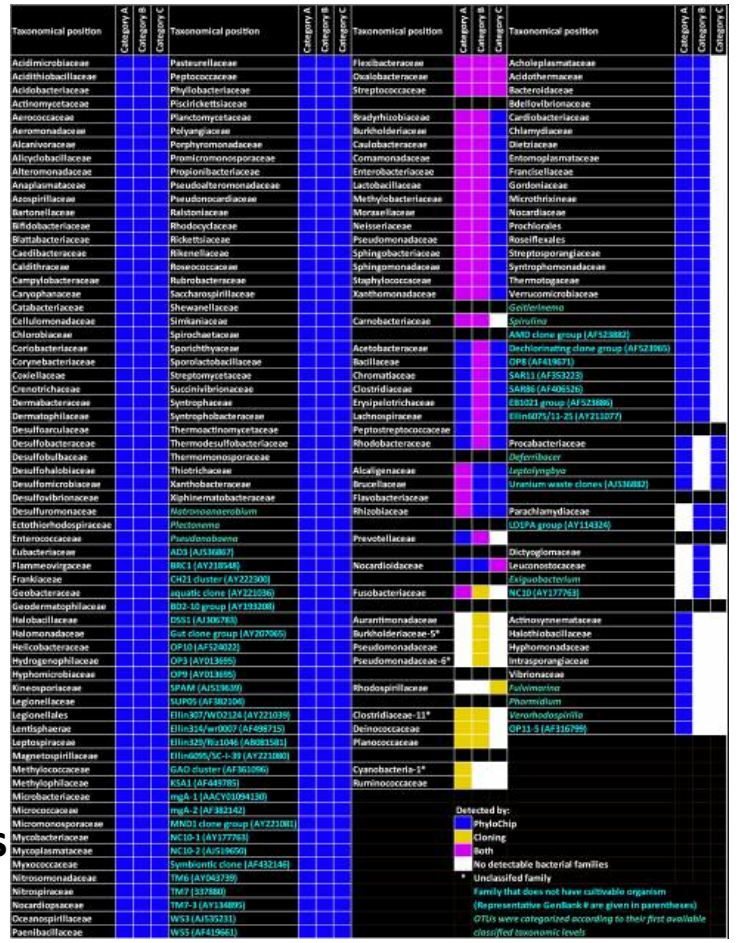


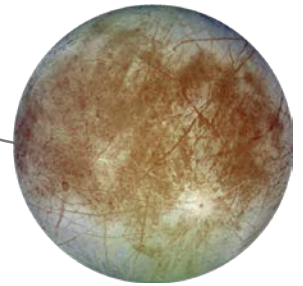
Figure 5: new species found

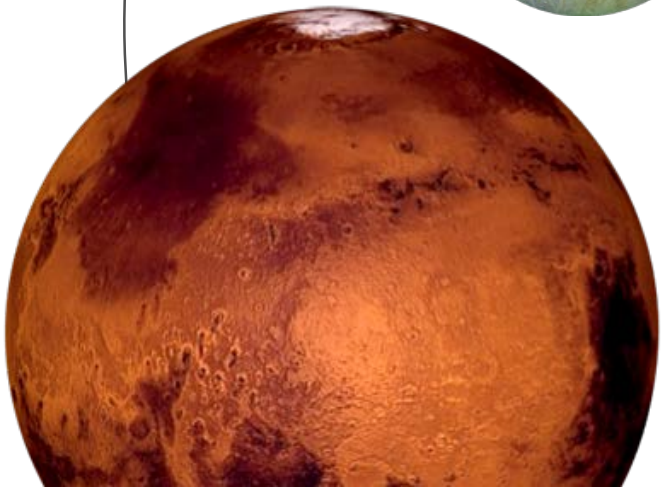
Current decontamination methods

- **<u>NASA-approved methods:</u>**
  - Dry heat microbial reduction
    - ***Kills*** microbes
  - Vapor phase H_2O_2
    - ***Kills*** microbes
- **<u>Cleanroom methods:</u>**
  - Protective clothing
    - ***Limits incoming*** contaminants
  - HEPA air filters:
    - ***Removes airborne*** contaminants
  - Wiping with water, detergent, alcohol:
    - ***Removes surface*** contamination
- **<u>Laboratory techniques:</u>**
  - Flushing with organic solvents
    - ***Removes*** contamination
  - Bake at 500° C
    - ***Destroys*** organic molecules

Figure 6: Spacecraft assembly cleanroom

Implications for lipid detection





- Living cells, dead cells, and pieces of cells **all contain lipids**
- Encapsulated contamination
  - Drawn out by the solvents used to extract lipids from soil
  - Can be released during atmospheric entry
- Ultra-low limit of detection
- Important to decontaminate **whole instrument after assembly** in the cleanroom
- *Killing microbes and washing contamination away is not enough- instead, break the molecules*

Proposed Solution: Electron Beam Irradiation

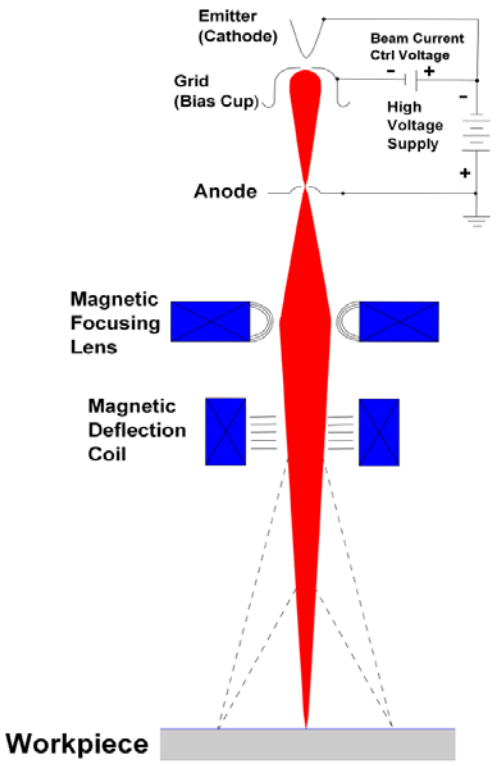


Figure 7: EBI

- ***<u>Concentrated dose</u>*** of ***<u>high energy electrons</u>***
- Used for food, medical, and wastewater CC
- Energetic enough to:
  - Kill microbes
  - Break down lipids
- Safe for many materials
- Machine generated: (SAFE, tunable, controllable dose, cheap, no radioactive material needed)

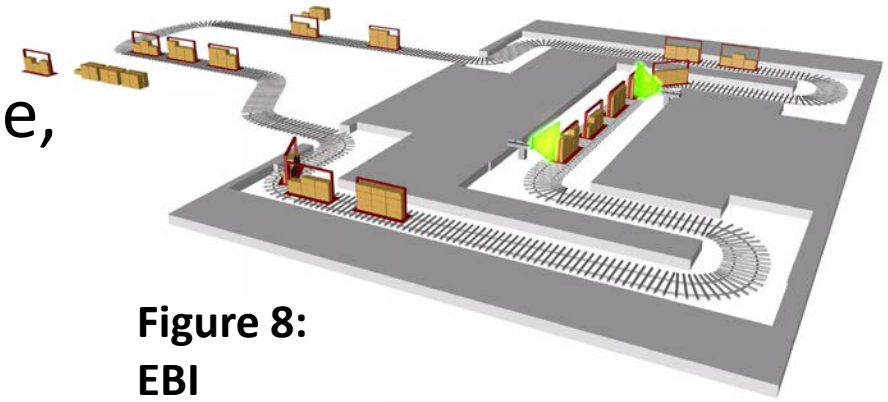
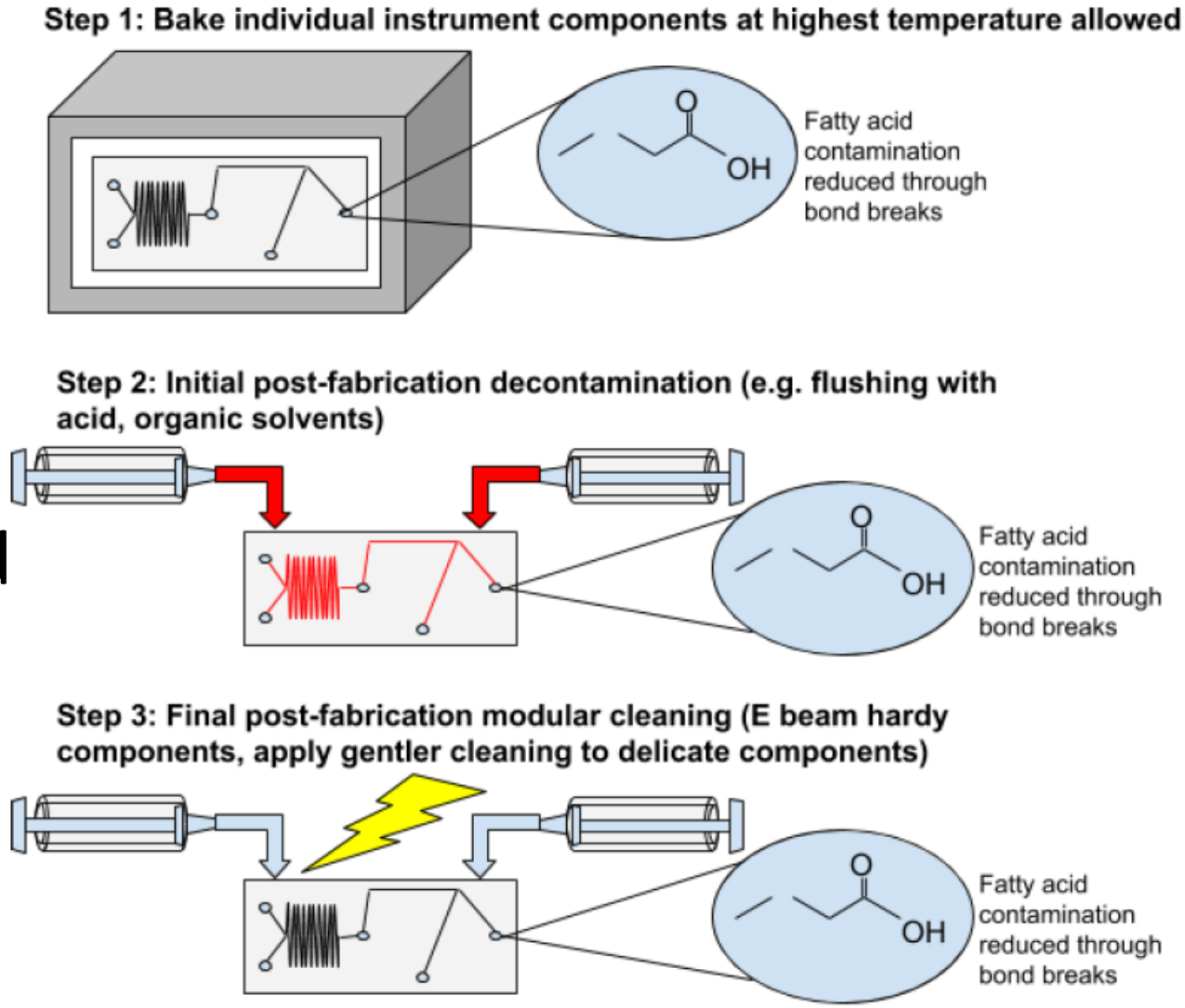


Figure 8: EBI facility

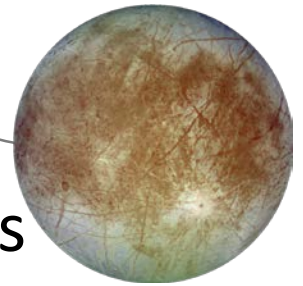
Goal

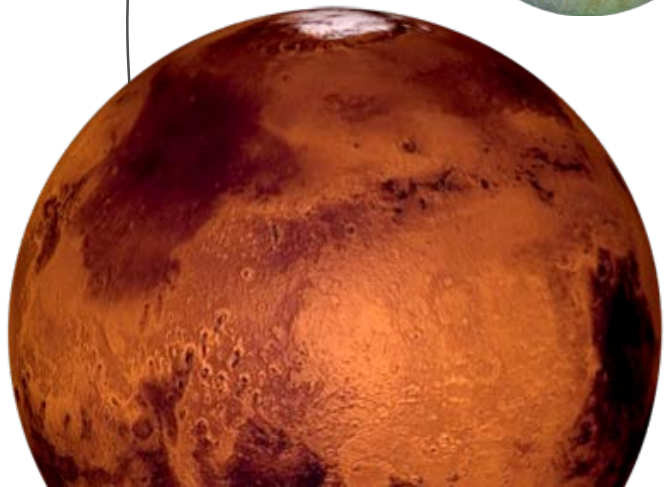
- Goal: Develop a whole-instrument decontamination plan for ExCALiBR that ***<u>eliminates lipid contamination</u>*** through molecular bond breaks instead of mechanically removing or flushing away contamination



Next steps

1. Quantify effects of NASA-approved, cleanroom, and lab decontamination techniques on lipids
2. Quantify effects of EBI on lipids
3. Determine material compatibility between EBI and ExCALiBR materials
4. Develop a whole- system CC plan to **<u>eliminate</u>** lipid contaminants by breaking molecular bonds





Thanks, References, Figures

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- NASA Ames Research Center
- University of North Dakota Department of Space Studies
- North Dakota Space Grant Consortium
- Dr. Mary Beth Wilhelm
- Sanjoy Som
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