

# Lipid decontamination procedures for life detection missions

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### **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 <u>biotically</u>
  - 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

#### Instrument capabilities

- *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</li>
- Controlled, sterile environment
- Recent research: <u>9-70x</u> more microbes found
- Measured *viable* microbes:
  - 10<sup>6</sup> cells/m<sup>2</sup> (spacecraft surfaces)
  - 4\*10<sup>3</sup> gene copies/5 g (embedded)
- HOWEVER, <u>4-8x</u> as many dead cells as alive
- Still meets planetary protection limits, but not clean enough to validate life detection <sup>Figure</sup> 5: new results!

Taxonomical position	Category A	Category B	Category C	Taxonomical position	Category A	Category B	Category C	Taxonomical position	Category A	Cotegory B	Category C	Taxonomical position	Category A	Cotegory B
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Aaromonadaceaa				Polyangiaceae			-	Buricholderiaceae				Chlamydiaceae		
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Bartonellaceae				Raistoniaceae		-	-	Moraxellaceae				Nocardiace.ive		
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Blattabacteriaceae				Rickettslaceae		⊢	-	Pseudomonadaceae				Roseiflexales		
Caedibacteraceae				Rikenellaceae		-	-	Sphingobacteriaceae				Streptosporangiaceae		
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Campylobacteraceae				Rubrobacteraceae		-	-	Staphylococceceae				Thermotogaceae		
Laryophanaceae	-			Saccharospinilaceae	-	+	-	tatthomonadaceae				vernucomicrobiaceae		
Catabacteriaceae			-	Shewanellaceae		+	-					Gettermento		
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Chloroblaceae	-		-	Spirochaeteorae		⊢	+					Amo clone group (Arszaniz)		
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Hydrogenophilaceae				OP3 (AY013695)				Pseudomonadaceae-6*				Intrasporangiaceae		
Hyphomicrobiaceae				OP9 (AV013695)								Vibrionaceae		
Kineosporiaceae				SPAM (AIS19639)				Rhodospinilaceae			1	Pulvimarina		
Legionellaceae				SUP05 (AF382104)			-					Phormidium		
Legionellales				Ellin307/WD2124 (AY221035)				Clostridiaceae-11*				Veromodospinilla		
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Leptospiraceae				Ellin329/Re1046 (AB081581)				Manococcaceae						
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Methylococcaceae				GAO duster (AF361096)				Cyanobacteria-1*		17.0				
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Mycobacteriaceae				NC10-1 (AY177763)						Clo	ning			
Mycoplasmataceae				NC10-2 (AJS19650)						Bot	h			
Myxococcaceae				Symbiontic clone (AF432146)						No	dete	ectable bacterial families		
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## Current decontamination methods

#### • <u>NASA-approved methods:</u>

- Dry heat microbial reduction
  - Kills microbes
- Vapor phase H<sub>2</sub>O<sub>2</sub>
  - Kills microbes

#### • Cleanroom methods:

- Protective clothing
  - Limits incoming contaminants
- HEPA air filters:
  - Removes airborne contaminants
- Wiping with water, detergent, alcohol:
  - Removes surface contamination

#### • Laboratory techniques:

- Flushing with organic solvents
  - *Removes* contamination
- Bake at 500° C
  - Destroys organic molecules



# 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 <u>whole instrument</u> <u>after assembly</u> in the cleanroom
- Killing microbes and washing contamination away

is not enough-instead, break the molecules



# Proposed Solution: Electron Beam Irradiation



Figure 7: EBI

#### **Concentrated dose** of *high energy electrons*

- 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)



### Goal

• Goal: Develop a wholeinstrument decontamination plan for ExCALiBR that eliminates lipid *contamination* through molecular bond breaks instead of mechanically removing or flushing away contamination

Step 1: Bake individual instrument components at highest temperature allowed



Step 2: Initial post-fabrication decontamination (e.g. flushing with acid, organic solvents)



Step 3: Final post-fabrication modular cleaning (E beam hardy components, apply gentler cleaning to delicate components)



### 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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