



Mars Astrobiology and Planetary Protection

- Life detection missions
- Site certification for human landing
- Human exploration

CoPP, 24 March 2021

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*My interest is in the search for life on Mars
- esp. a second genesis.*

Icebreaker Mission to Mars

- Assess the habitability of Mars ice-rich soils
- Search for organic biomolecules and patterns of biomolecules indicative of life.

Payload

Lander based on PHX -
InSIGHT (LMA)

Cameras (MSSS)

1 meter drill
(Honeybee/ARC)

Sample arm (Maxar)

WCL (Ames & JPL)

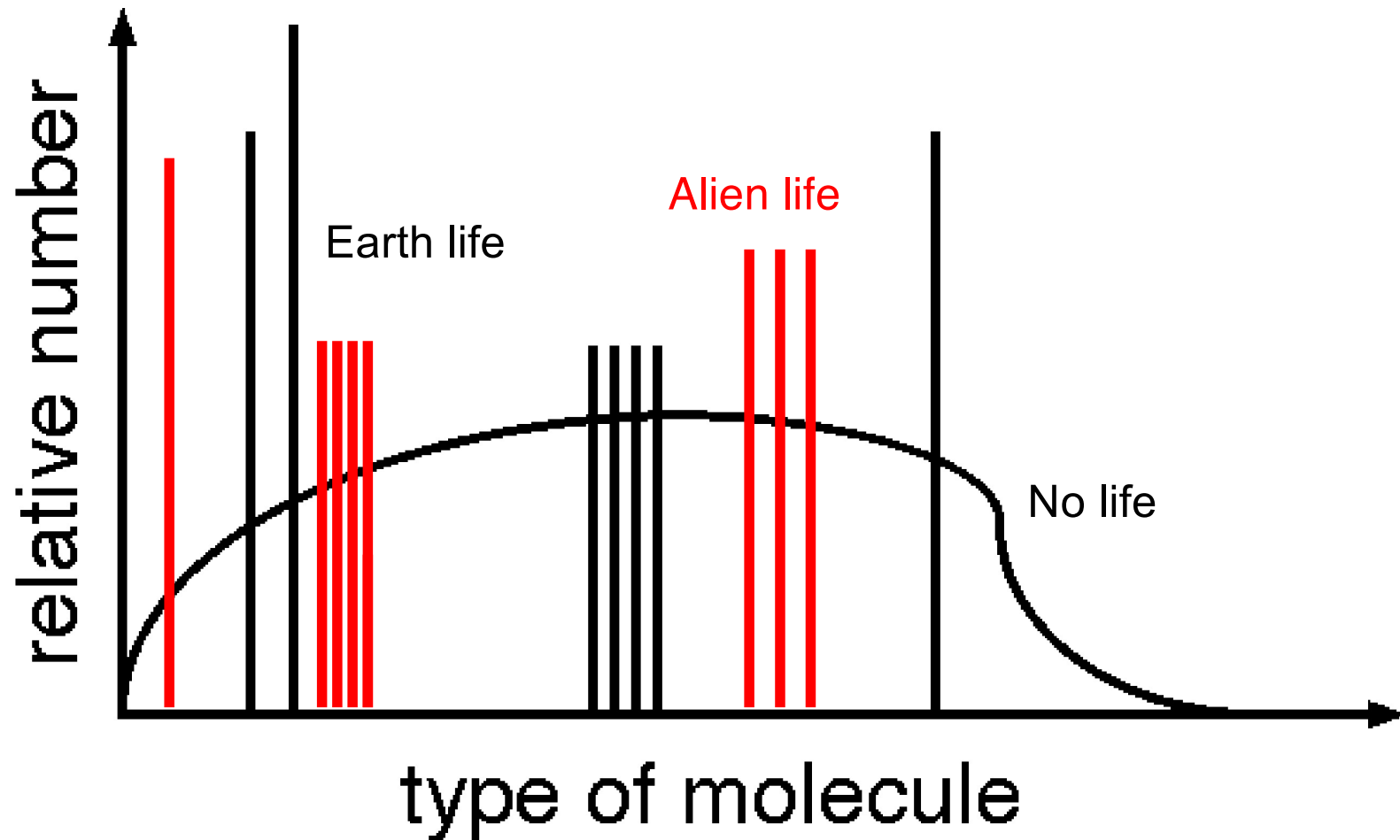
GCMS (Goddard)

SOLID (CAB Spain)



Search for biomarkers in ice-cemented ground with
Phoenix/Insight Lander . Discovery class mission.
PI: Chis McKay

Current approaches to life detection (including Icebreaker) are based on biomarkers not metabolism or growth. This alters contamination control and allows detection of a second genesis.



Icebreaker Science Approach

- **Land** in the polar regions at the start of summer, operate ~100 days.
- **Drill** 1 m deep to reach ice that may have been habitable ~5 Myr ago.
- **GCMS** (Gas Chromatograph Mass Spectrometer):
 - Patterns in amino acid abundance
 - Enantiomeric excess in amino acids
 - Patterns in fatty acid mass distribution
 - Patterns in the molecular structure of fatty acids
- **SOLID** (Signs of Life Detector):
 - Fluorescence sandwich immunoassay using hundreds of antibodies
 - Detects selected large molecular weight (up to 10^5 Da) compounds akin to those found in terrestrial organisms
 - Works even after exposure to ionizing radiation levels equivalent to >1 Myr beneath 1 m of Martian regolith
 - Focus on detecting peptides
- **WCL** (Wet Chemistry Lab):
 - Quantifies soluble aqueous components, including salts and oxidants. Characterizes energy sources and nutrients for life.

Planetary Protection (PI's perspective)

- Not a problem, our science requirements exceed the PPR requirements. Even for Special Regions.
- Tuned to Viking era methods of life detection which rely on metabolism and growth.
- Very short list of approved methods – typically not the methods of choice for our mission.
- No useful input to our mission, just a box checking exercise.

Planetary Protection (PI's desiderata)

- Provide an independent technical authority on contamination control and life detection
- Funded by HQ, not in the PI-managed cost cap
- PPR individual assigned to the mission as CO-I
- Focus on whatever state-of-the-art methods work best to prevent false positives and false negatives for each instrument on our mission



Life Detection in Advance of Human Return Missions to Mars: a Requirement of the Outer Space Treaty

Nov 2018

Debate on Mars Exploration and Research in Sweden

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Article IX: Outer Space Treaty

“States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.”

- This is the basis for COSPAR regulations
- Sample returns from beyond the Moon (Stardust, Genesis, Hayabusa) were unrestricted.
- Sample return from Mars would be restricted.
- Human return from Mars would be a restricted sample return.
- In the USA compliance with Treaties has the force of Federal Law on all US entities including private space companies (by the Supremacy Clause of the Constitution.)



Can we assume no life on Mars?

- The relevant data are:
 - Viking Biology Experiments (GEx and LR) - 1976
 - Phoenix discovery of perchlorate - 2007
 - MSL organic analysis - 2015
- Most Mars scientists hold the view that the reactivity seen in the Martian soil is chemical and no biology is present.
- This view is not unanimous, see Levin, G.V. and Straat, P.A., 2016. The case for extant life on Mars and its possible detection by the Viking labeled release experiment. *Astrobiology* **16**, 798-810.
- NASA and COSPAR both consider sample return from Mars as a potential biological risk.
- It is unlikely that public opinion or legal procedures will support an assumption of no life on Mars for the purposes of astronaut return to Earth without further analyses on Mars.



Life Detection for Human Return: BioSafe

- Plan on In-situ life detection to demonstrate lack of biology at the human landing site for compliance with the Outer Space Treaty.
- We propose a payload adapted from the Icebreaker Mars mission concept:
- Samples from the surface and subsurface (1 to 10 m drill) and collected by fetch rovers.
- Instrument suite
 - GCMS (similar to SAM) to detect amino acids and lipids
 - Micro-capillary electrophoresis for amino acid detection
 - Wet chemistry laboratory (from Phoenix)
 - SOLID immunoassay detection of small chain and complex organic molecules.
- A “lack-of-life” result would show amino acids and lipids but only as expected from meteoritic input.

Human exploration could be a key advance in the search for life on Mars, and in fact may be required.



Image: pia23302-nasa

**Don't send humans
because they will
contaminate Mars before
we have a chance to
determine if it has life
and its potential for life**

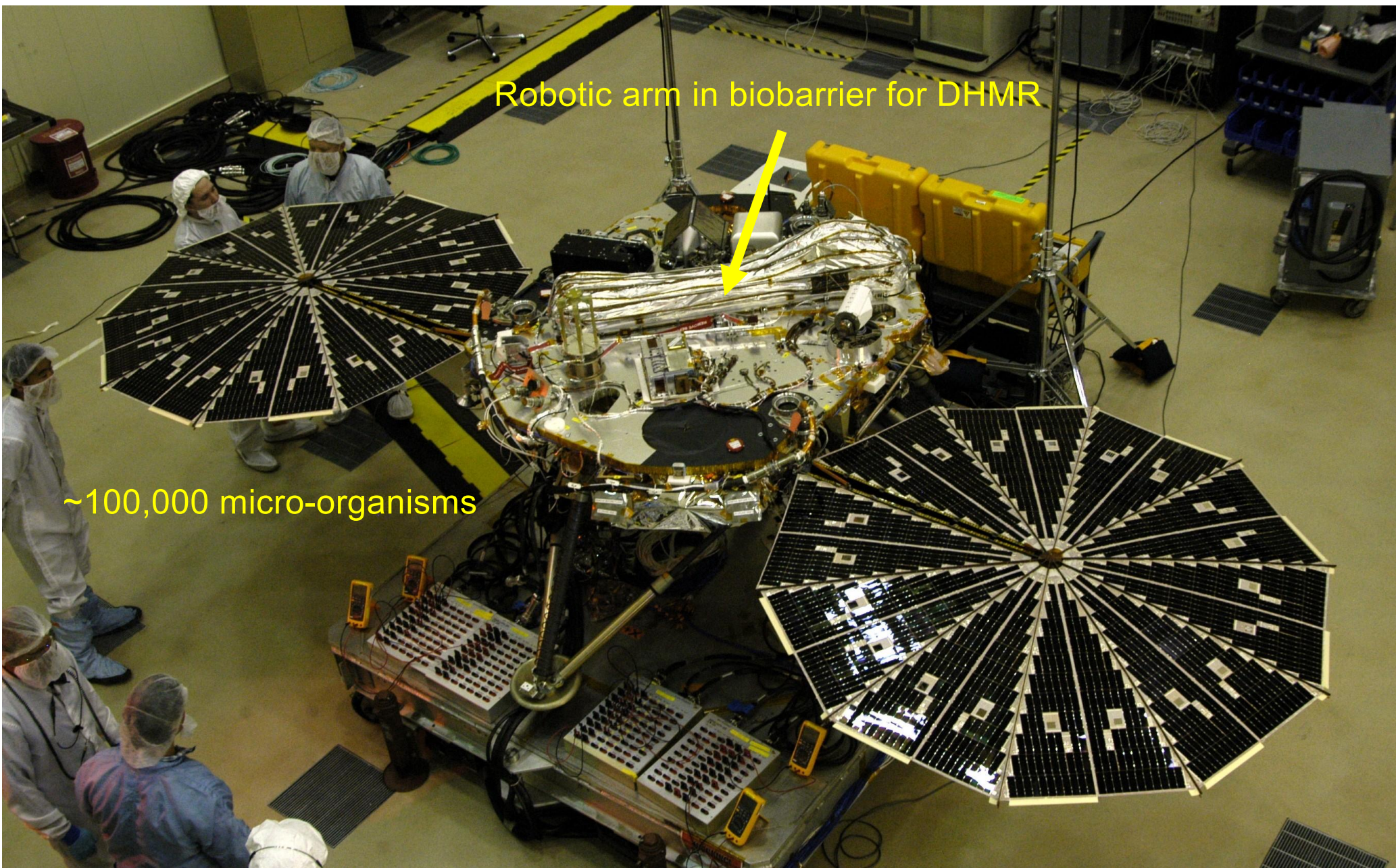


This is an exaggeration

**We've already
contaminated Mars**



Phoenix Mission to Mars into a Special Region: May 2008 to Nov 2008



“Biologically Reversible Exploration”

- Make biological reversibility the basis of planetary protection
 - The difficulty of clean up is linear not exponential.
- Not much change for current robotic missions
- Provides a basis extendable to human exploration
- Preserves future options at reasonable cost related to restoration ecology on Mars
- Track all landing sites and pieces on Mars.
- Design in the use of UV sterilization on Mars.
- Drilling or subsurface exploration must be rigorously sterile.

McKay, C.P., 2009. Biologically reversible exploration. *Science*, 323, 718.



Biologically Reversible in Antarctica, not in Australia

Human exploration could be Biologically Reversible.



Image: pia23302-nasa