Detection of the Biohazards of Living Martian Organisms

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Introduction

- Over the last 20 years there have been significant steps to create a system, which allows researchers to study Martian samples that are returned to Earth while accurately assessing the presence of biohazards.
- A draft test protocol developed in 2002 provides steps to assess the biohazards of possible living Martian organisms returned from Mars missions [1].
- Following the release of this document, NASA published an article that outlined plans for a Mars Sample Receiving Facility [2].
- However, the protocol has not been re-evaluated since 2002, despite advances in technology and biology since then [3].
- In addition, the developed plans for a Mars Sample Receiving Facility require development in specific areas in the future [2].
- Our objective was to analyze the approach taken to detect biohazards of living Martian organisms.

"BIOHAZARD" TESTING
(Minimal Assumptions
& Regulatory Requirements)
CHALLENGE TESTING ON
EARTH ORGANISMS
- Functional Anomalies
- Pathological Indications
- Null Testing/Dead Mars (Toxicology?)
- *In Vivo* vs. *In Vitro* Testing
- How Many Phyla?
- Ecosystem Testing?

Figure 1: Summary of biohazard testing techniques reproduced from Rummel et al. (2002)

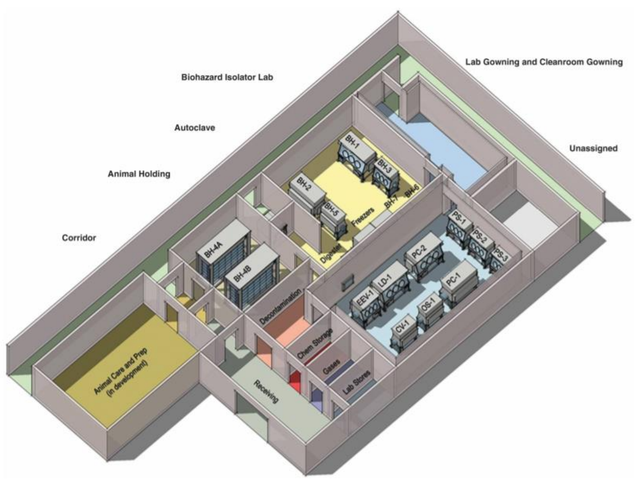

Figure 2: The Mars Sample Receiving Facility floor plan proposed by the Industrial Design and Construction group, reproduced from Beaty et al. (2009)

Analysis

- Biohazard testing in draft protocol included genetic, molecular, pathogenicity, and biological tests [1].
- Other tests include exposing Martian samples to unicellular or multicellular terrestrial organisms and introducing the samples to terrestrial ecosystems [1].
- The goal of these tests was to examine the effect that unfamiliar living Martian organisms had on terrestrial biological systems [1].
- However, the protocol only included general guidelines for testing.
- Rummel et al. suggested enforcing fixed guidelines only in the final protocol to account for evolving practices within toxicogenomics [1].
- Indeed, development in artificial intelligence and machine learning may potentially influence this field in the near future [4].
- Molecular and cellular tests have replaced the need for plant and animal in-vivo testing, however, it is still required as per the protocol [2].
- This makes it more difficult to plan a Mars Sample Receiving facility [2].

- As presented by Beaty et al., three groups created different designs for a Mars Sample Receiving Facility: The Flad and Associates (FLAD) group, the Lord, Aeck, Sargent (LAS) group, and the Industrial Design and Construction (IDC) group [2].
- These groups operated independently of one another, and each had a different area to test for biohazards depending on the design of the Sample Receiving Facility [2].

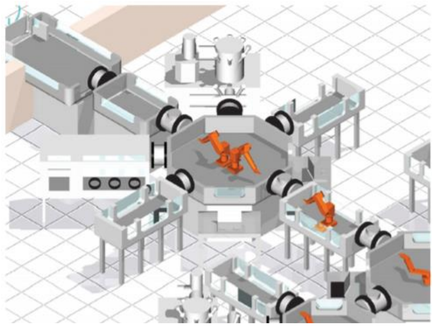

Figure 3: The Mars Sample Receiving Facility floor plan proposed by the Lord, Aeck, Sargent group, reproduced from Beaty et al. (2009)

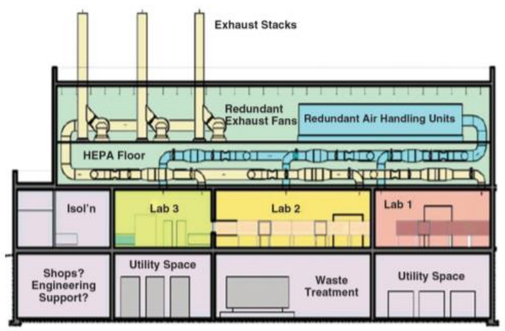

Figure 4: The Mars Sample Receiving Facility plan proposed by the Flad and Associates group, reproduced from Beaty et al. (2009)

- However, specific methods to test for biohazards were not included in the plans.
- The three plans also required development in a couple of areas, including: Sample preservation, equipment for sample analysis, robotics, and techniques for decontamination [2].

Recommendations

- The draft protocol should be reviewed to account for technological and biological advancements, as well as development in the field of toxicogenomics.
- The review should also include the implementation of specific biohazard testing techniques that are in accordance with modern technologies and techniques.
- The new protocol will allow NASA to implement simpler techniques of biohazard testing within the Mars Sample Receiving Facility plans [2].
- These changes will be applicable to planning a Mars Sample Return Mission, as well as detecting biohazards in Martian meteorites.

Conclusions

- The draft protocol and plans for a Mars Sample Receiving Facility provide a good review of biohazard testing and can be revised to provide more specific methods to test living Martian organisms.
- By accounting for the advancements in biology and technology since 2002, more detailed plans can be implemented to test for biohazards and preserve the Earth's biodiversity.

References

[1] Rummel J.D. et al. 2002. NASA/CP-2002-211842.
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