

# A VISION FOR EXPLORATION FOR LIFE-- SYNTHESIS

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# Summary of the Vision

- Search for life will require engaging researchers and including results and expertise from many “non-life” fields, missions that explicitly search for life will also make gains in broad fields (and across targets). Most planetary science has its own intrinsic value, while also informing the evolution of habitable environments and the co-evolution of life and its host planet/star.
- Work towards an operational (vs complete) definition of life, applicable across different targets/environments and responsive to discovery
- Study complexities of habitability through time – system approach, processes, stability
- Planetary protection policy that continues to be iteratively responsive to research/discovery

## Other (not life-specific)

- Improve propulsion/power/communication/mobility/sample return technologies
- Continue workforce development – target entry-level missions (e.g. cubesats, instrument), data analysis, sustained predictable support, engagement, diversity
- Consider our research and planetary protection in the context of human exploration

# Primary Targets

- Exoplanets
- Icy/Ocean Worlds (Europa, Enceladus, etc.)
- Mars
- Ceres? Venus? Triton? (these came up in discussion or later sessions)
- Terrestrial Analogues (across space and time)

# Potential 2050 Vision

- Some progress on all targets
- Major progress on one (or one of each)
- Different targets help us understand different parts of the definition of life and habitability questions
- Moon as target for early Earth investigations (cryo)
- How do you get to certain types of extreme life from prebiotic chemistry (e.g. atmospheric floaters)

## Mission Approaches to Life Detection

- Astronomy [exoplanets]
- Remote sensing [orbital, flyby]
- *In situ* instrumentation on/under/near the surface
- Sample Return to Earth

## Potential 2050 Vision

- Need to look for extant life, in addition to past life
- Look for system approach to life (plus it gets you addnl science), understanding complexity of habitability over time
- Risk vs. cost vs. time for different types of exploration (currently very risk-averse)
- If/when we find life, then what do we do?

## Technology

### Development

- Propulsion/launch technology (not paved exclusively with rockets)
- Power/comms/computing/EDL
- Scalable robotic systems: Lander/rover access, mobility and robustness
- Sampling: tools, systems, encapsulation and return
- (stability)
- Instrumentation (signal detection, noise rejection, new detectors, new vantage points)
- Systems engineering/payload challenges to obtain required environmental context

## Potential 2050 Vision

- Multi-decade Tech Dev plan
- Multiple sample return
- Subsurface access
- Multiple investigations with single sample
- MORE resources for NEW technologies

# Modeling/Research Efforts

- Exoplanet, Earth and Mars environmental/climate modeling
  - observability
  - remote sensing
  - past habitability
  - models validated across targets
  - requires cross-divisional expertise
- Weather prediction tied to current climate and rare phenomena
- Subsurface/surface energetics and interactions
- Terrestrial analog work (habitability and biosignature preservation)

# Potential 2050 Vision

- Periodic table of life
  - DEFINITION of life (to understand from only one element or column is impossible)
  - Vs operational definition
  - Negative? Theory of “Dead”
- Understanding stability of habitable bodies/environments

## Human Exploration

[currently limited to Mars]

- What benefits to Exploration for Life? What costs relative to robotic exploration?
- What to do? and For how long?
- How much do we need to know ahead of time?

## Potential 2050 Vision

- Significant HEOMD/SMD partnerships – including in-space construction

## Planetary Protection/ Contamination Control

- Further community engagement in process of setting requirements
- Investment into designs and methods
  - Forward CC
  - Reverse PP
- Hazard determination protocol complementary to scientific objectives

## Potential 2050 Vision

- Contamination recognition (false positives)? Or false negatives
  - If overwhelmed by abiogenic molecules, how do you look find biogenic ones
- Moon opportunity to start exploring these methodology
- Further study of the life on Earth
- Planetary protection policy that continues to be iteratively responsive to research/discovery