

Understanding Planetary Habitability

**Where Does Life Exist Beyond Earth
and How Can We Find It?**

Summer 2018 Pop-Up Institute

A joint effort of:

Dept. of Astronomy
McDonald Observatory
Dept. of Geological Sciences
Institute for Geophysics
Dept. of Molecular Biosciences

Dept. of Integrative Biology
Dept. of Aerospace Engineering
Dept. of Civil Engineering
Center for Space Research
Vice President for Research

Where Does Life Exist Beyond Earth and How Can We Find It?

- Life probably originated very early in the history of Earth.
- Habitable environments may exist on Mars, Europa and Enceladus in our solar system, and on many planets orbiting nearby stars.
- What physical conditions does life require to start and to flourish?
- Where should we look for life beyond Earth?
- How will we recognize it when we find it?

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Pop-Up Institute Goals:

1. Convene world experts on the topics of origins of life, planetary dynamics and habitability and how to find and recognize life.
2. Identify the most important questions in these research areas.
3. Develop long-range plans for a coordinated campus-wide research effort in planetary habitability.
4. Draft proposals for significant external funding of this research effort through NASA, NSF, or private foundations.
5. Explore possible international collaborations with aligned initiatives in other countries.

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Pop-Up Institute Meeting Format:

- Meet on Tuesday, Wednesday, Thursday for 6 weeks in June and July 2018.
- The first 4 weeks will feature presentations from external and UT experts.
 - These will be in the form of extended interactive discussions.
 - We will encourage significant informal and unstructured discussion.
 - The first two weeks will be centered at the Pickle Campus, and the rest of the Institute will be on the main UT Campus.
- The final two weeks will concentrate on development and implementation of long-range UT plans for interdisciplinary research on planetary habitability.

Understanding Planetary Habitability Schedule

june

2018

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
28 May	29	30	31	1 June	2/3
4	5	6	7	8	9/10
11	Origins of Life			15	16/17
18	Planetary Dynamics			22	23/24
25	Planet Habitability			29	30/1 July
2	3	4	5	6	7/8

july

2018

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
25 June	26	27	28	29	30/1 July
2	3	4	5	6	7/8
9	How to Find and Recognize Life			13	14/15
16	Next Steps			20	21/22
23	Focus on Implementation			27	28/29
30	31	1 August	2	3	4/5

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Pop-Up Institute Meeting Format:

- Each week will feature 2-3 external “keynote” speakers. We are now in the process of finalizing these speakers, so please let us know if there are particular people you want!
- There will also be presentations by internal UT people, as well as some number of panels, discussions, and unstructured break-out groups. Many of these will be designed to bring everybody “up to speed” on topics.
- We will allow plenty of time for informal interactions and social events.

Week 1. Origin of Life

Organizers: Sean Gulick (Jackson School of Geosci.) & David Hoffman (College of Natural Sci).; June 12-14

The origin of life is an unsolved problem.

Where and how did life originate?

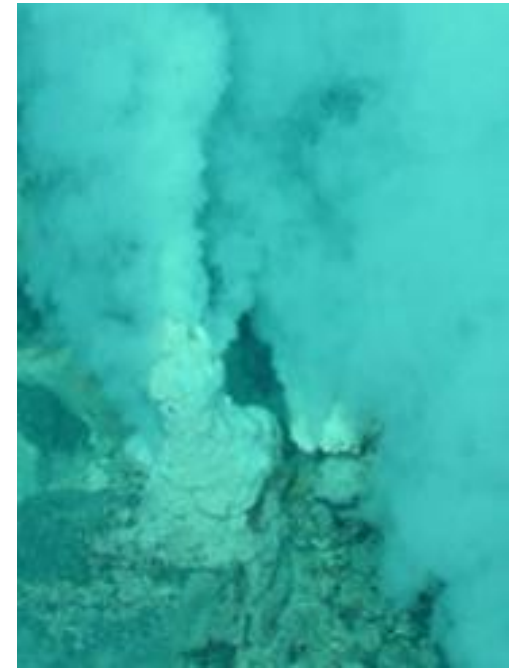
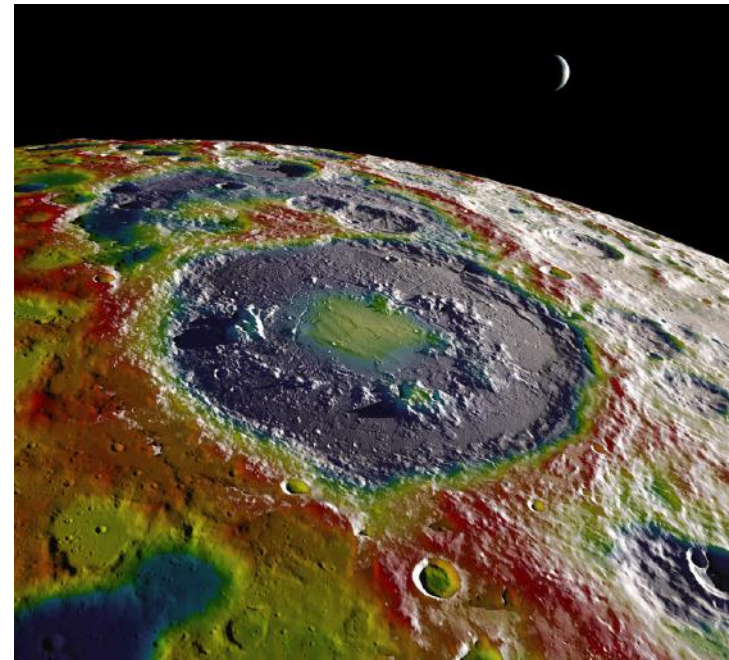
Hypotheses- Mid-ocean ridges, hot springs, and impact craters

How are precursors for life produced, and where are they found?

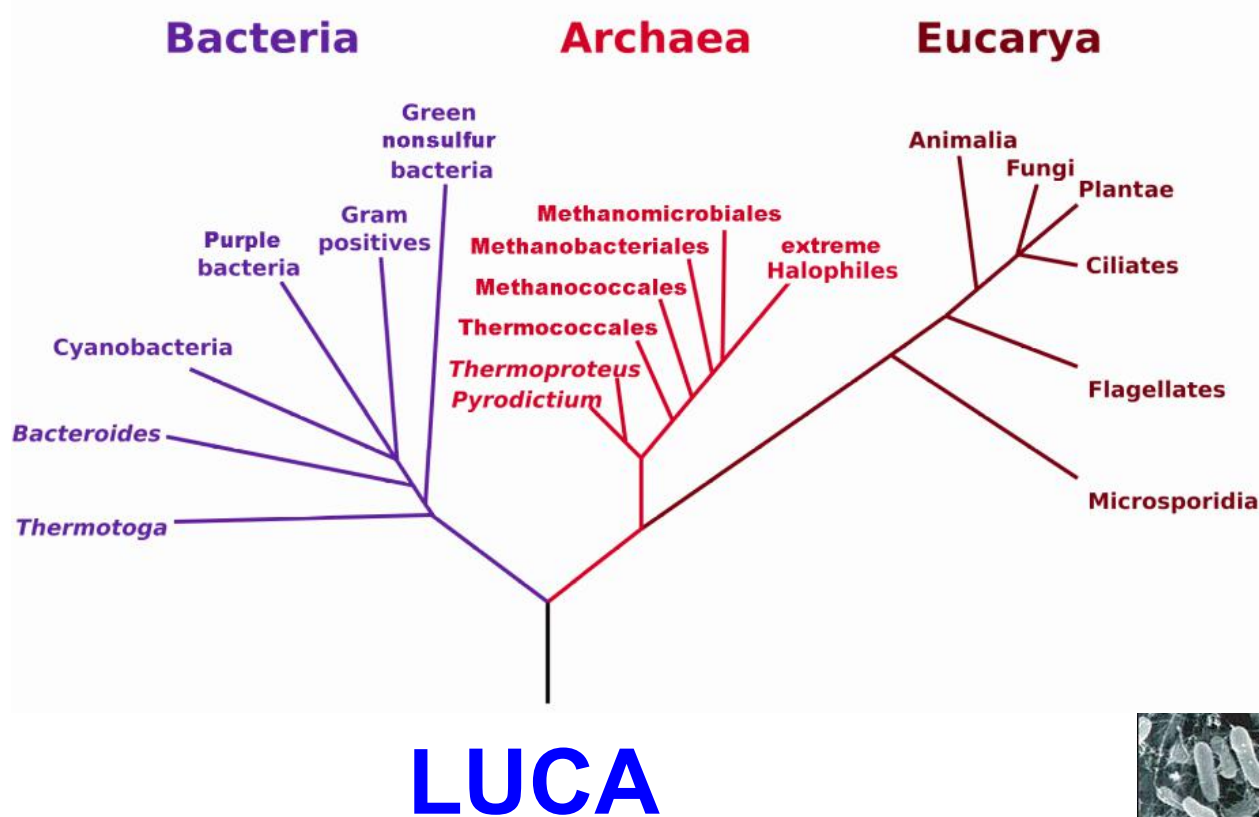
How does abiotic chemistry make the transition to a system that can replicate and evolve?



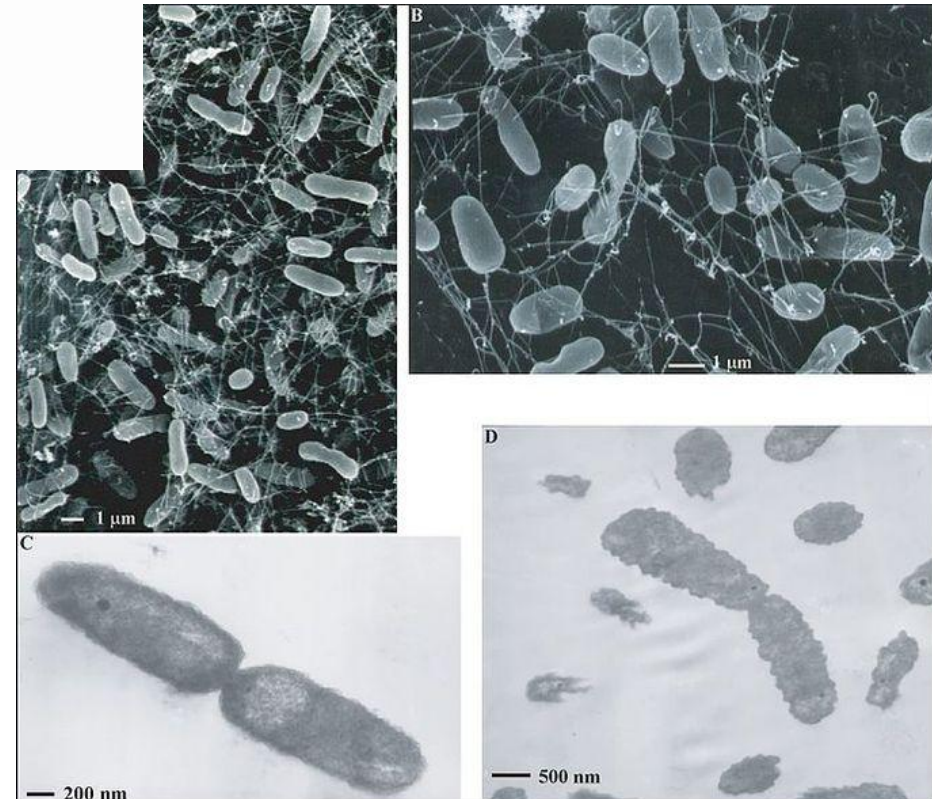
Is panspermia possible?



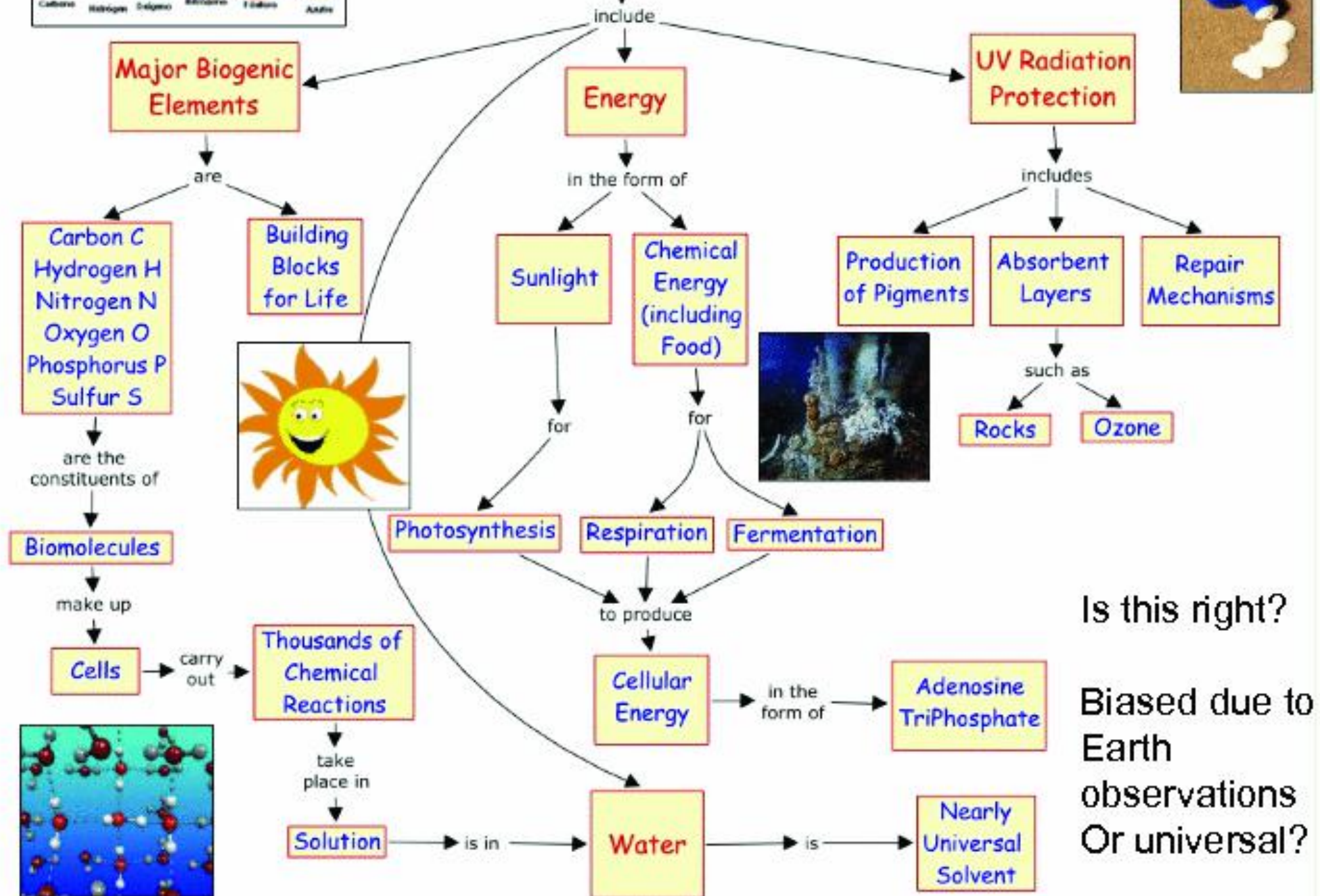
Do the genes present in all branches of life provide clues about the habitat and metabolism of the Last Universal Common Ancestor (LUCA)?



Latest research suggest LUCA was a thermophilic autotroph (e.g. Weiss et al., 2016; Nature Microbiology)



Essential Requirements for Life



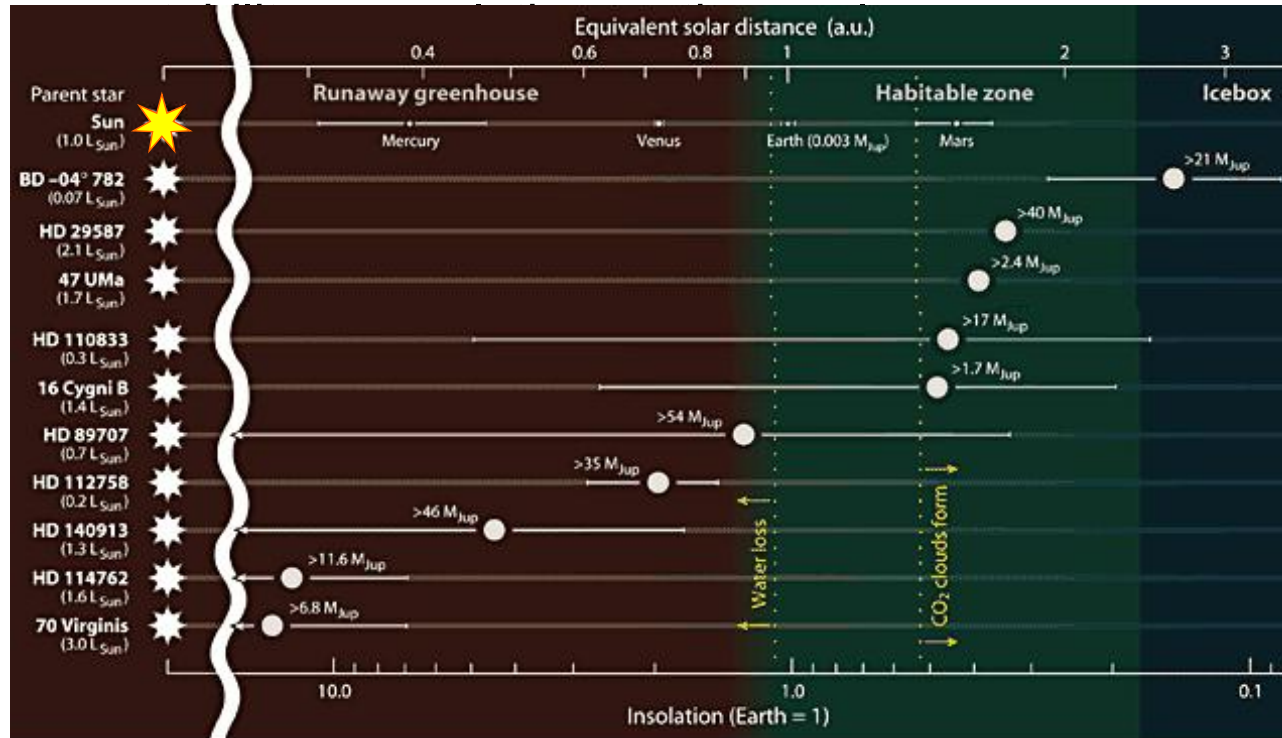
Is this right?

Biased due to Earth observations
Or universal?

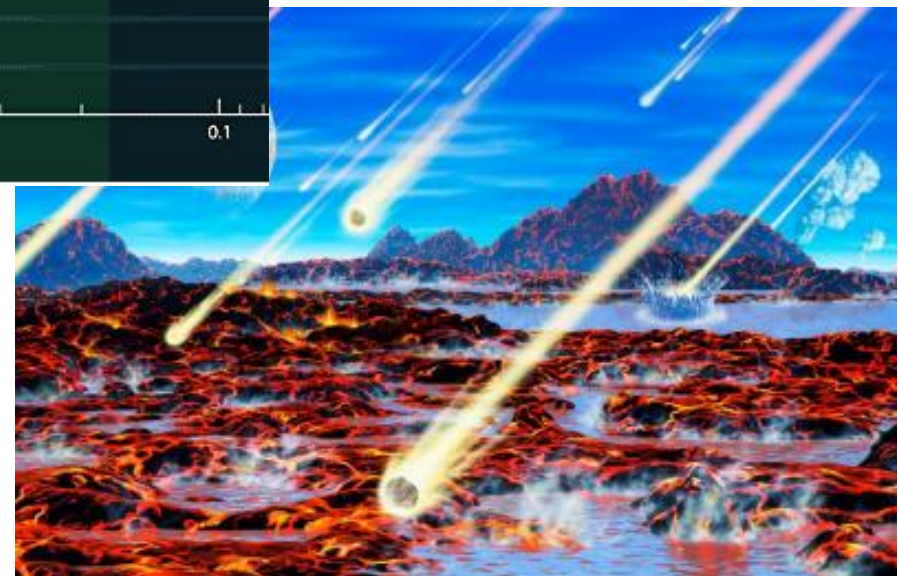
Week 2 – Planetary dynamics June 19-21

Organizers: Mark Hesse, Jackson School of Geosciences
Judit Györgyey Ries, McDonald Observatory

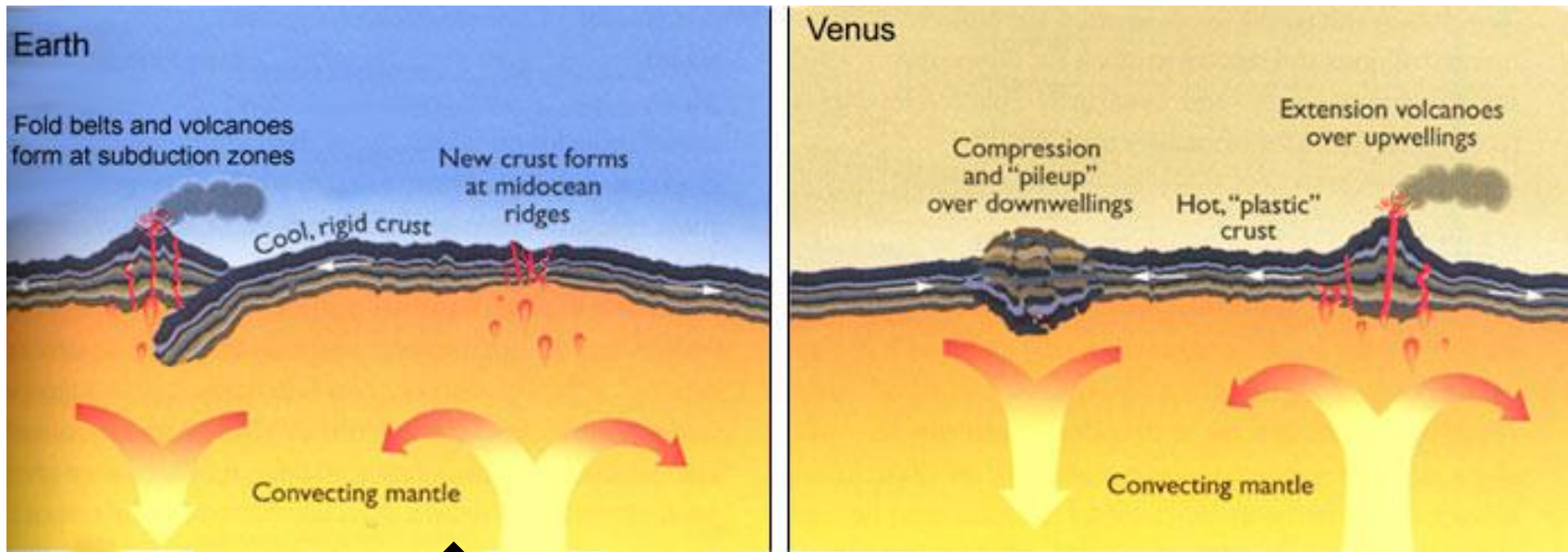
- Architecture of planetary systems – stability, frequency of impacts



- Role of impacts
 - extinction,
 - delivery of water, organics
 - starting plate tectonics

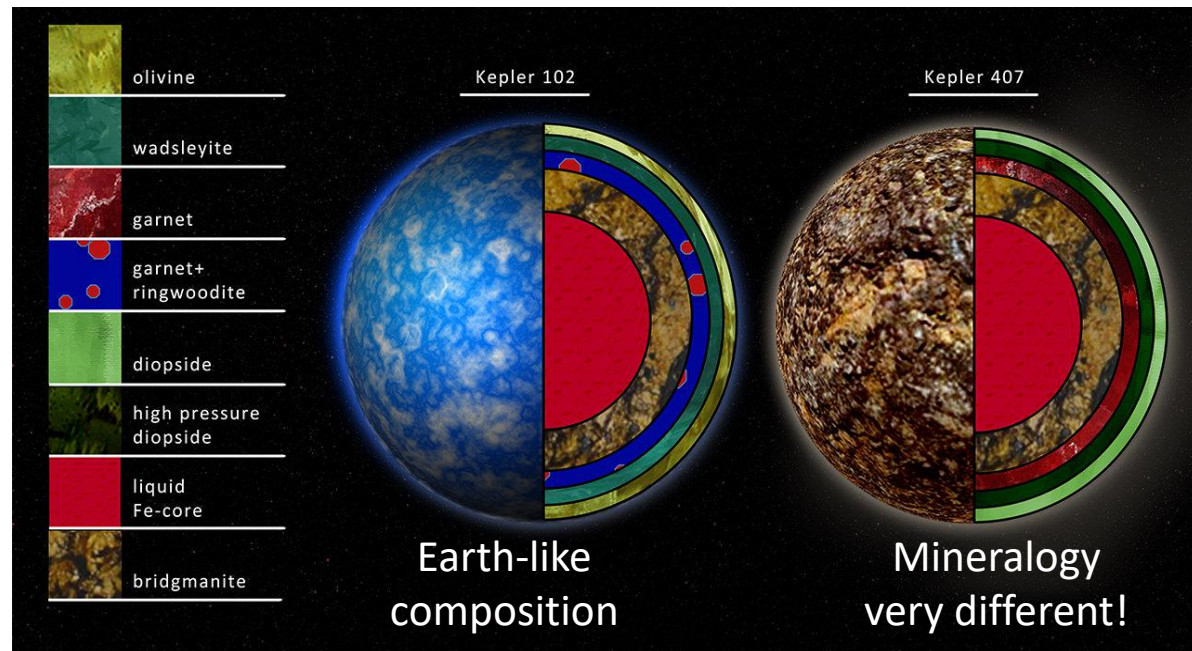


In the habitable zone - Life on the surface

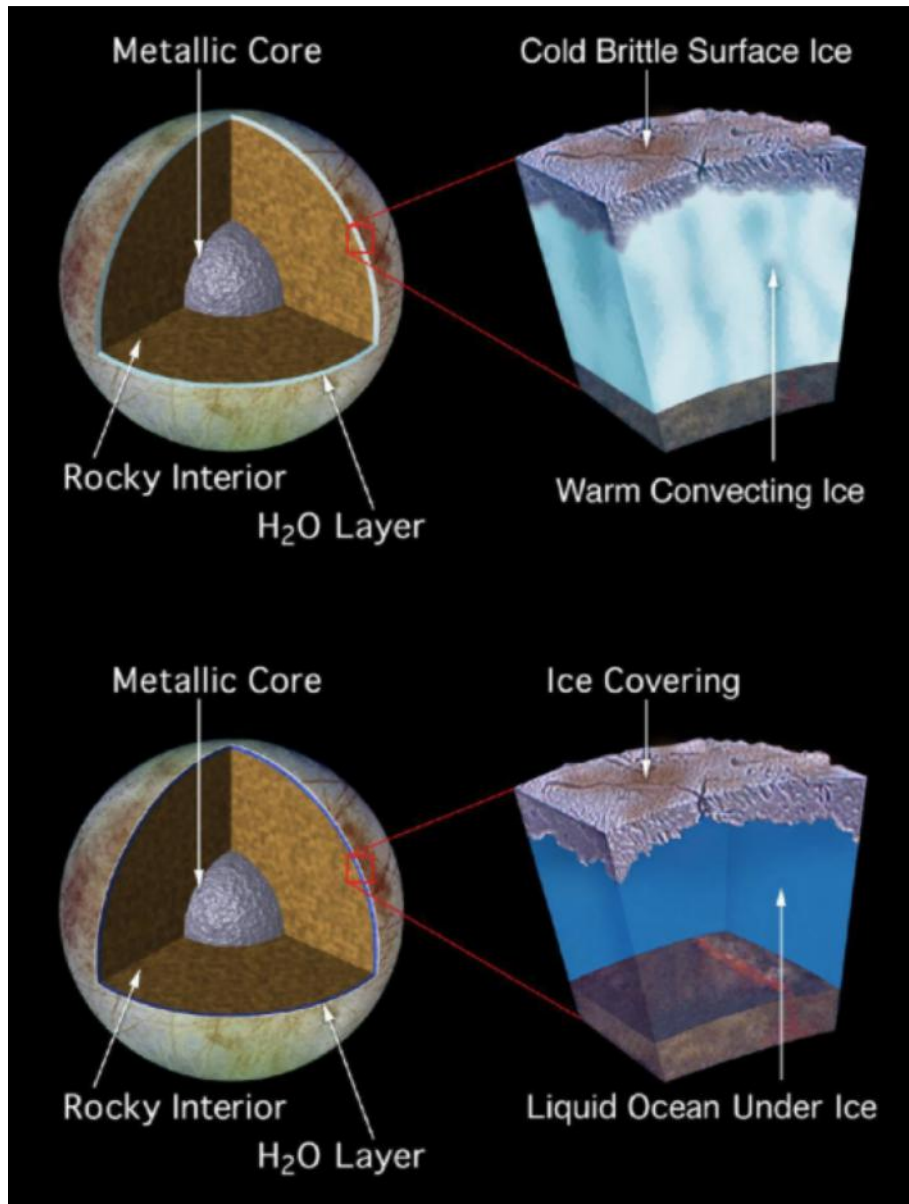


Key interaction 1: ↑
Atmosphere and Tectonics

Key interaction 2: →
Composition and temperature
affects tectonics



Outside the habitable zone - Icy and Ocean worlds



Persistence of liquid (water)

Requires energy:

- Radiogenic heating
- Tidal heating (resonances) planets and satellites
- Exothermic reactions
Hydrothermal convection

Maintain geochemical gradients:

- Hydrogen production
- Mass transfer through ice shell
- Nature of internal ocean
clear vs. muddy

Week 3: Habitability June 26-28

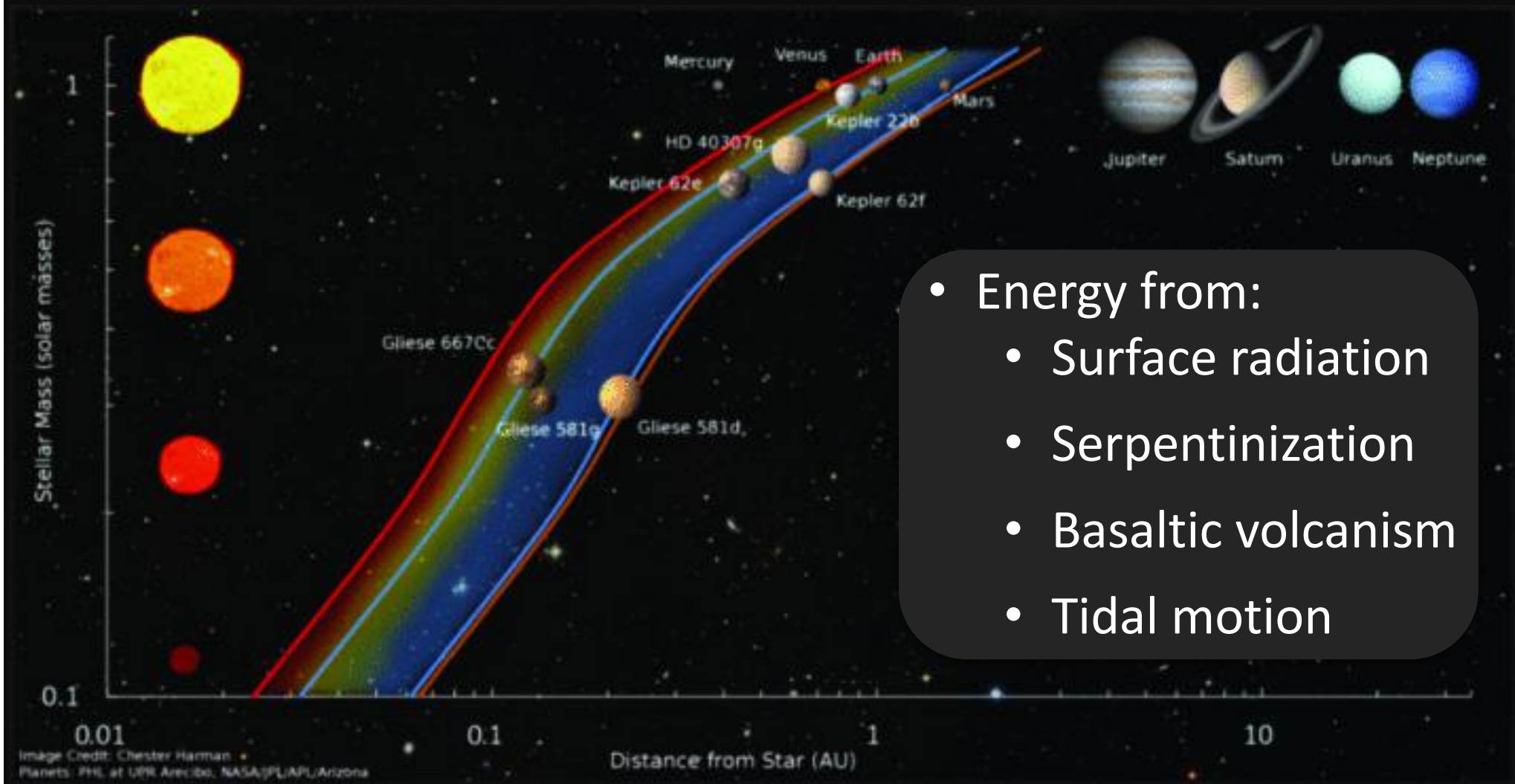
- Based on Earth, life requires:
 - Liquid water
 - Chemical disequilibria, with suitable redox species
 - Carbon source
 - Habitable temperature range
 - Macro(N,P)-micro nutrients

A DOZEN OCEAN WORLDS ARE WITHIN REACH



And CARBON sources (carbonates, CH₄) are indicated on several

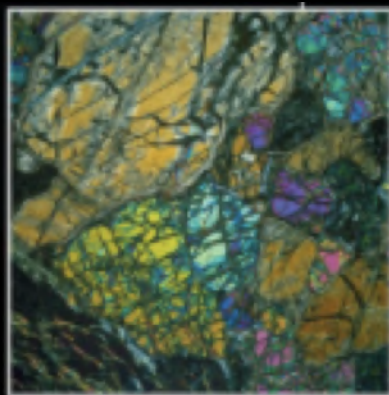
Planetary Energy Is Required to Sustain Habitable Temperatures, and Maintain Production of Redox Species & Chemical Disequilibria



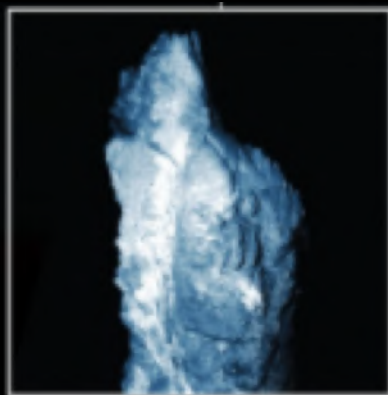
Week 3: Logistics

- Contacts/Organizers
 - Bill Cochran <wdc@astro.as.utexas.edu>
 - Charlie Werth <werth@utexas.edu>

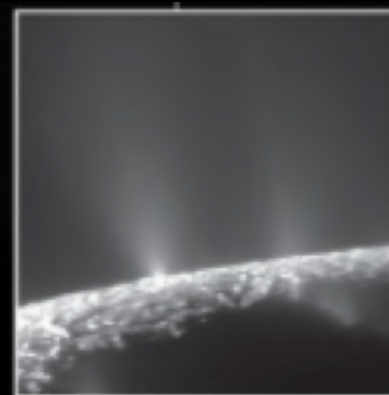
- Potential Speaker Topics:
 - Speaker #1: Processes that establish and maintain habitability
 - Speaker #2: Simulating terrestrial atmospheres of icy worlds
- Potential Discussion Topics
 - What redox species are available to drive life?
 - How do redox species mix across ice sheets and liquid oceans?
 - Can life be non-water based?
 - ????



WATER-ROCK REACTIONS



HYDROTHERMAL VENTS
("WHITE SMOKERS")



SURFACE JETS

Week 4: July 10-12, 2018

How to Find and Recognize Life

Organizers:

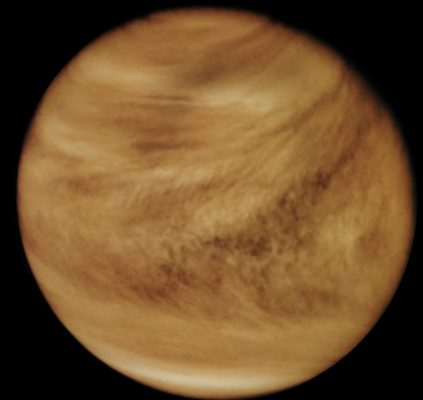
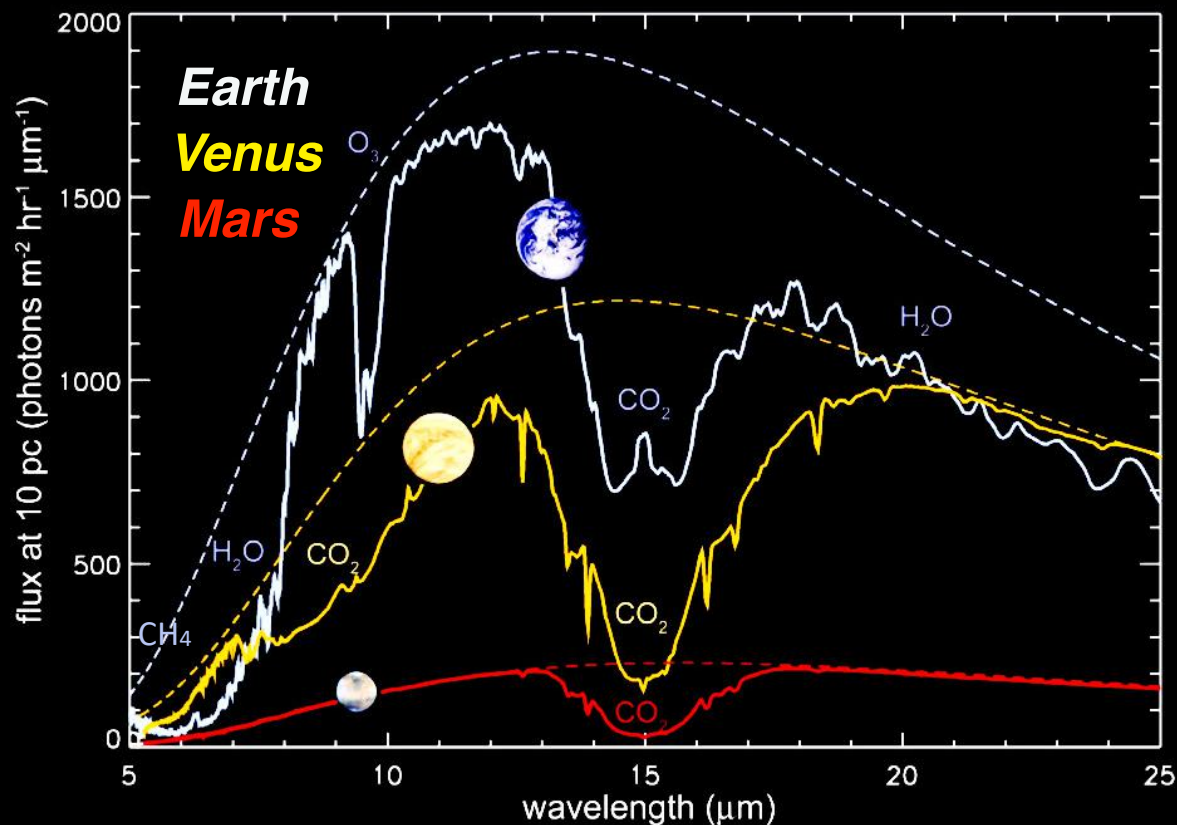
Brendan Bowler (bpbowler@astro.as.utexas.edu)

Andrew Vanderburg (avanderburg@utexas.edu)

Michael Endl (mike@astro.as.utexas.edu)

Where?

UT main campus (specific location TBD)



Purpose and goals for the week

Identify the most important questions, core themes, and strategic approaches we could best address in a longer-term center that take advantage of existing strengths at UT.

How to find life?

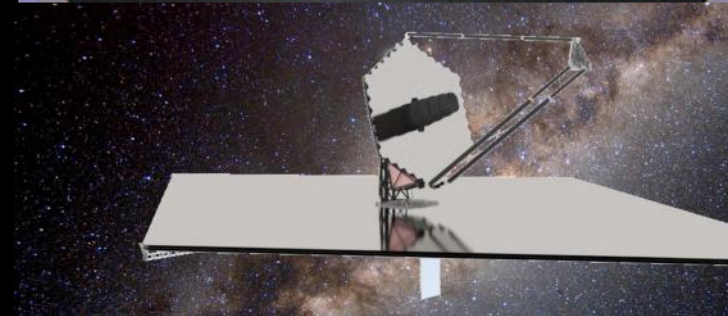
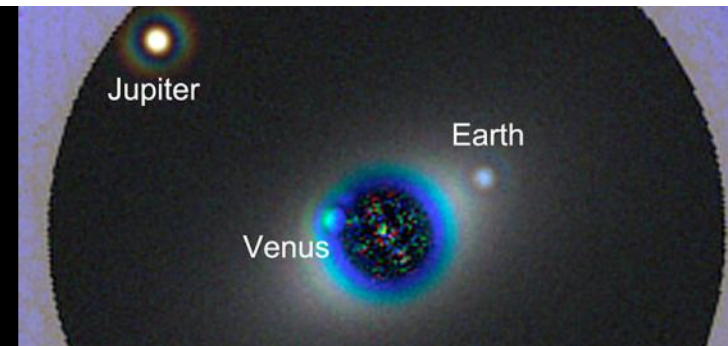
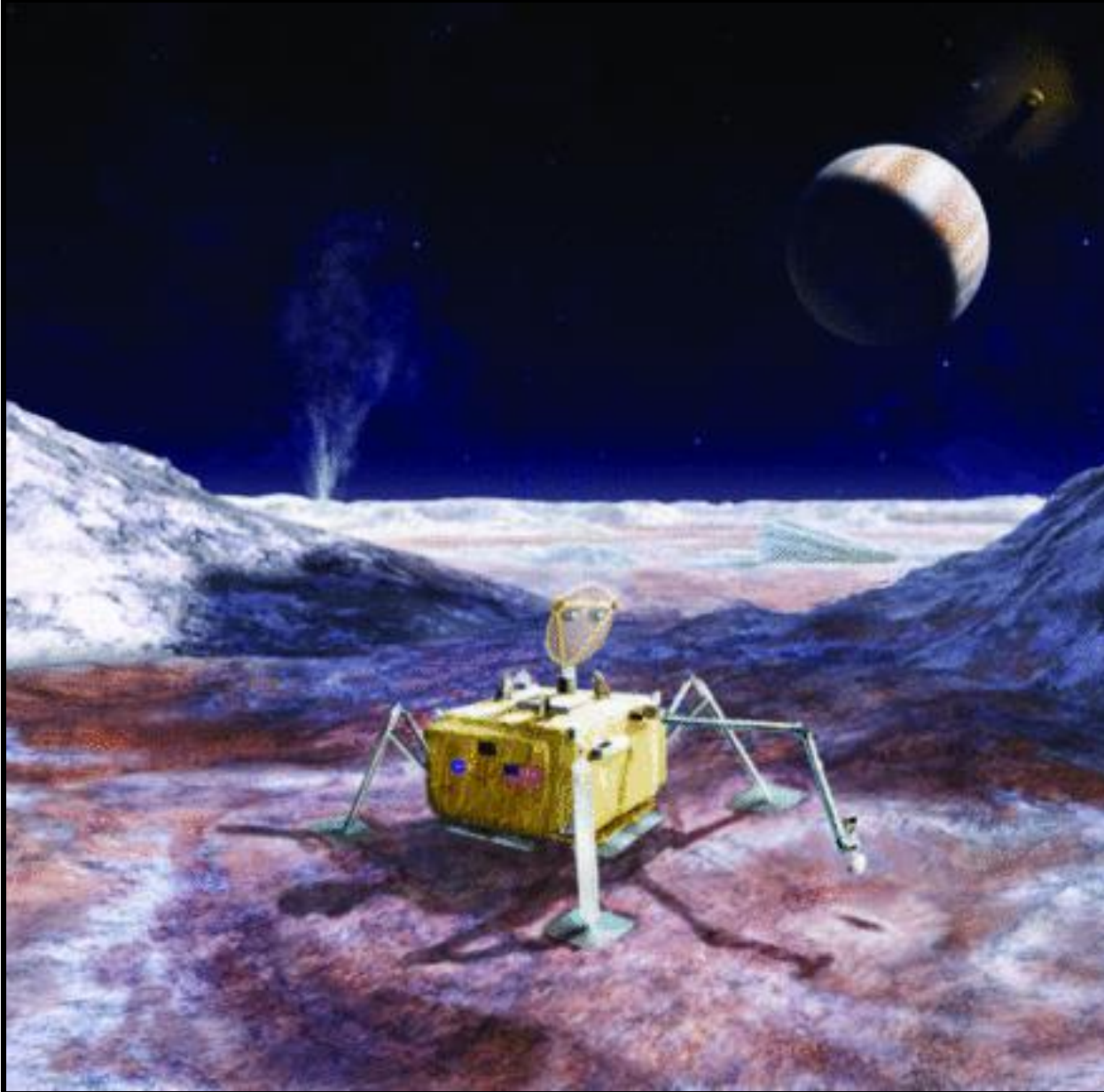
...on Earth, throughout the Solar System, and on exoplanets.

- What are the various ways that life can be detected?
- What capabilities are needed to find life? What is the pathway forward?

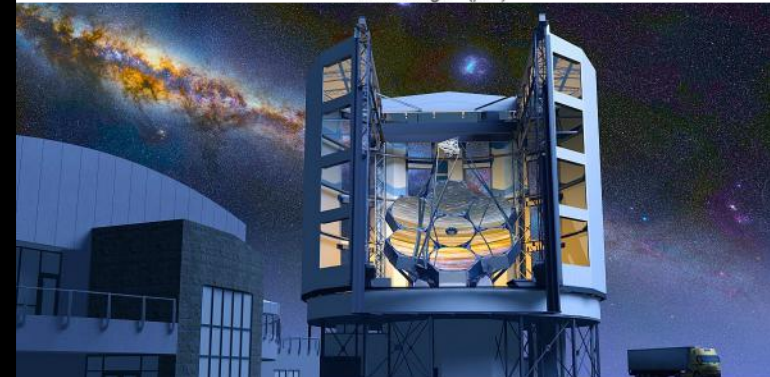
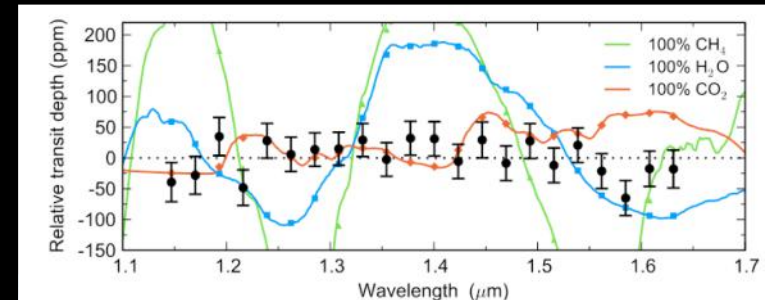
How to recognize life?

- Are there robust proxies for life?
- What are the best biomarkers that are free from geological/atmospheric false positives?
- How do these biosignatures evolve over short (chemical equilibrium) and long (geological) timescales?
- A metacognitive approach: what do we know, what do we not know, and what do we not know that we don't know?

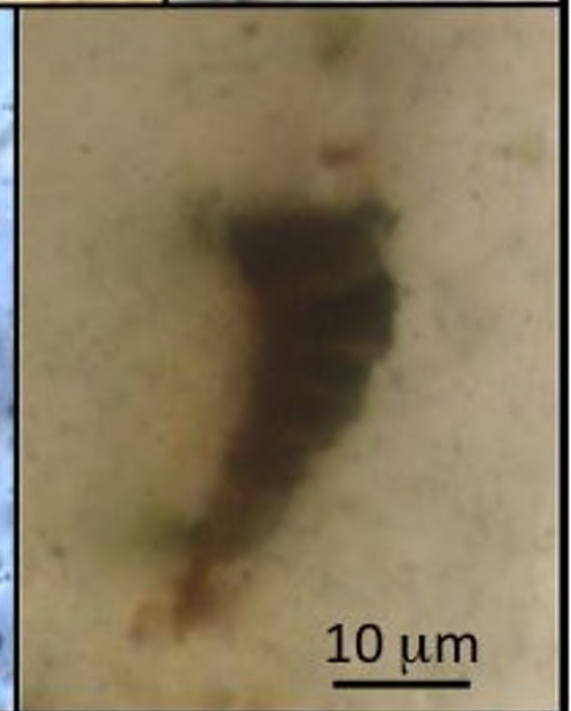
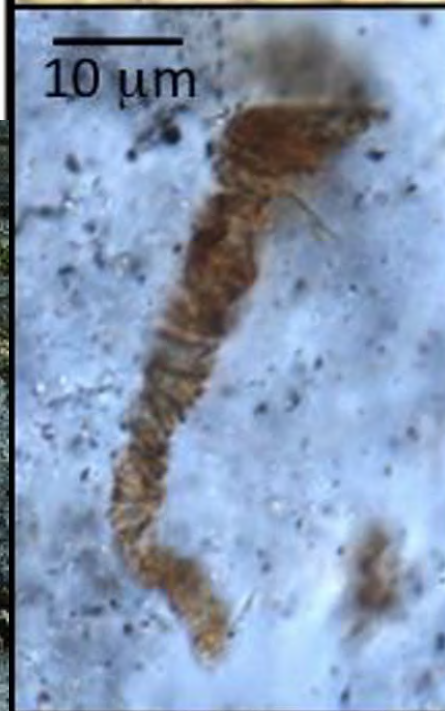
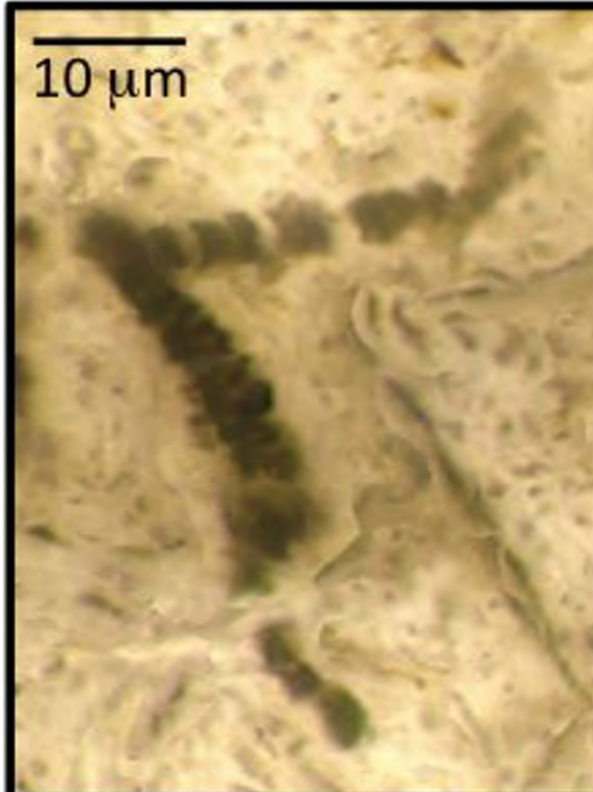
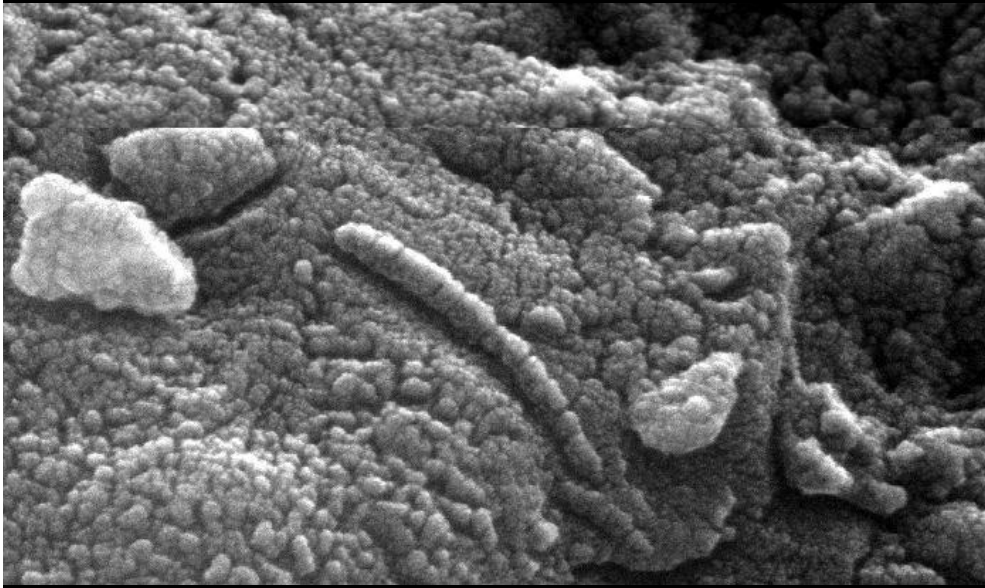
Finding biosignatures in our Solar System...



...and beyond



Recognizing life in an ocean of false positives



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Week 5: Next Steps July 17-19

Where do we, as a University of Texas community, want to go from here? Do we want a more formal, long-lasting cross disciplinary relationship among the various scattered research groups across U.T. that are now separately addressing different parts of this overall question of planetary habitability in the universe?

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Week 5: Next Steps July 17-19

- What have we learned?
- Are there significant opportunities for interdisciplinary collaboration?
- Are there core research themes that take advantage of existing strengths at U.T.?
- Do we want to pursue more formal and more permanent collaborative efforts?
- What about interdisciplinary *academic* as well as research efforts?
- Do we want to propose to join an existing national or international effort, such as the NASA Astrobiology Institute?
- Do we want to pursue a proposal to a major funding source (either private or governmental)

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Week 6: Implementation

July 24-26

Once we decide where we want to go from here, how do we get there?

- If we want a more formal interdisciplinary collaborative structure within U.T., how should we implement it?
- Block out a draft proposal structure to seek outside funding for the direction we have decided for collaborative research efforts.
- What about interdisciplinary *academic* as well as research efforts?

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Please join us!

We welcome your participation for as much or as little of the Pop-Up Institute as you wish.

Sign up outside this room, or on our webpage:

<https://research.utexas.edu/vpr-initiatives/pop-up/understanding-planetary-habitability/>

We will keep you informed of our plans as they develop. Please send us your suggestions and comments.