

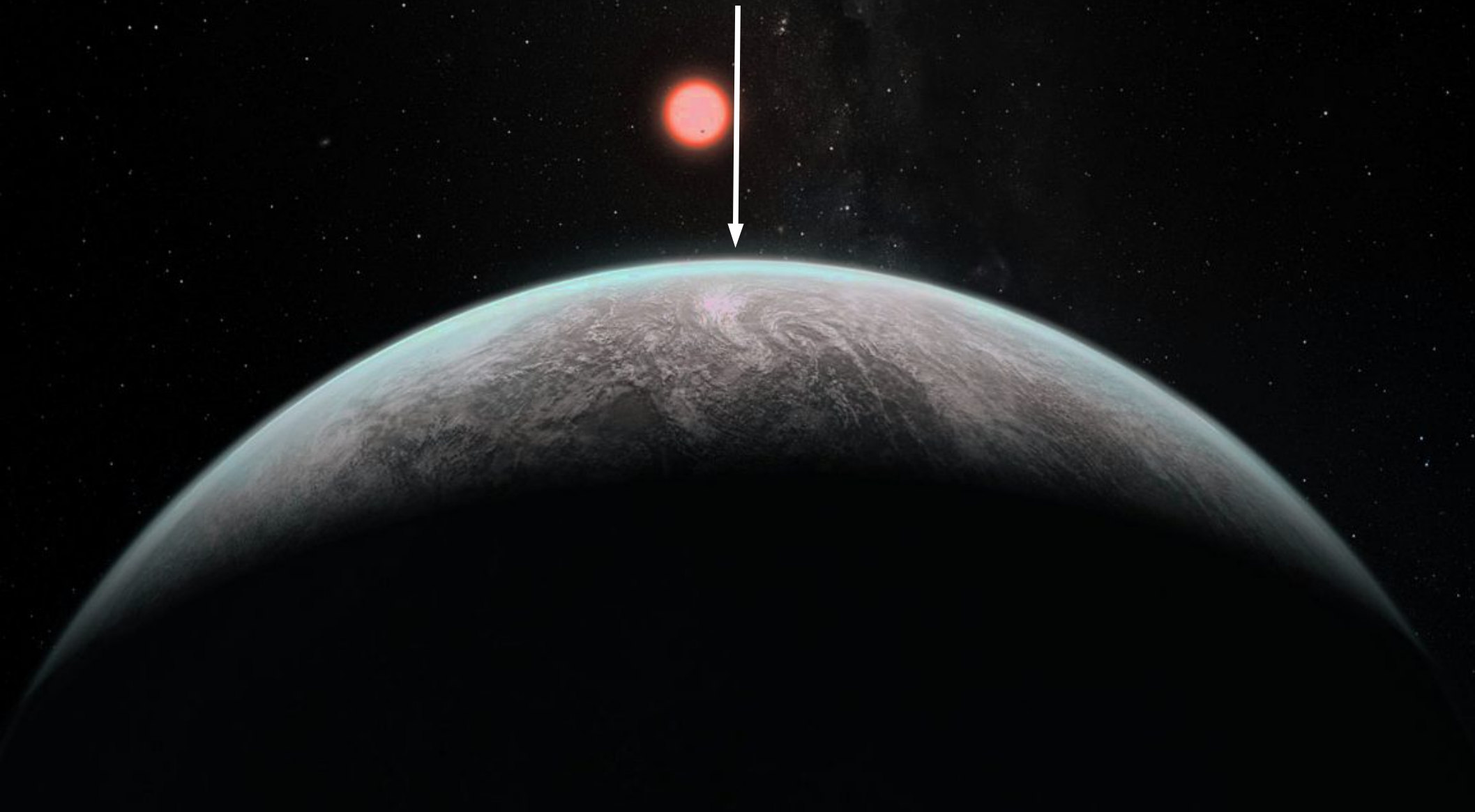
Definitions and Caveats of the Habitable Zone



Stephen Kane



Astronomy



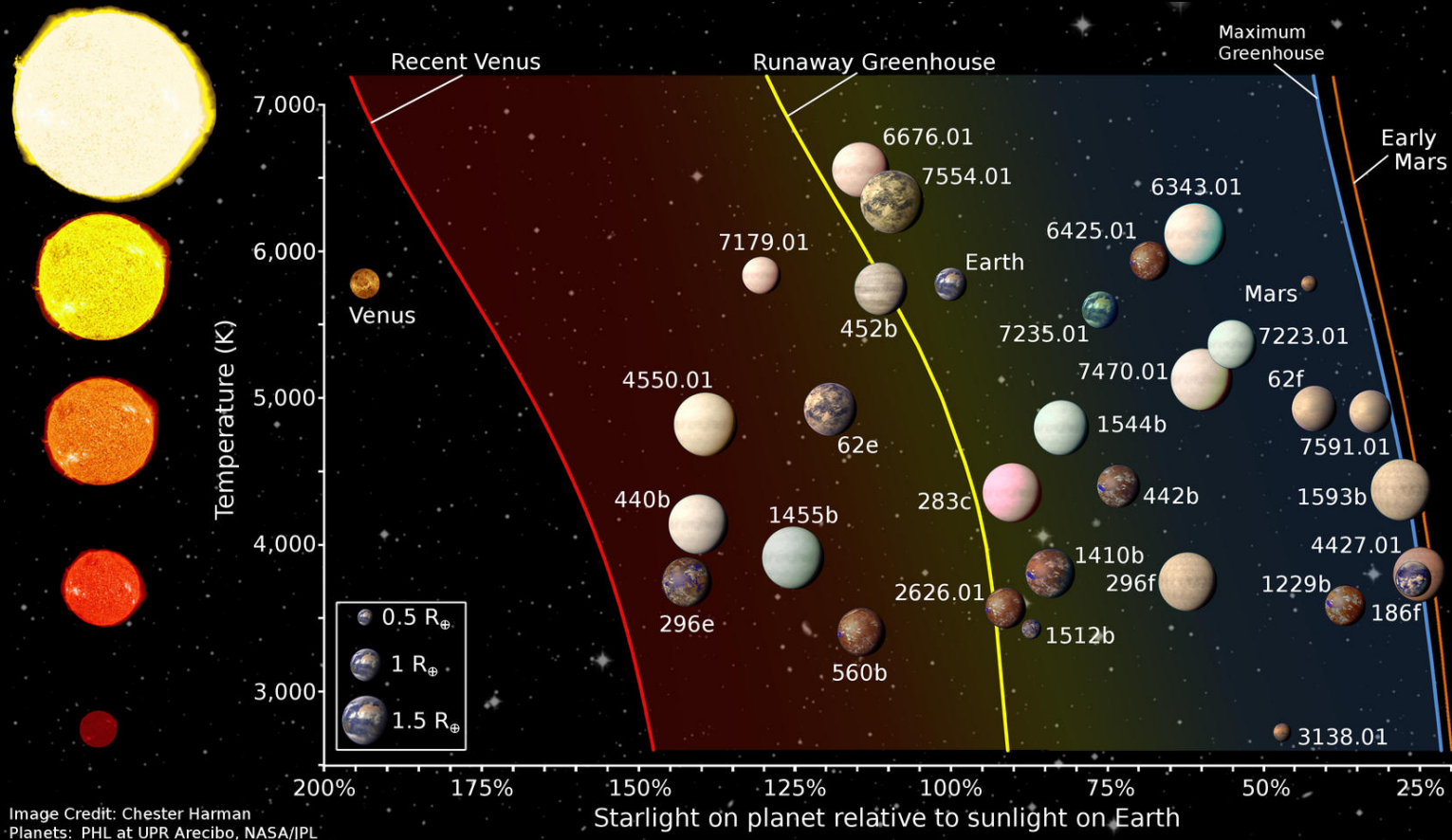
Astronomy



**Biology, Climate,
Geophysics, Planetary Science**

What is the “Habitable Zone”?

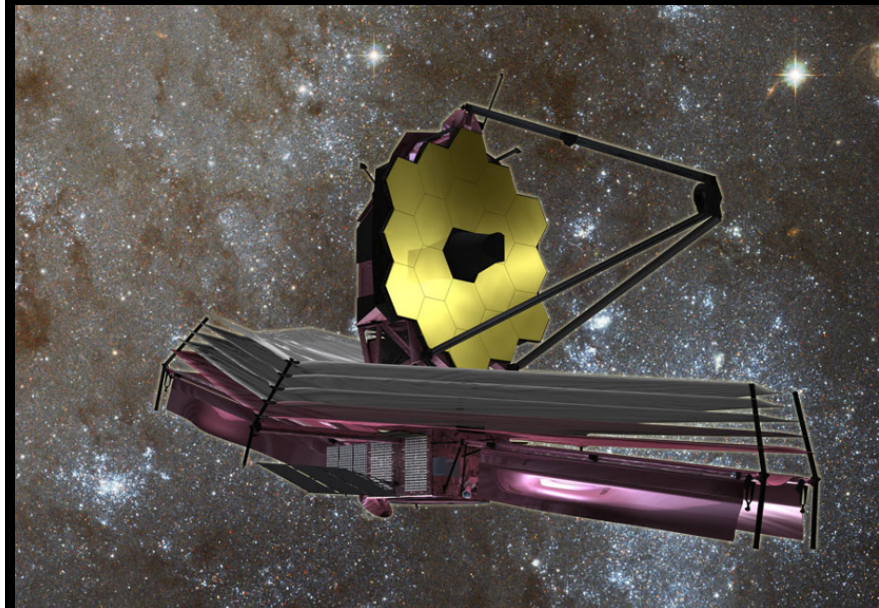
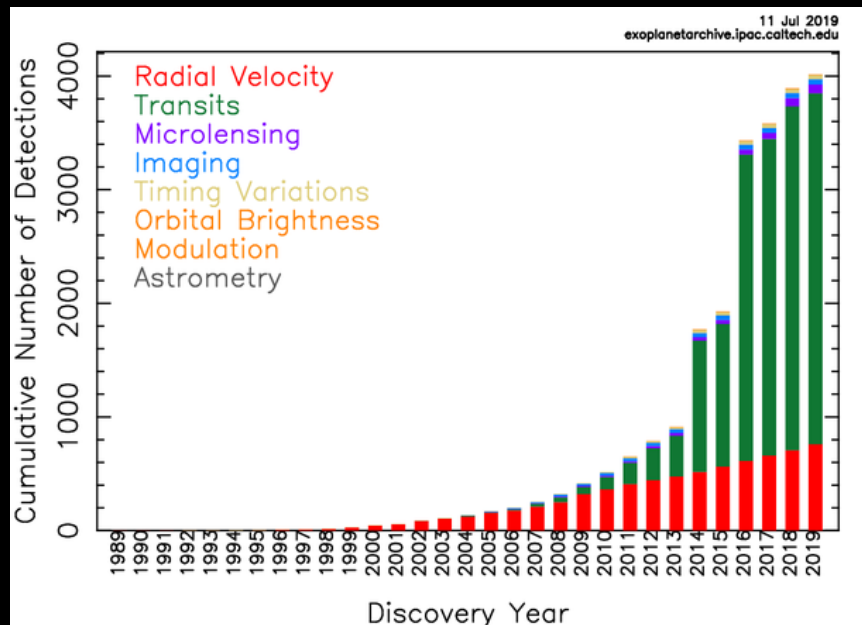
- The “Habitable Zone” is the region around a star where water **COULD** exist in a liquid state on the surface of a planet **IF** it has sufficient atmospheric pressure.



Kane et al. “A Catalog of Kepler Habitable Zone Exoplanet Candidates”, 2016, *ApJ*, 830, 1
See also the Habitable Zone Gallery (hzglory.org).

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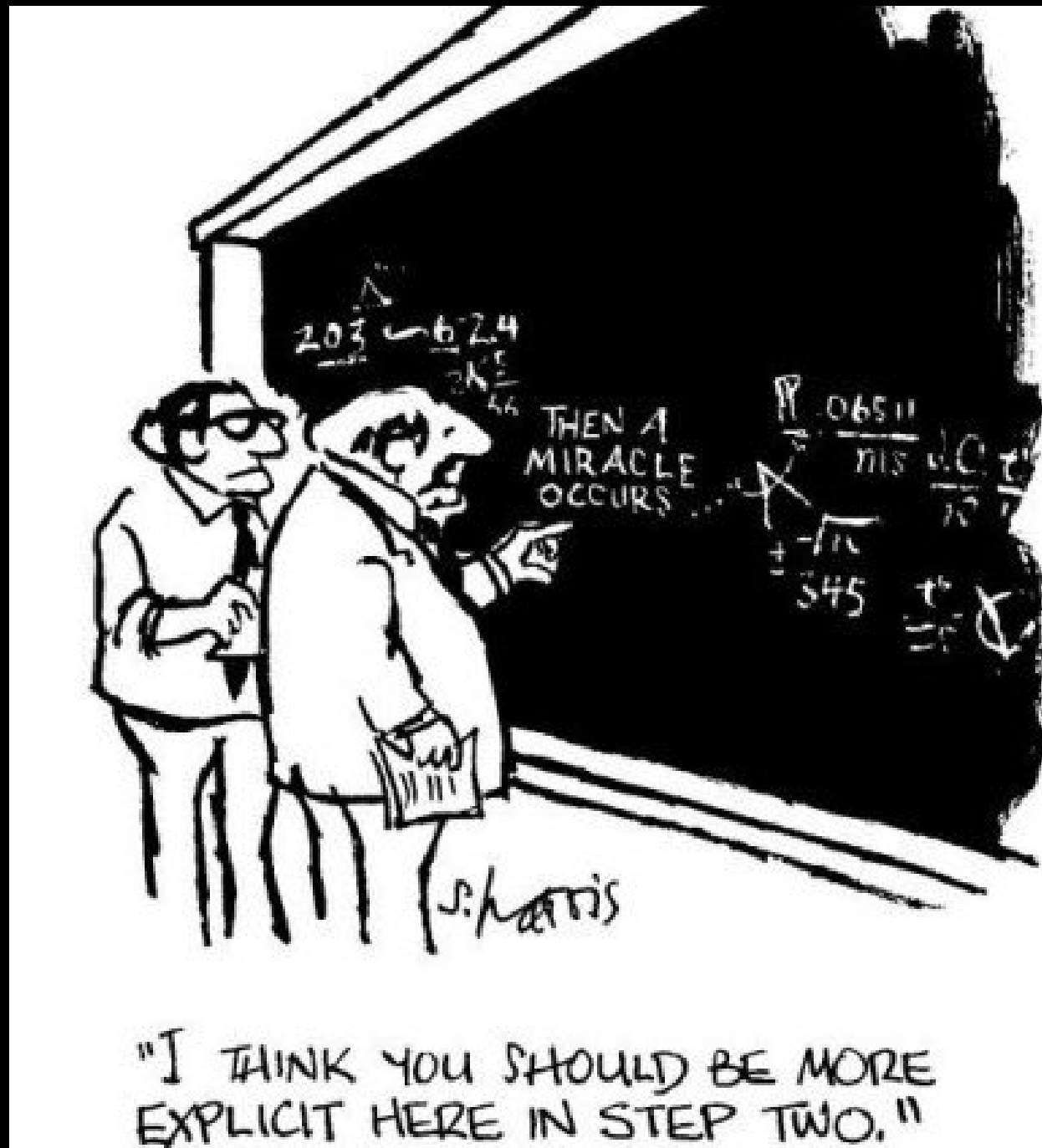
- The “Habitable Zone” is the region around a star where water **COULD** exist in a liquid state on the surface of a planet **IF** it has sufficient atmospheric pressure.
- The entire purpose of the Habitable Zone is as a **target selection tool** so that limited resources may be used more effectively if the purpose is to optimize the observations for biosignature detection.

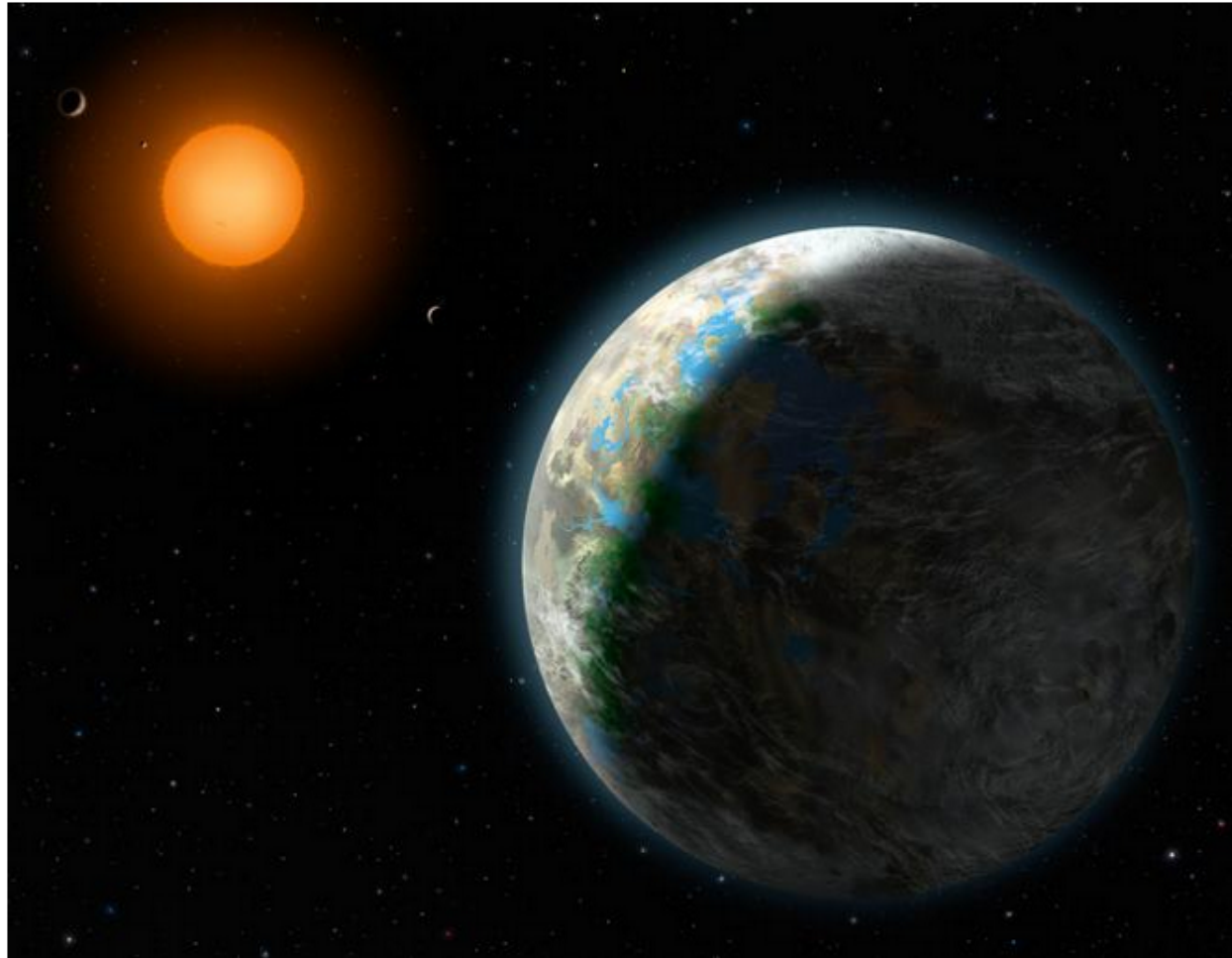


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***1. Habitable Zone
planets implies
habitable planets.***

Planet in the Habitable Zone \neq Habitable Planet





The new planet Gliese 581g bears Earthlike blues and greens in an artist's conception.

ILLUSTRATION COURTESY LYNETTE COOK

First Truly Habitable Planet Discovered, Experts Say

Earthlike world in elusive "Goldilocks zone."

NASA Telescope Reveals Largest Batch of Earth-Size, Habitable-Zone Planets Around Single Star



This illustration shows the possible surface of TRAPPIST-1f, one of the newly discovered planets in the TRAPPIST-1 system. Scientists using the Spitzer Space Telescope and ground-based telescopes have discovered that there are seven Earth-size planets in the system.

Credits: NASA/JPL-Caltech

[View this and many more images, as well as several videos, in an extensive multimedia gallery highlighting this discovery.](#)

Until we get better tools, excited reports of 'habitable planets' need to come back down to Earth

February 8, 2017 2:39am EST

Have we really discovered other "Earth-like" planets orbiting around other stars? Understanding what we do and do not know about exoplanets is the key to answering this question. ESO/L. Calçada/N. Risinger/Reuters

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In 1950, physicist [Enrico Fermi famously asked](#), "Where are they?" as a kind of lament about the lack of observational evidence for alien intelligence in our universe. Today, the question is still asked in the context of the always-hoped-for discovery of other worlds like our own,

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Earth-Like Planet? Not So Fast — Scientist Says to Watch Your Words

By Leonard David December 13, 2017 Science & Astronomy



Artist's illustration of a hypothetical planet covered in water in the binary star system Kepler-35AB. (Image: © NASA/JPL-Caltech)

The art of exoplanet detection is on the upswing, and scientists are perhaps at the cusp of a watershed moment — detecting life on other worlds.



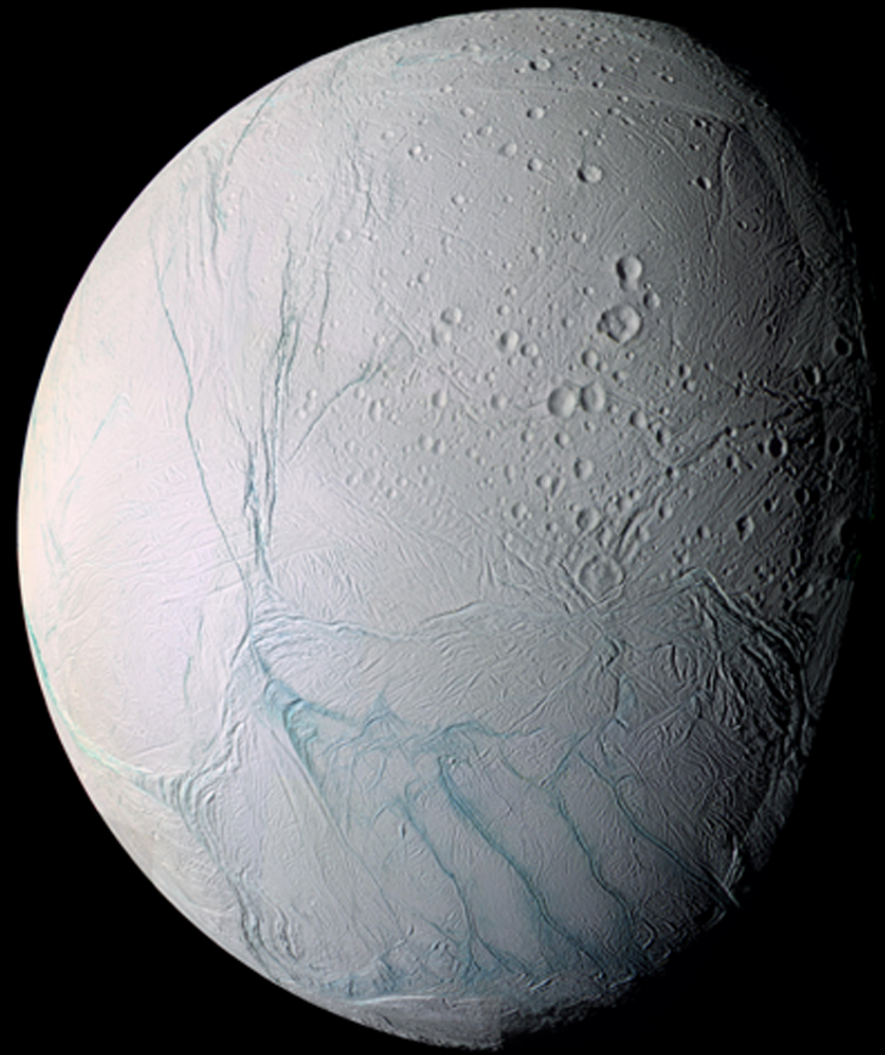
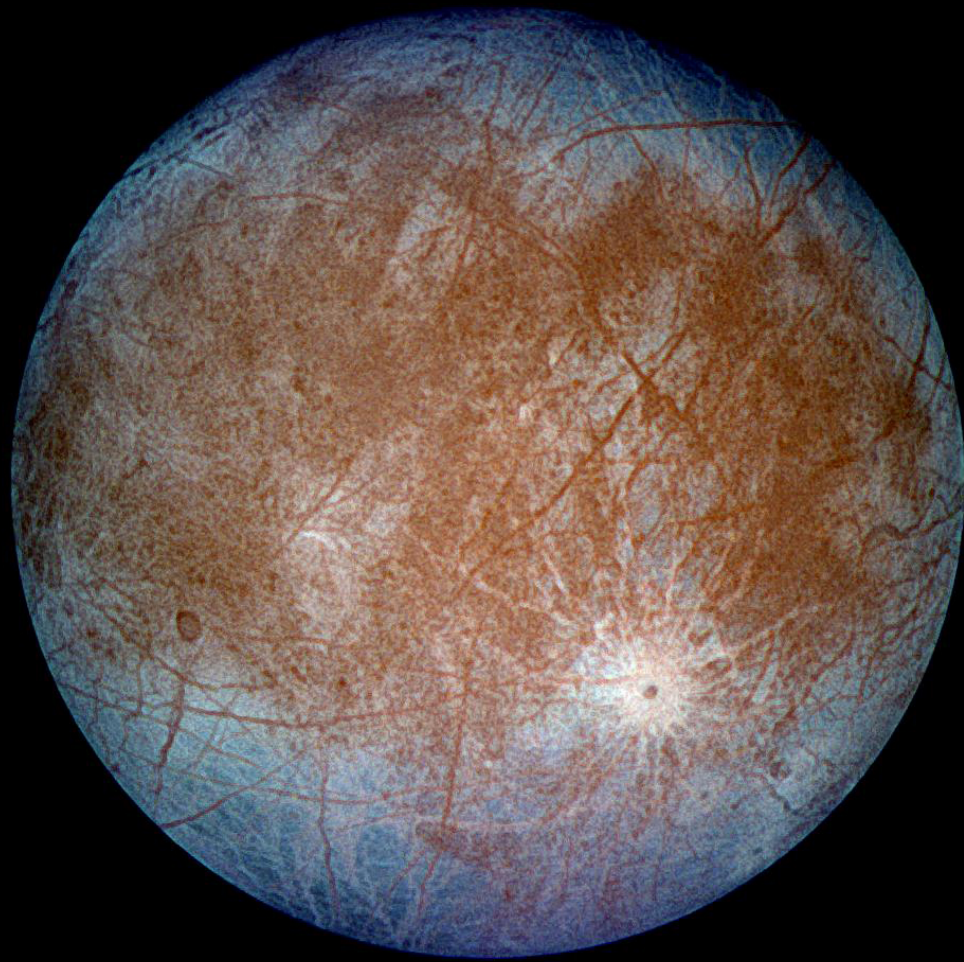
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2. Earth's moon being in the Habitable Zone means it's an invalid concept.

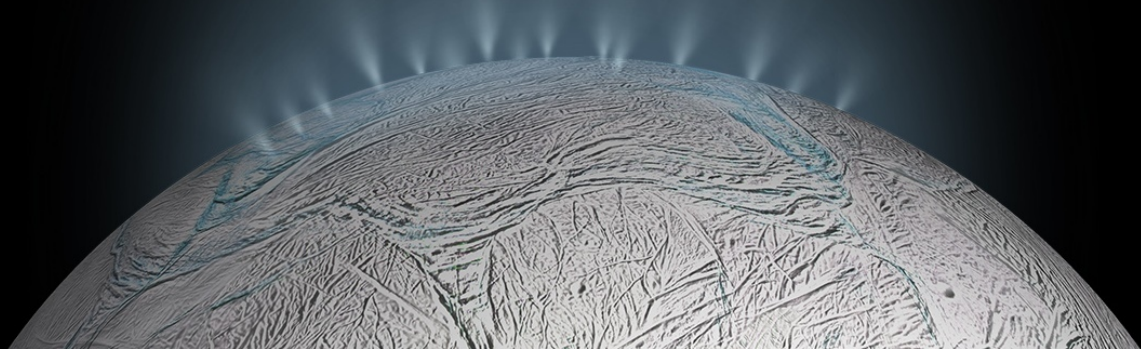
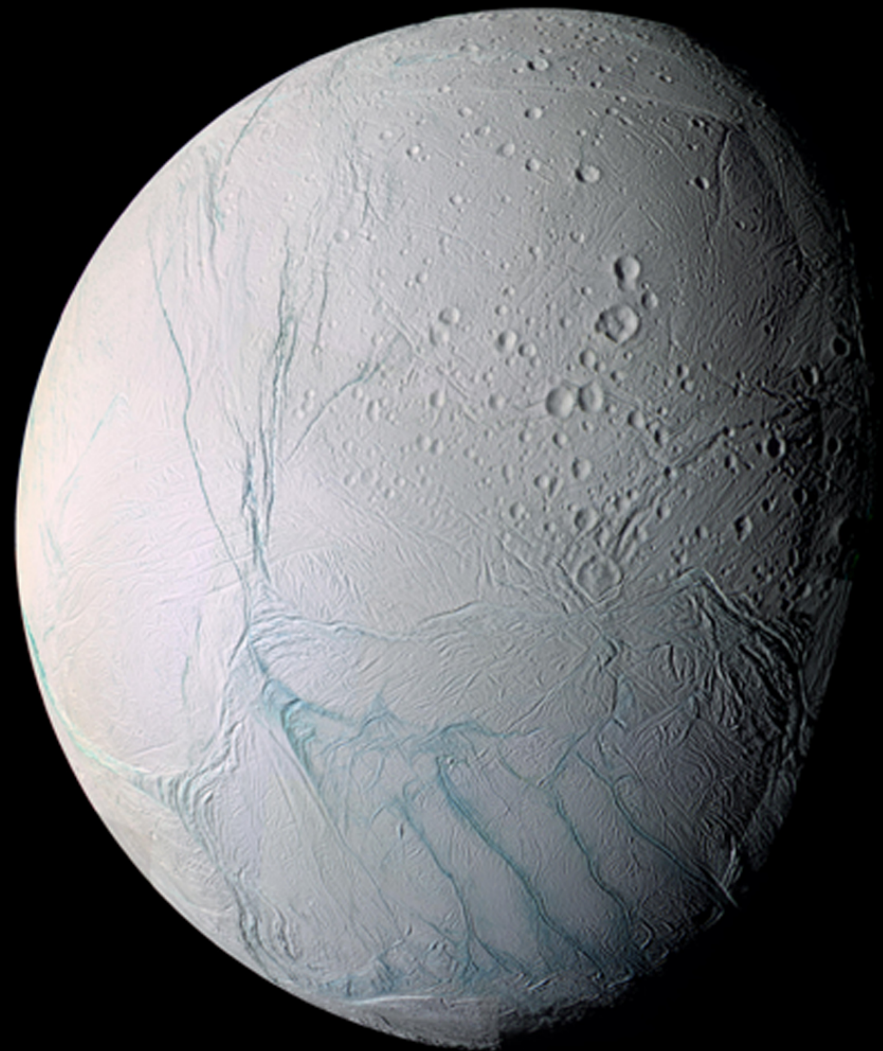
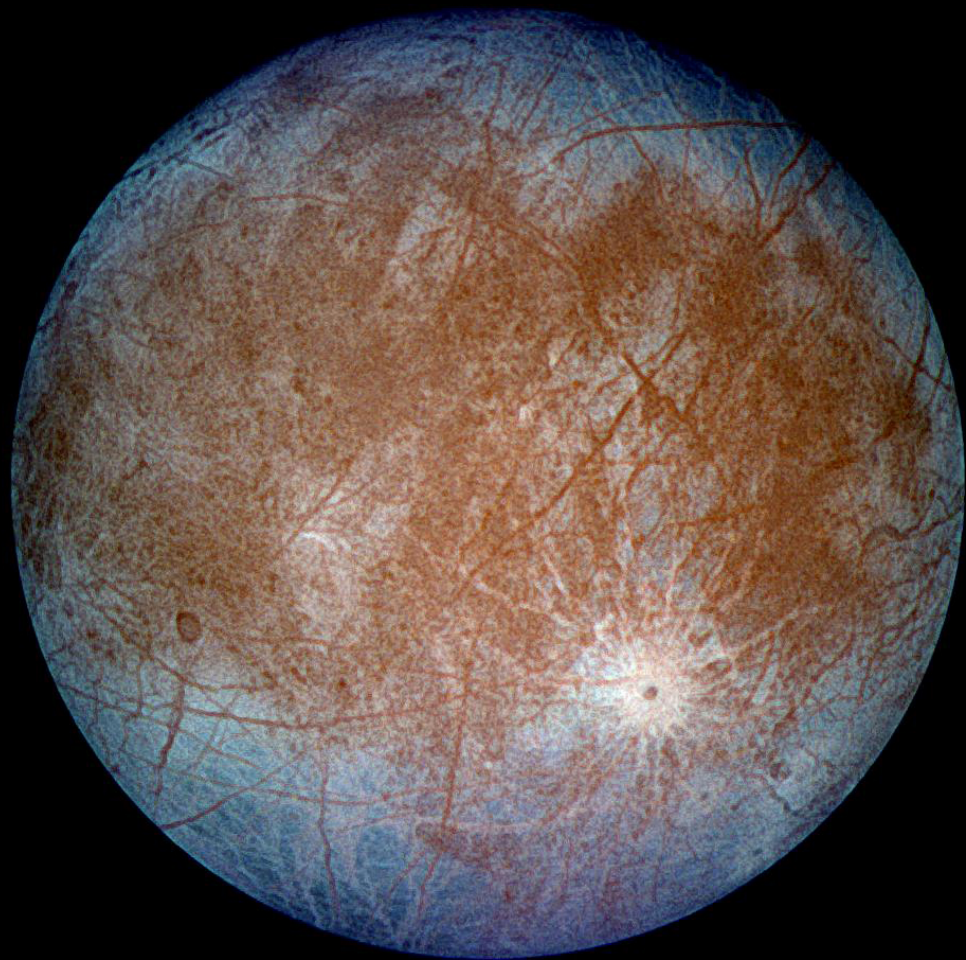
***2. Earth's motion being
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3. The Habitable Zone should include icy moons (Europa and Enceladus).



Could we remotely sense the presence of a sub-surface ocean for an exomoon?

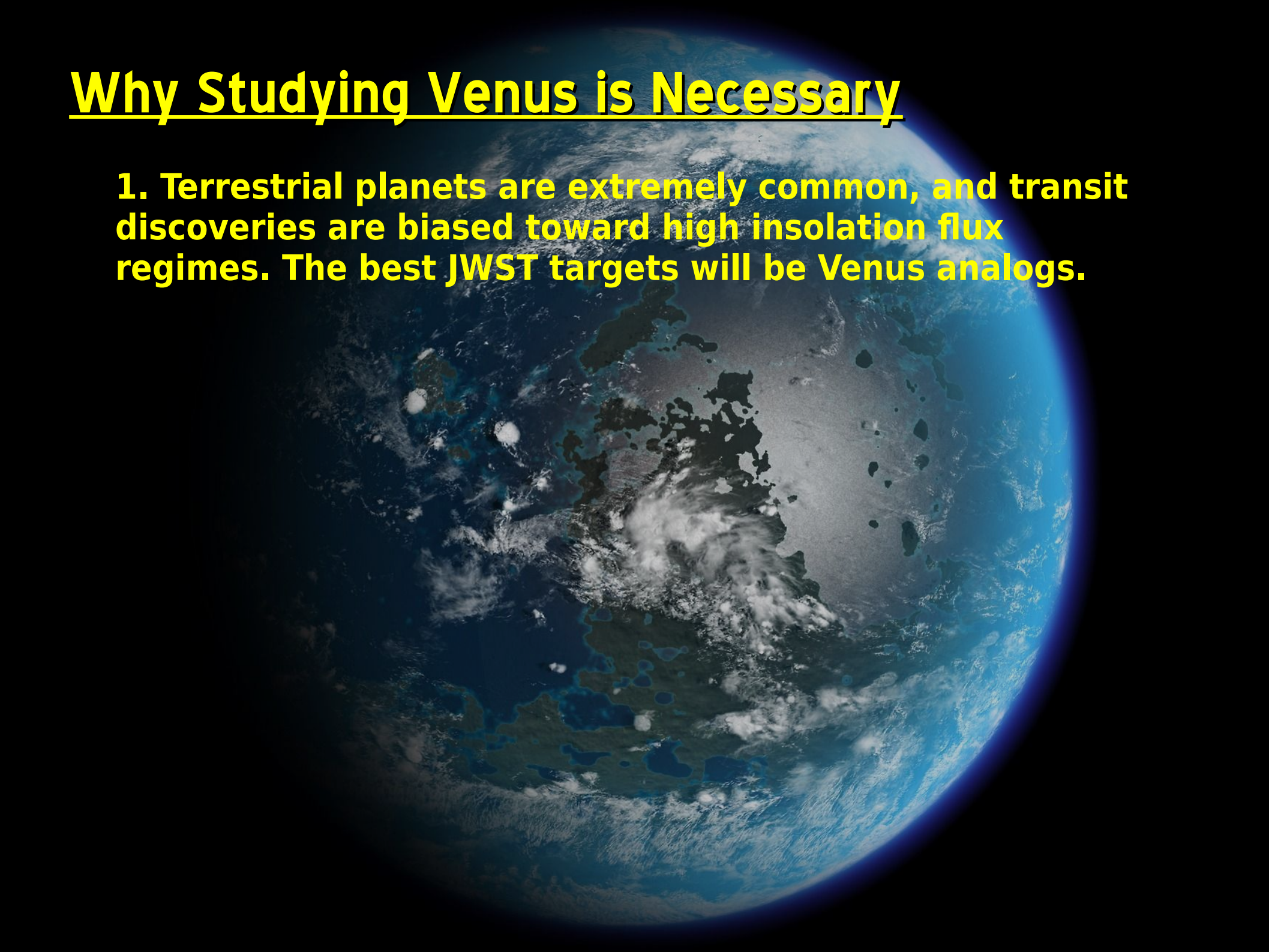


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***4. Venus is in the
Sun's Habitable Zone.***

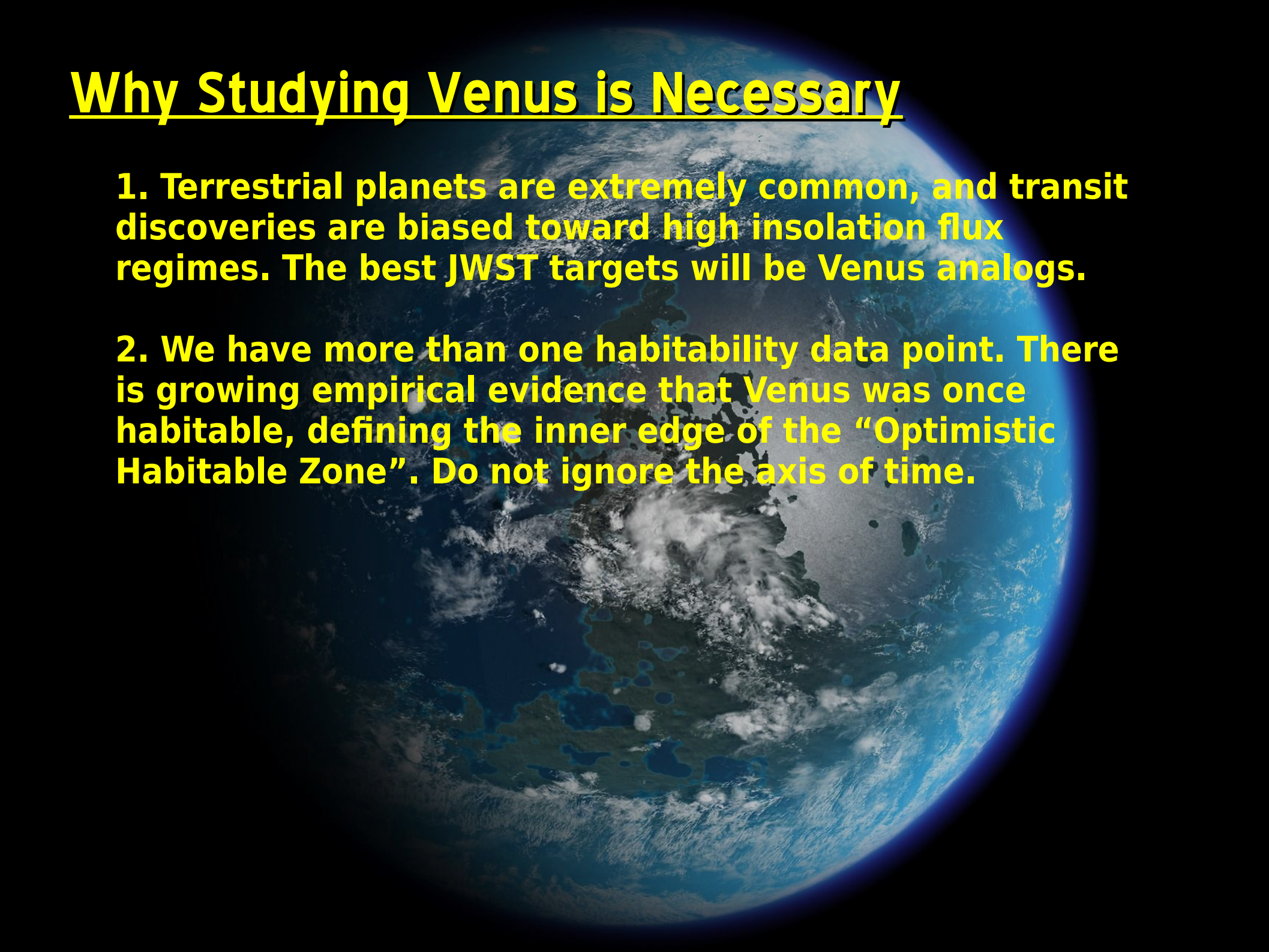
Why Studying Venus is Necessary

1. Terrestrial planets are extremely common, and transit discoveries are biased toward high insolation flux regimes. The best JWST targets will be Venus analogs.



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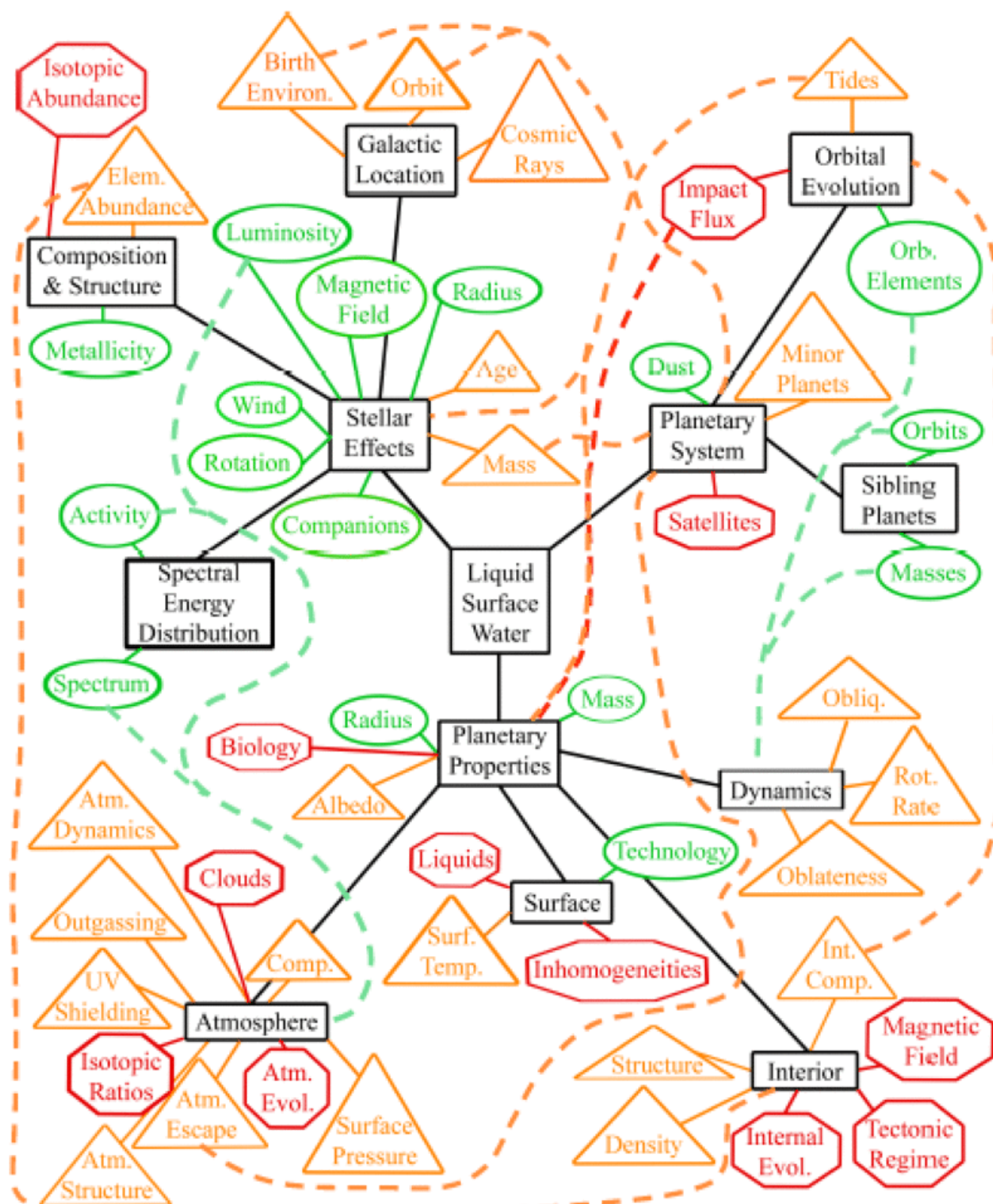
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- 2. We have more than one habitability data point. There is growing empirical evidence that Venus was once habitable, defining the inner edge of the “Optimistic Habitable Zone”. Do not ignore the axis of time.**
- 3. We did not fully understand the severity of Venusian surface conditions until probes penetrated the atmosphere (mid-late 60s).**
- 4. We will never have in-situ data for an exoplanet. Surface conditions will always be inferred from models based on solar system data.**

***“If Venus did not exist in our solar system,
we would not dare to imagine it”
- Francois Forget***



**4. Venus is ~~not~~ in the
Sun's Habitable Zone.**

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An Incomplete List of Habitable Zone Caveats

- **How is water delivered?**
- **When did Mars have surface water?**
- **When did Venus have surface water?**
- **Did Venus and Earth have near identical starting conditions?**
- **How small can a planet be and remain habitable?**
- **Why don't we have a super-Earth?**
- **What does the T-P profile of a super-Earth look like?**
- **Does a giant planet beyond the snow line matter?**
- **Can life survive extreme eccentric orbits?**
- **How do terrestrial atmospheres respond to flux variations?**
- **Are circumbinary planets habitable?**
- **How does atmospheric erosion depend on magnetic field?**
- **Does a substantial moon create a more habitable world?**
- **How well do we need to understand the star?**

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- How well do we need to understand the star?
- ***What observations/measurements do we need to make to test the Habitable Zone hypothesis?***