

## The Rare Earth Hypothesis

(Ward & Brownlee)

While microbial life is common in the Universe, complex life (plants and animals) are rare. Very many conditions had to be “just right” in order for large multi-cellular animal life to develop on Earth. We had to have the right:

type of star, distance from star, size of planet, size of other planets in Solar system, geochemical composition, molten core and plate tectonics, large size of Moon, even the right location in the galaxy....

It is quite possible that complex animal life is *incredibly* rare, perhaps only once in the entire galaxy! This may be at odds with the current optimistic viewpoint, but it is plausible.

This makes the current human-caused global extinction on Earth all the more tragic. We should take responsibility and be better stewards of the planet Earth.

### Signposts of Habitability and Life: “Bio-signatures”

- find a terrestrial planet
- find a thick atmosphere (look for CO<sub>2</sub>)
- find a warm, wet atmosphere (H<sub>2</sub>O)
- find an atmosphere out of chemical equilibrium: a global presence of life will modify the atmosphere producing O<sub>2</sub> and ozone, methane, N<sub>2</sub>O, etc.

Mid-infrared spectroscopy can identify all the above.

### What’s planned for the future?

Continuing ground-based discoveries of exoplanets via spectroscopy and photometry  
Continuing discoveries in biology, especially extremophiles, Archaea, viruses, genetics, and topics related to the origin of life

Hydrothermal vent, deep ocean, and Lake Vostok exploration

Some current astrobiology-related missions:

Cassini/Huygens (Saturn & Titan)  
2001 Mars Odyssey, Mars Global Surveyor (MGS)  
Mars Express, Mars Exploration Rovers (MER)  
Mars Reconnaissance Orbiter

and future Mars orbiters and landers

Venus Express; StarDust; New Horizons  
Hubble Space Telescope and Spitzer Space Telescope

Future Solar System Missions:

Mars return mission  
Europa Orbiter and “Cryobot” ice driller  
James Webb Space Telescope (the next generation Hubble telescope)

Future Exoplanet missions:

*Corot* and *Kepler* (transit searches)  
*SIM* and *GAIA* (astrometry)  
*Darwin & Terrestrial Planet Finder* (spectroscopy)

## Topics in Critical Thinking

What is a “UFO”?

UFO stands for *Unidentified Flying Object*. It does *not* imply ET, or alien invaders, or anything supernatural. It means something was seen that was not identified.

There *are* such things as UFOs. Many have been sighted. But this does not necessarily mean they are extraterrestrial in origin!

Usually it is the planet Venus; often it is an unusual atmospheric phenomenon; in rare cases, it is a military experiment. But there is not evidence, not even weak evidence, for the ET hypothesis. Remember that the mind is complex, so not only do “eyewitness” accounts and “abduction” claims not provide physical evidence, they aren’t even reliable non-physical evidence!

Remember Loftus’ work on “False Memories” (pun intended!) and things like “inattention blindness” (the “gorillas in the midst”).

UFOs tell us much more about ourselves and our psychology/sociology than about extraterrestrial life!

**“Extraordinary claims require extraordinary evidence.”** – attributed to **Carl Sagan**.

Sagan was arguably the greatest astrobiologist of the late 20<sup>th</sup> century and he dearly wished to detect life beyond Earth. But it was his demand for rigorous scientific evidence, not his desires or hopes or faith, that shaped his conclusions. He completely rejected the ET hypothesis for UFOs, while still strongly believing in extraterrestrial life. Ask yourself why?

Be skeptical – think! Do UFO “conspiracy theories” even make the slightest bit of sense?

**“No testimony is sufficient to establish a miracle, unless the testimony be of such a kind that its falsehood would be more miraculous than the fact which it endeavors to establish...”** – David Hume