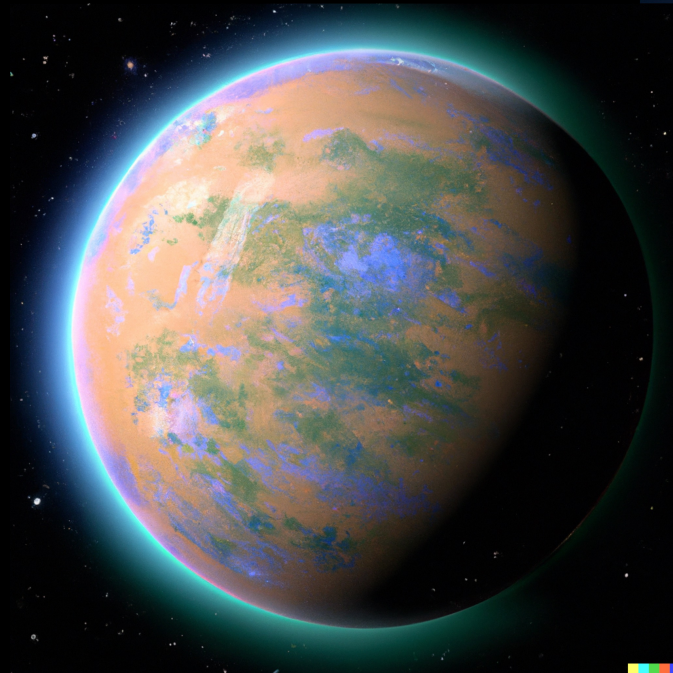
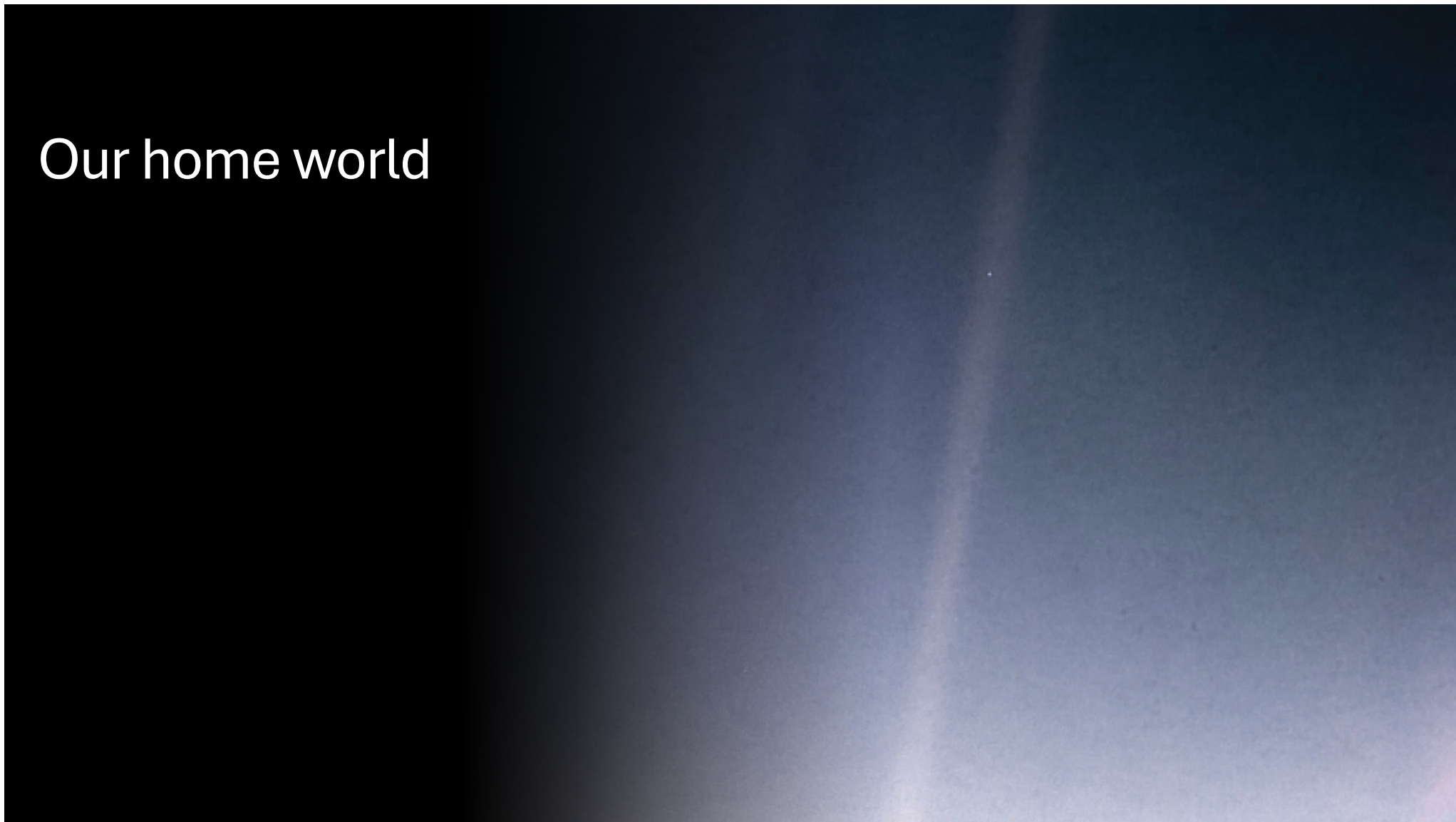


# The Search for Habitable Worlds in Our Galaxy



Ravi Kopparapu  
(NASA Goddard)

Our home world



# Earth from Voyager 1



# A habitable (and inhabited) planet with biology & Technology



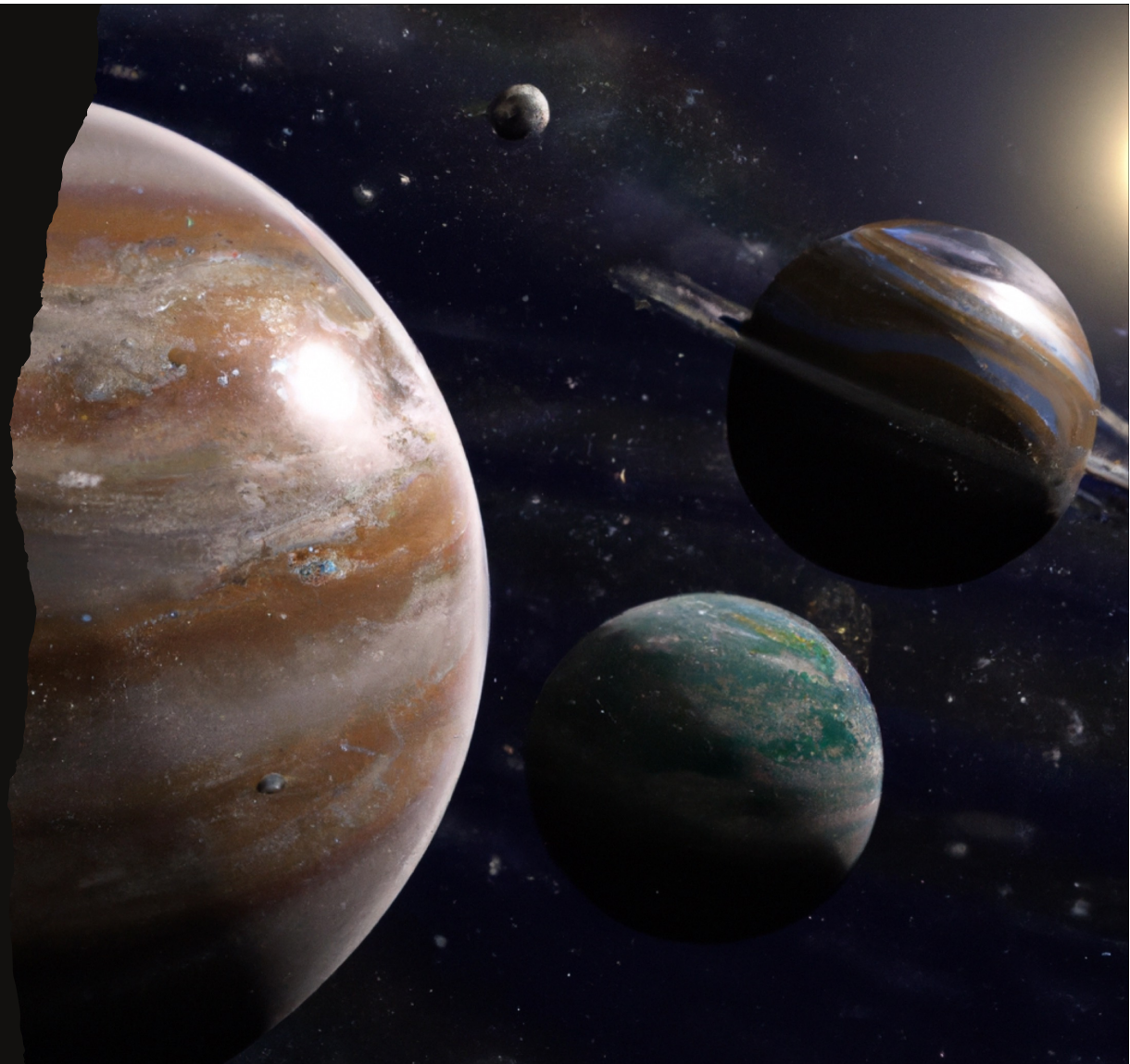
# Biology & Technology on Earth

How do we find such habitable worlds?



# Identifying Planets with Life

- Find “Exo” planets (outside the solar system)
- Find habitable zone planets
- Find bio and techno signatures



**30%**  
**GAS GIANT**

The size of Saturn or Jupiter (the largest planet in our solar system), or many times bigger. They can be hotter than some stars!



**31%**  
**SUPER-EARTH**

Planets in this size range between Earth and Neptune don't exist in our solar system. Super-Earths, a reference to larger size, might be rocky worlds like Earth, while mini-Neptunes are likely shrouded in puffy atmospheres.



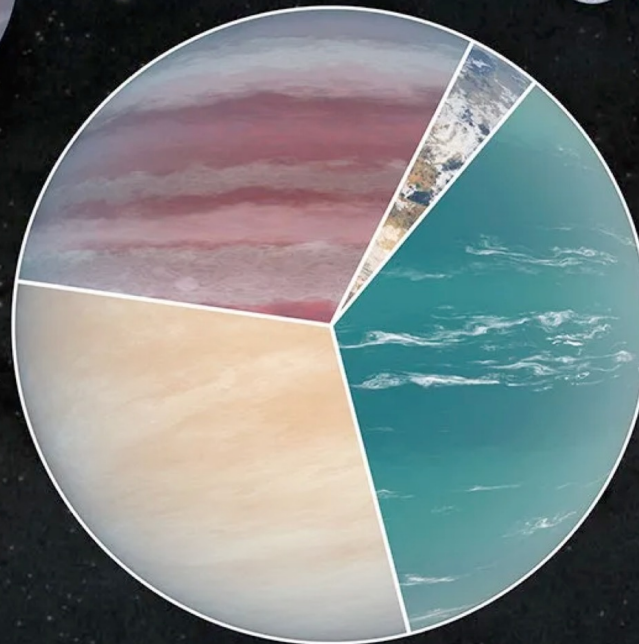
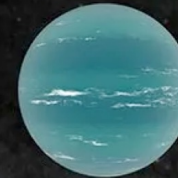
**4%**  
**TERRESTRIAL**

Small, rocky planets. Around the size of our home planet, or a little smaller.



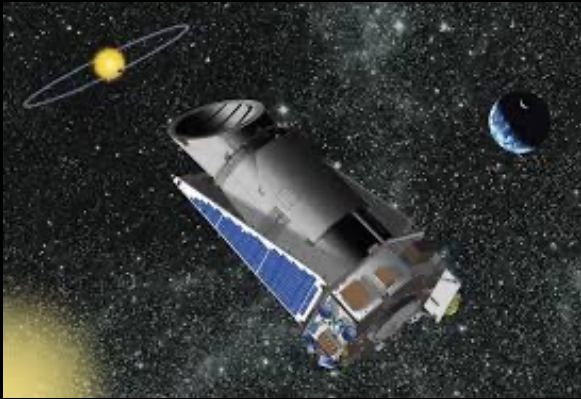
**35%**  
**NEPTUNE-LIKE**

Similar in size to Neptune and Uranus. They can be ice giants, or much warmer. "Warm" Neptunes are more rare.

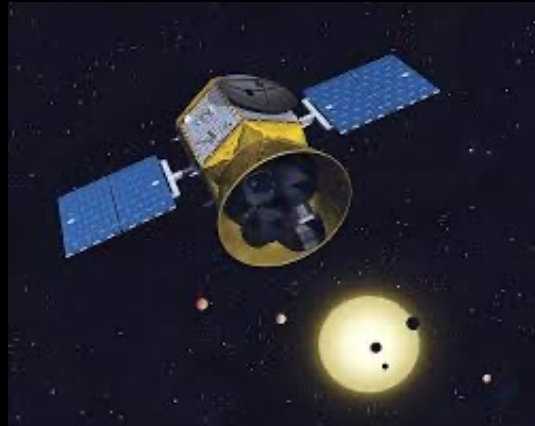


**5000+**  
**PLANETS FOUND**

# NASA missions to explore and discover habitable planets



**Kepler**



**TESS**



**JWST**



# Habitable Worlds Observatory

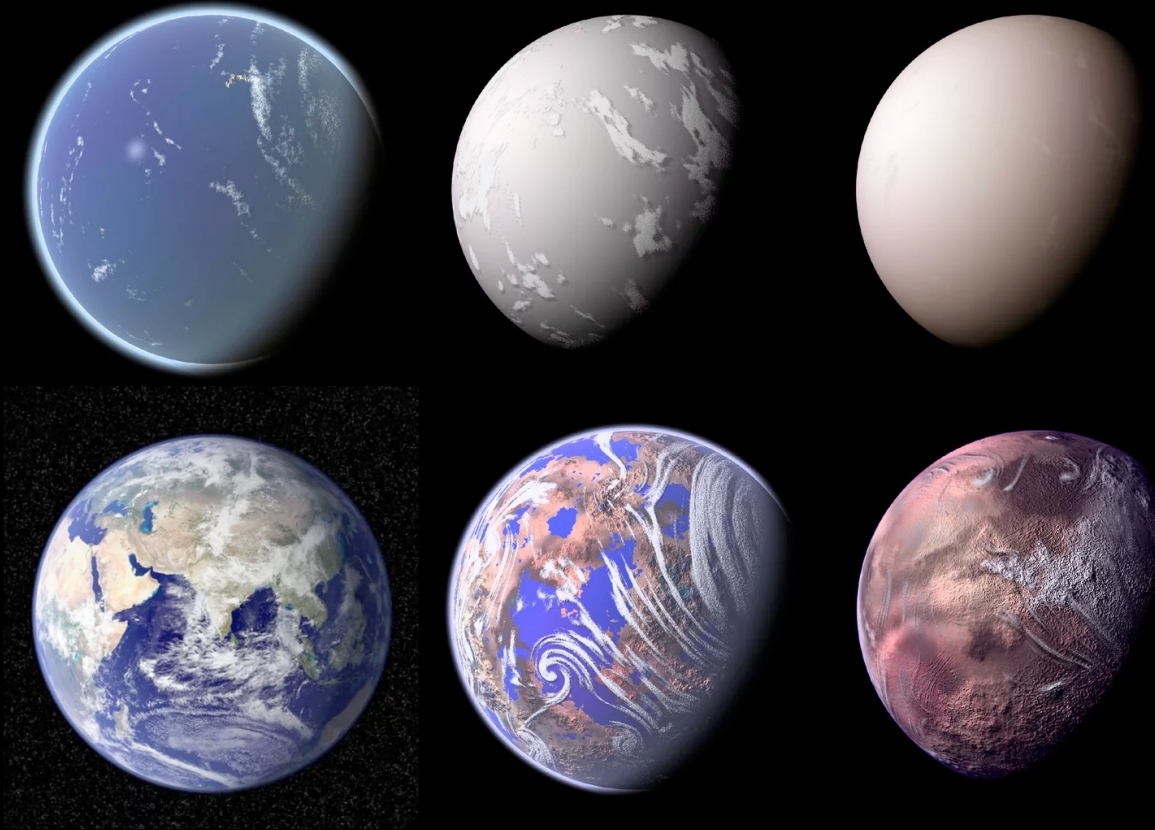


For the first time in the history of our civilization, a mission dedicated to find  
Inhabited planets.

Habitable Worlds Observatory  
Simulated Solar System Time-lapse  
Observed from 33 light-years away  
Time = 10 years, 1 second = 72 days

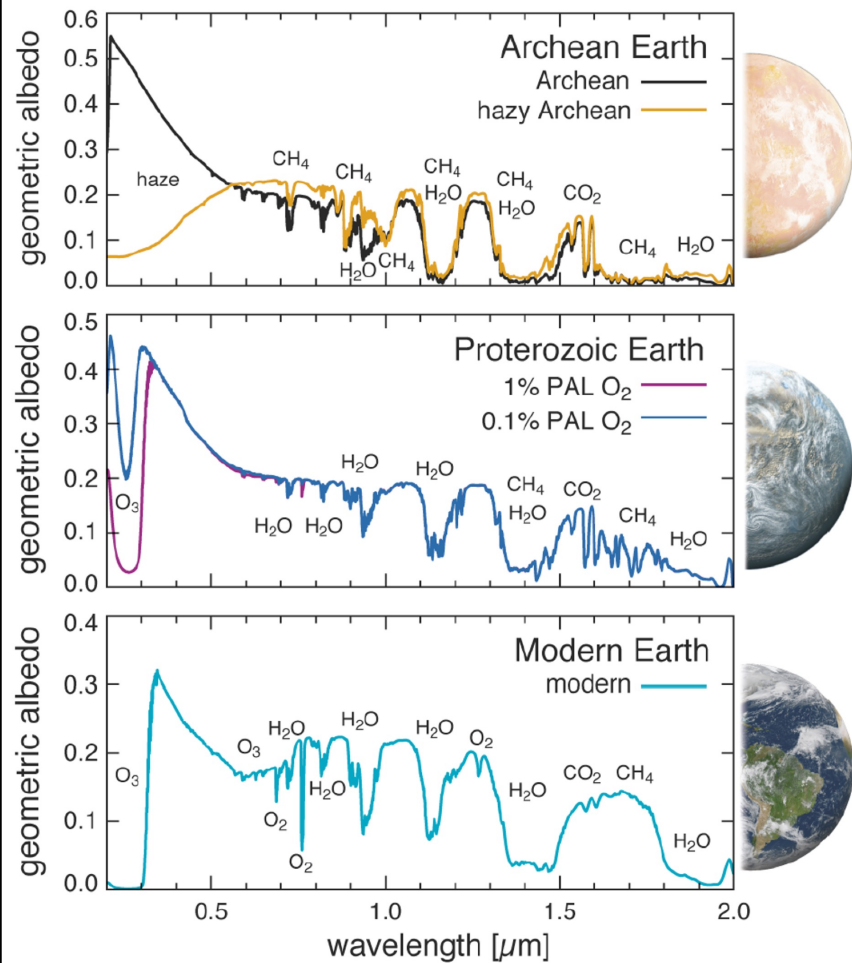


I want to find Earth-like planets!



Great! Which Earth do you want to find? Earth was not the same.

# Biosignatures



3.8-2.5 billion years ago

2.5 - 1.6 billion years ago

Current Earth

# Technosignatures



Surface structures



Laser pulses



Radio communication



Night side lights



Probes

# Pollution as a Technosignature

- Nitrogen dioxide (fossil fuel burning)
- Chlorofluro Carbons (CFCs)
- Sulfur compounds (Industrial)



# Collaborations/Participations

- NASA summer internships
- Postbac programs
- Graduate work collaborations
- ROSES proposals



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