

One-shot Outer Solar System Exploration with Software-defined Space Systems

Unsolved Mysteries In the outer solar system (and beyond)

Morgan L. Cable, Jet Propulsion Laboratory, California Institute of Technology

Short Course

Oh the Places You'll Go...

- Life in ocean worlds
- Titan's missing ethane (and other hydrocarbon tales)
- Uranus' tilt
- Triton's origins and cryovolcanism
- What's beyond Pluto?

Life in Ocean Worlds

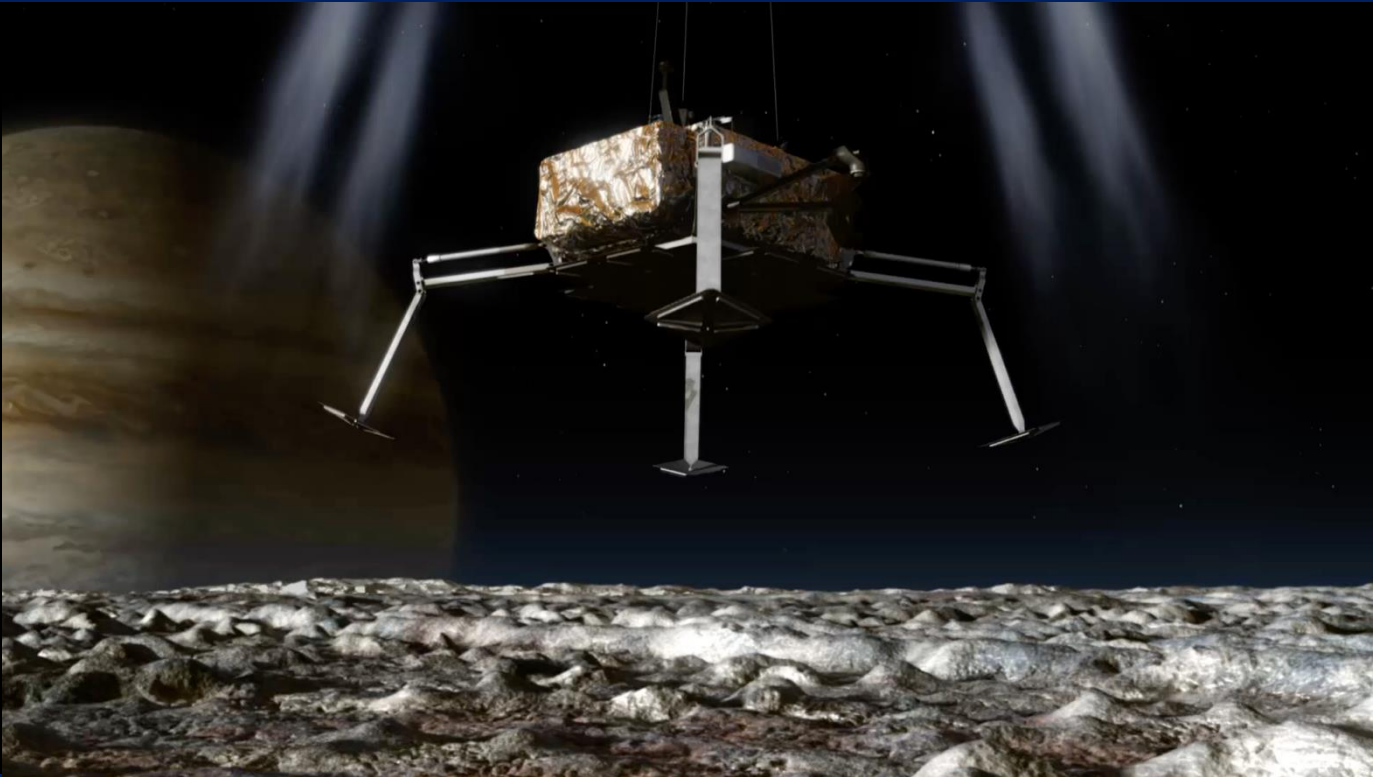


Life in Ocean Worlds

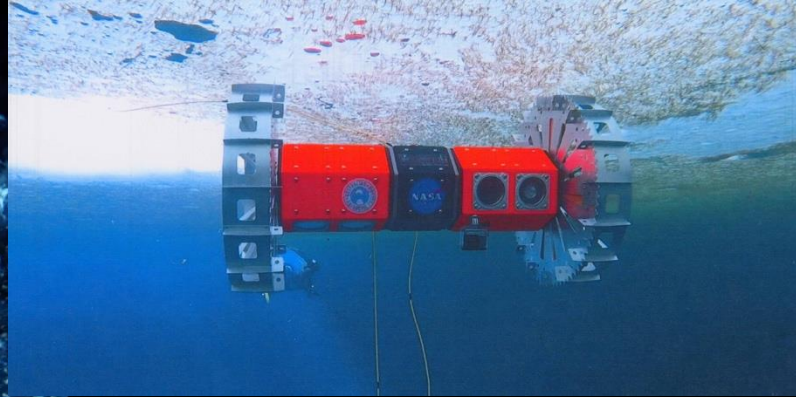
Life in Ocean Worlds



Life in Ocean Worlds



Life in Ocean Worlds



Life in Ocean Worlds

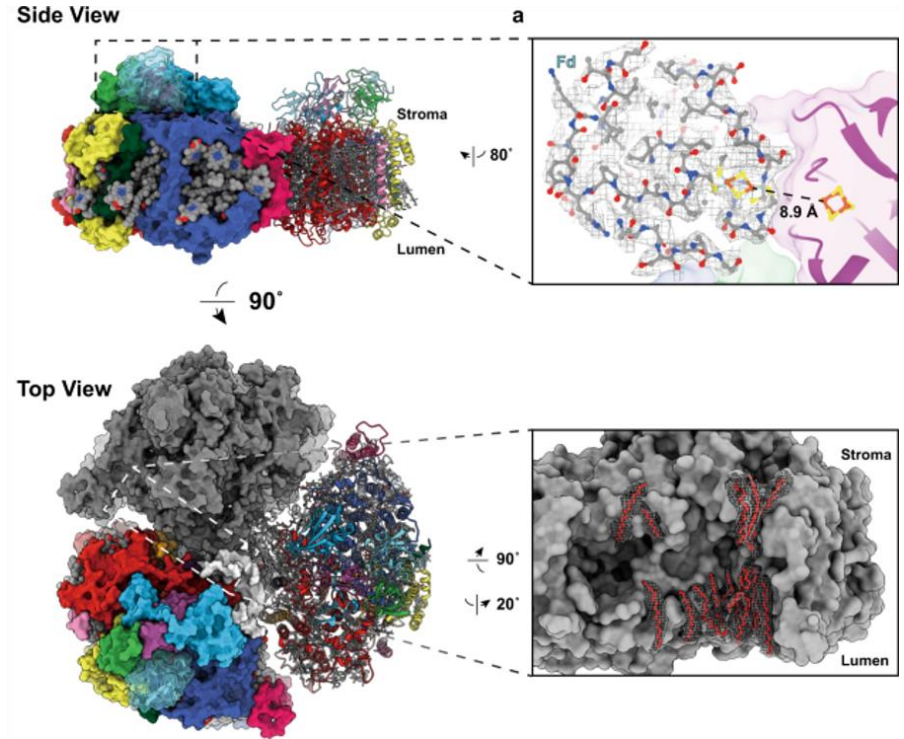
Life in Ocean Worlds



Strategies to look for biosignature molecules

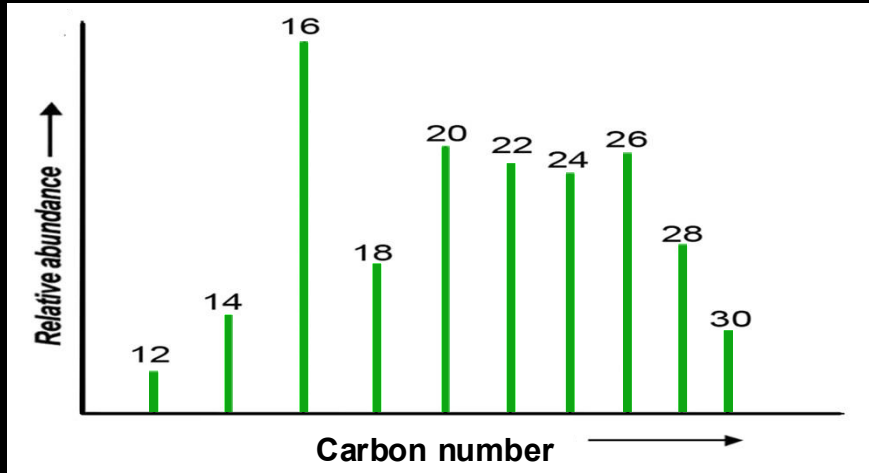
Presence of Molecules

Certain molecules such as proteins, DNA and carotenoids are so large and complex, it would be unlikely for them to form abiotically in high concentrations.

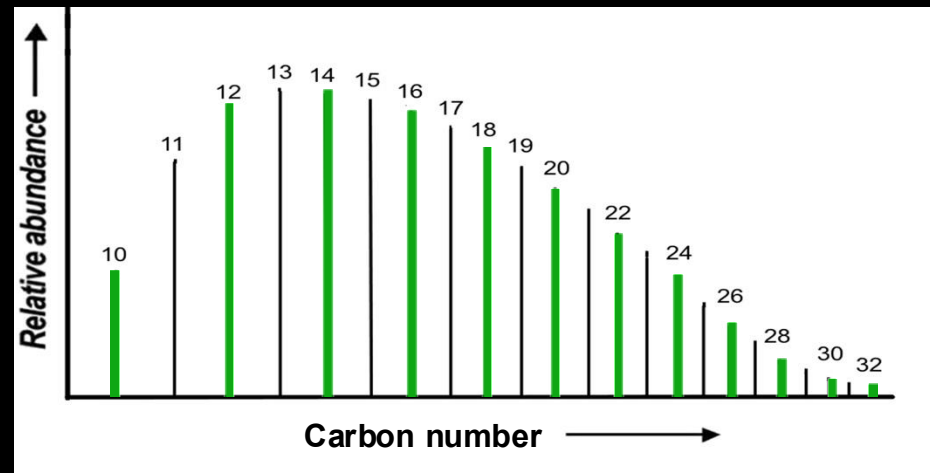


Patterns of Molecules

Fatty acids in bacteria



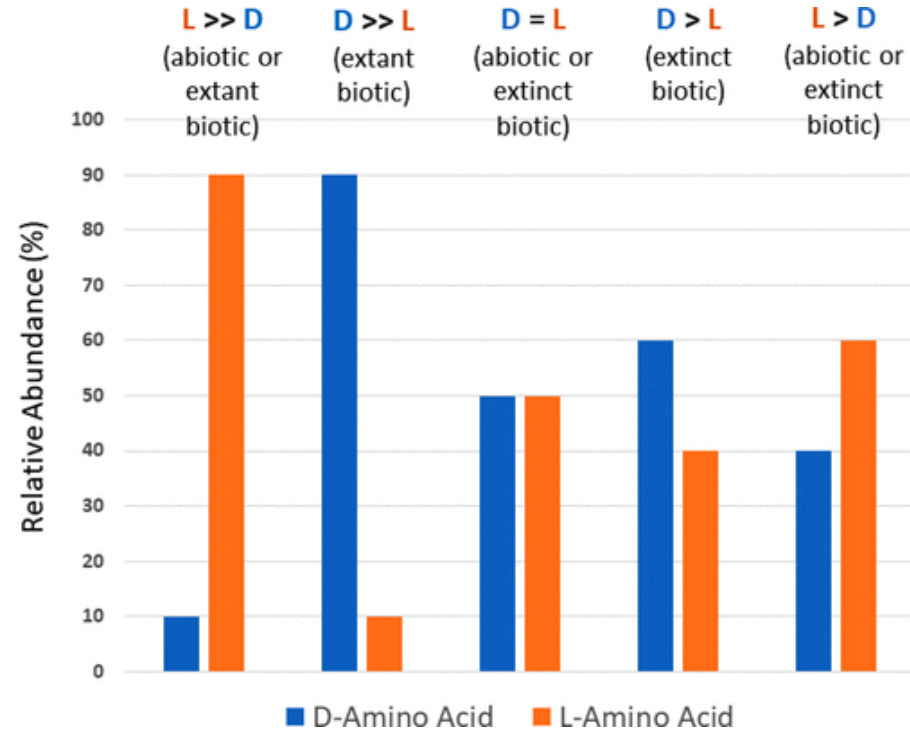
Abiotic chemistry



Biotic membranes exhibit repeating carbon subunits; abiotic environments do not.

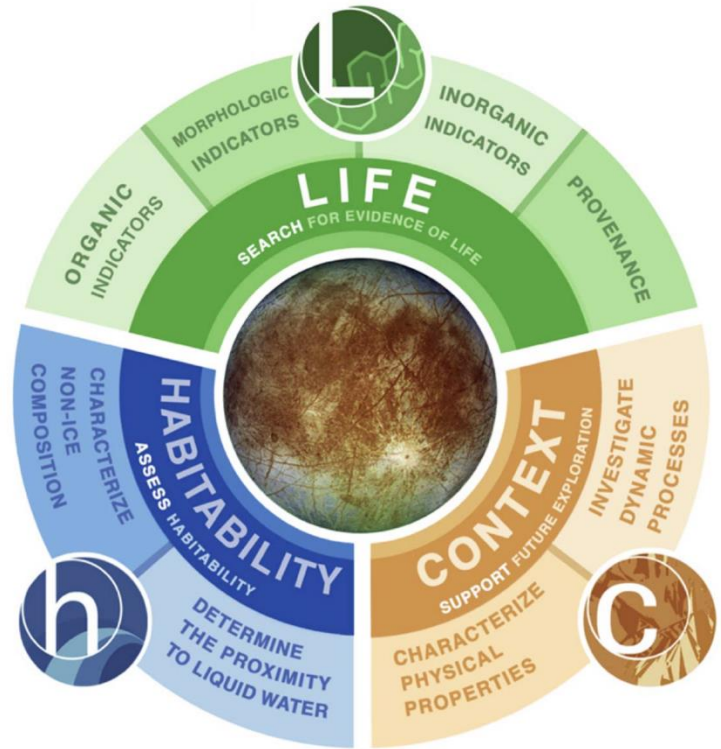
Properties of Molecules

Abiotic systems have racemic (50/50) mixtures, whereas biotic systems show enantiomeric excess in amino acids, sugars, etc.

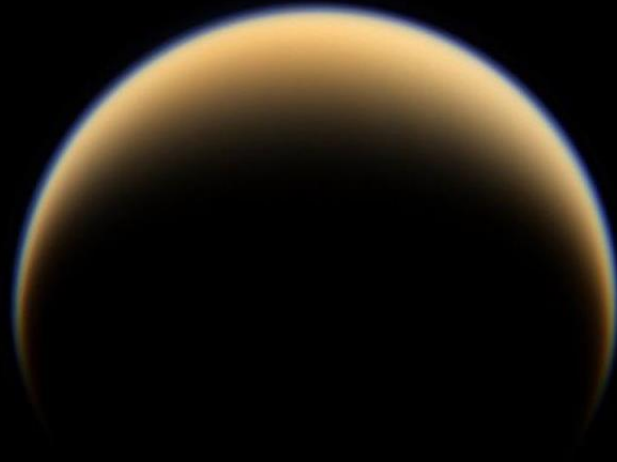


Life in Ocean Worlds

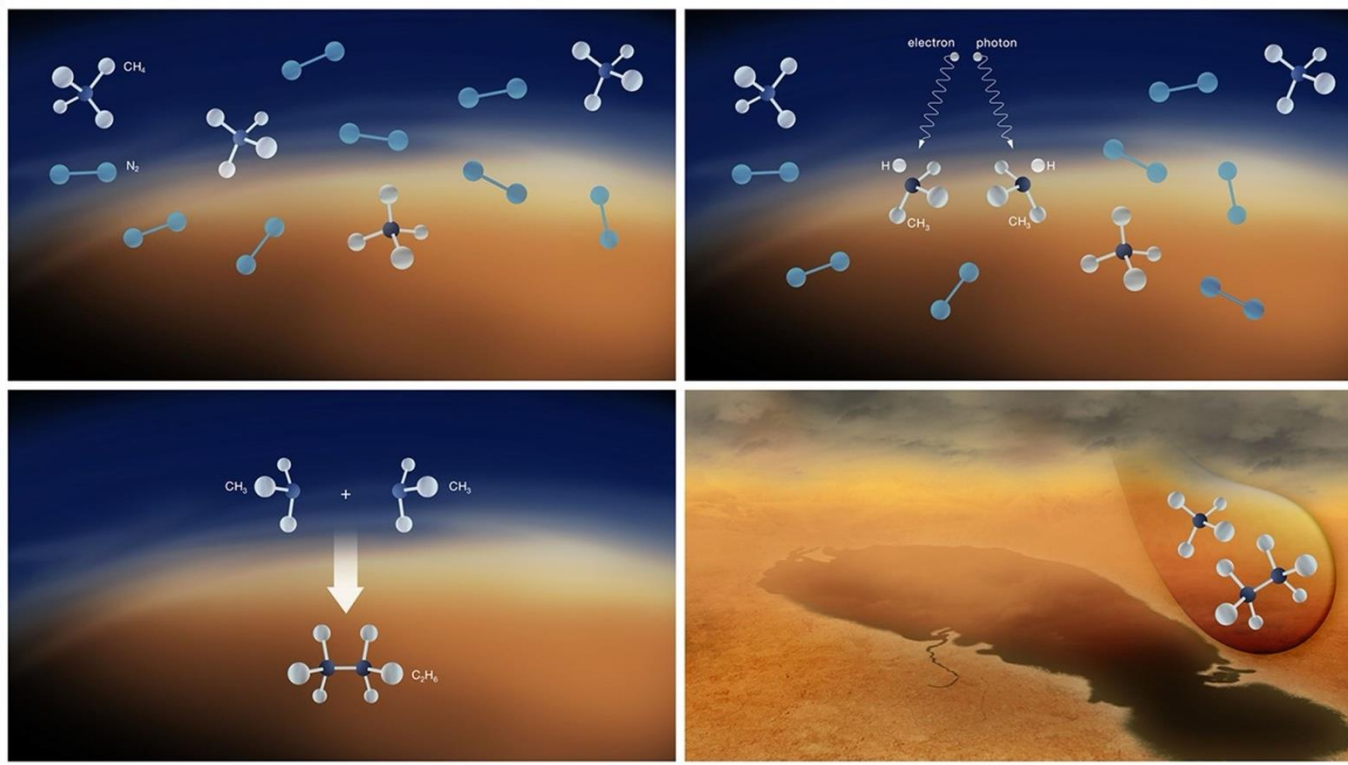
- Biosignature searches via remote sensing and in situ payloads
- Surface exploration, ultimately leading to subsurface/ocean investigations
- Physicochemical measurements to help interpret life tests



Titan's Missing Ethane (and other Hydrocarbon Tales)



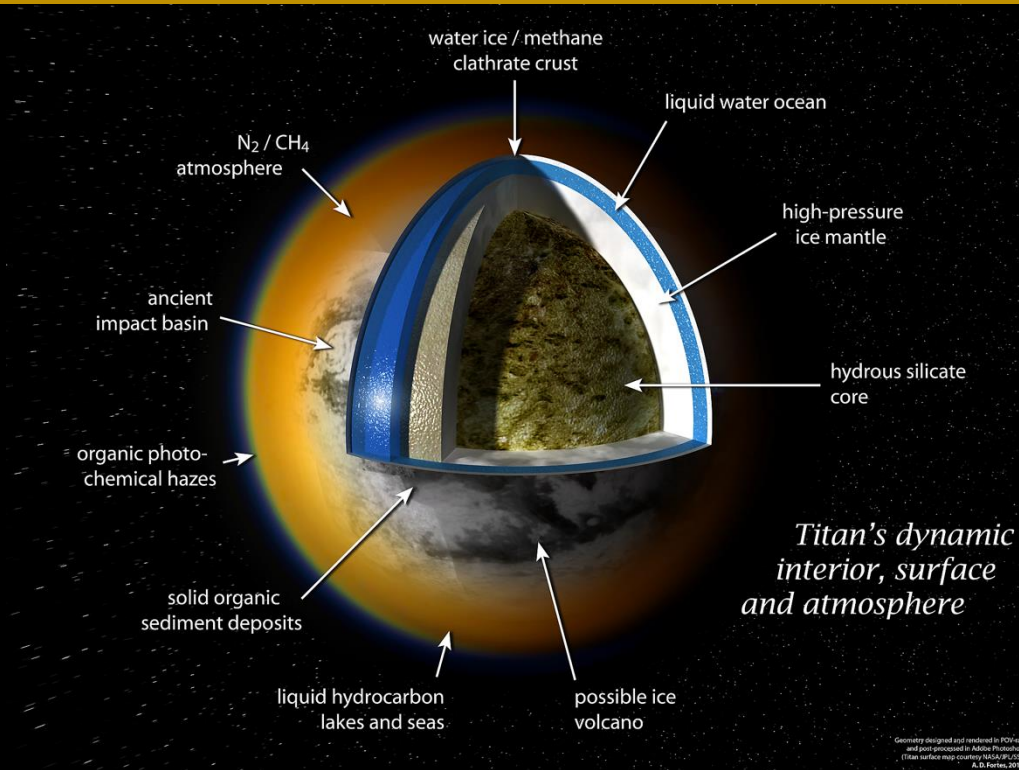
Titan's Missing Ethane (and other Hydrocarbon Tales)



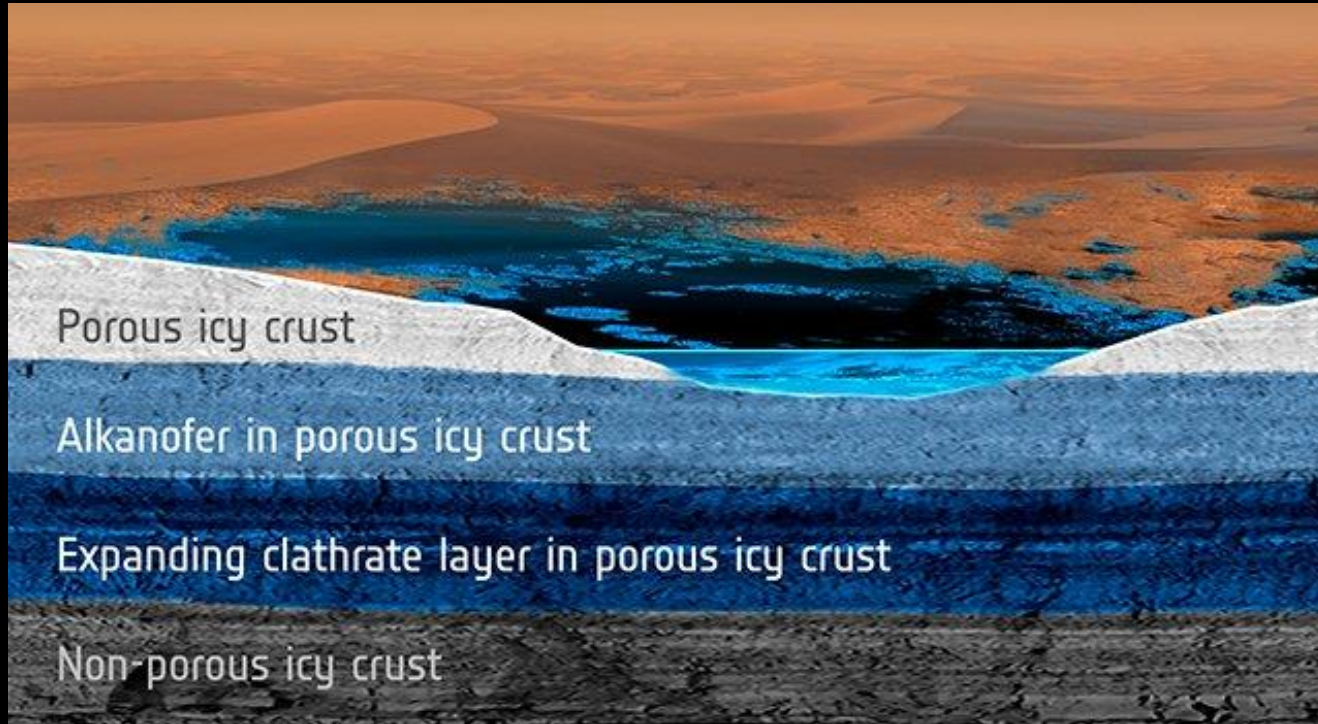
Titan's Missing Ethane (and other Hydrocarbon Tales)



Titan's Missing Ethane (and other Hydrocarbon Tales)



Titan's Missing Ethane (and other Hydrocarbon Tales)

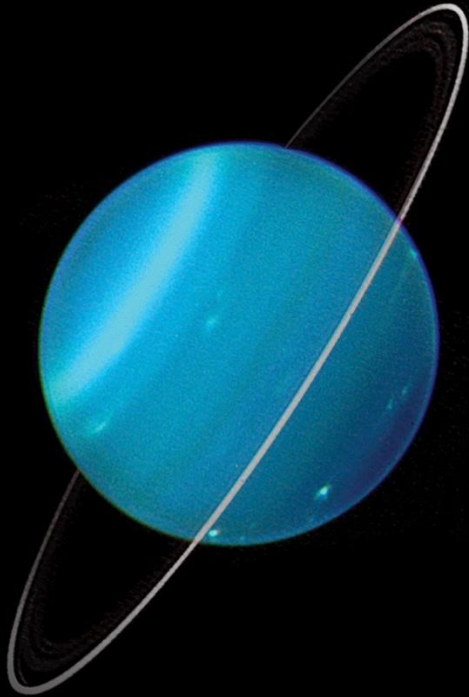


Titan's Missing Ethane (and other Hydrocarbon Tales)

- Titan surface composition
- Depth of clathrate layers (if present)
- Detailed characterization of Titan's mesosphere and thermosphere (150-900 km not sampled by any mass spectrometer)
- More detailed model of differentiation of Titan's interior
- Continued advancement in modeling Titan's atmospheric photochemistry



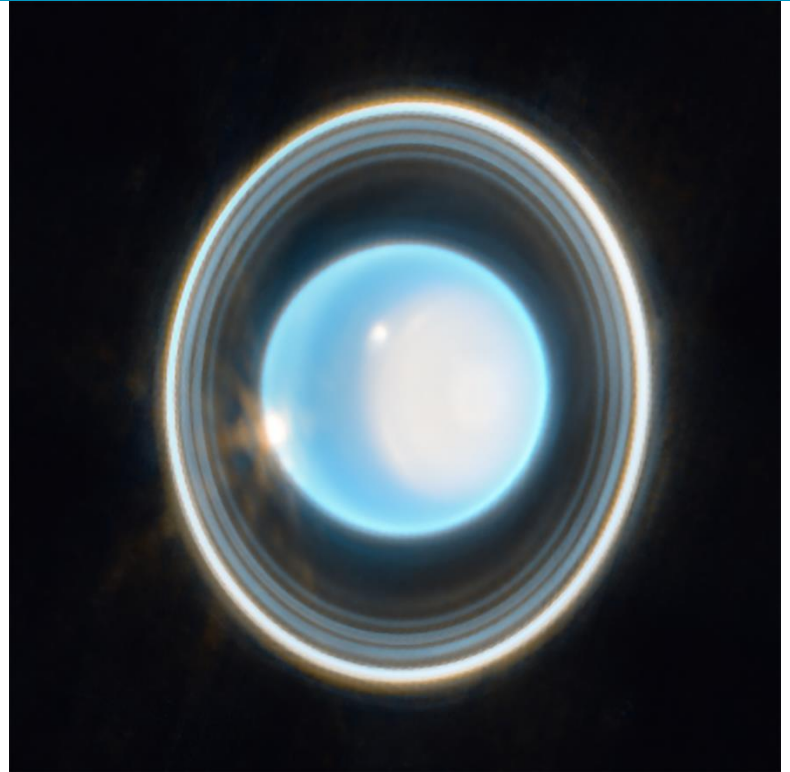
Uranus' Tilt



- Single collision/giant impact (by a protoplanet)
- Series of smaller collisions
- Large lost moon

Uranus' Tilt

- Uranian moon compositions
- Ring composition
- Atmospheric circulation and structure
- Detailed observations of Uranus' complex magnetic field



Triton's Origins

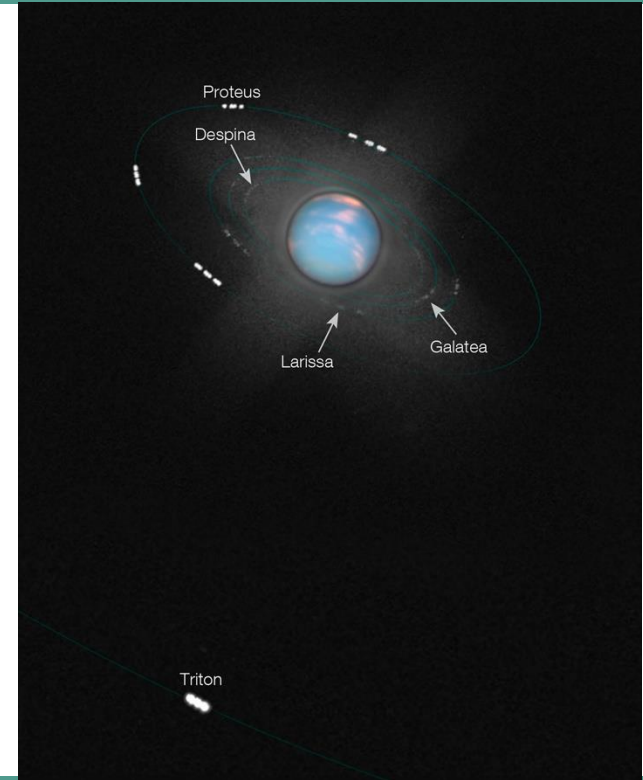
- Retrograde orbit
- Chaotic capture mechanics (broken up binary?)

Triton's Cryovolcanism

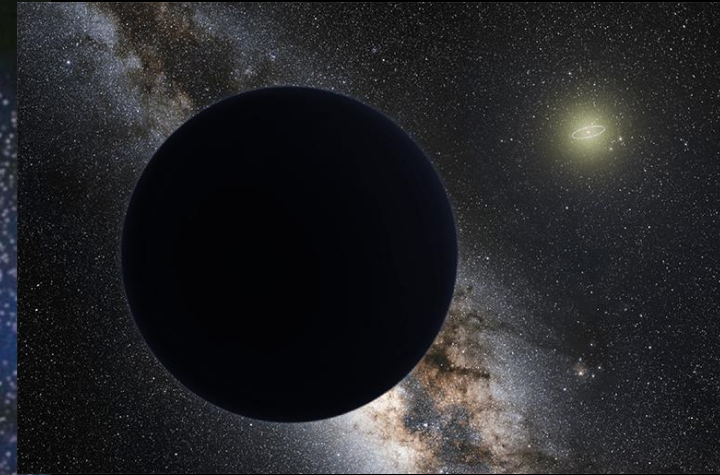
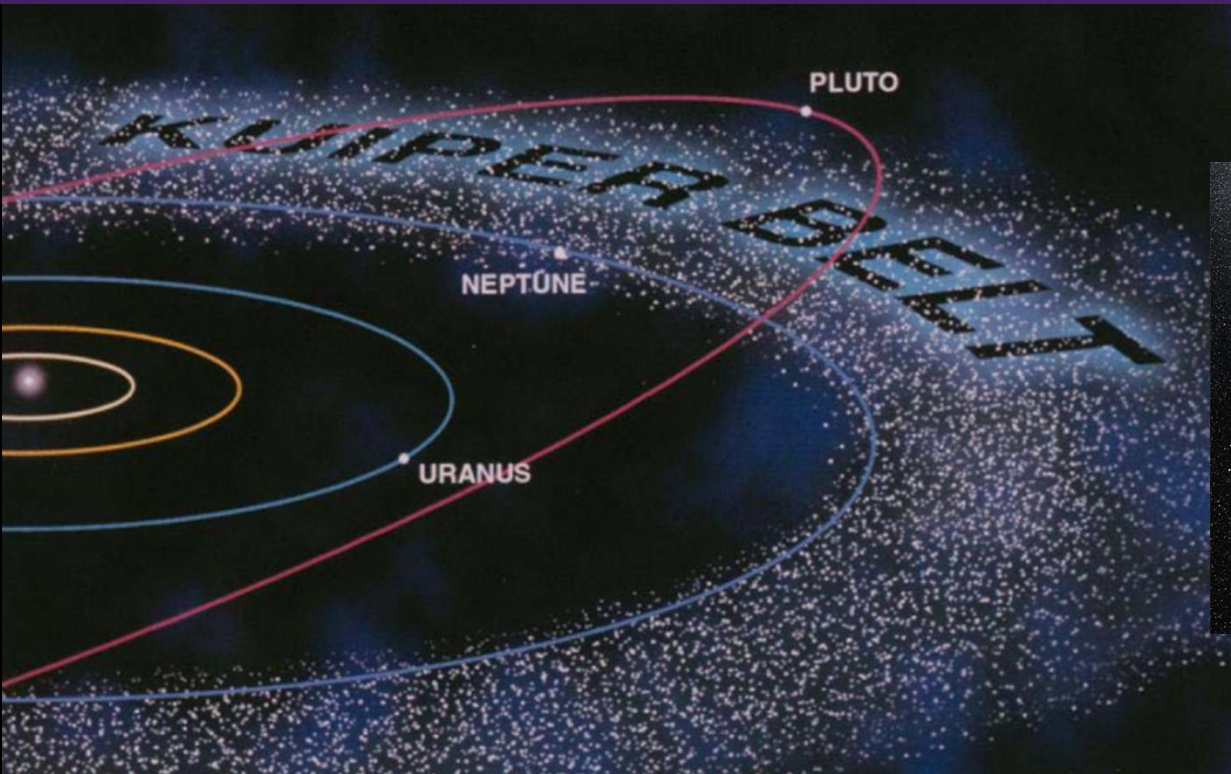
- Young surface, thin atmosphere
- Over 100 dark surface fans on bright south polar terrain
- Solar driven?
- Radiogenic heating?
- Clathrates?

Triton's Origins and Cryovolcanism

- Neptunian moon ephemerides and compositions
- Global imaging and spectroscopy of Triton to resolve active plumes
- Modeling of moon orbit evolution around Neptune
- Kuiper belt object compositions for comparison

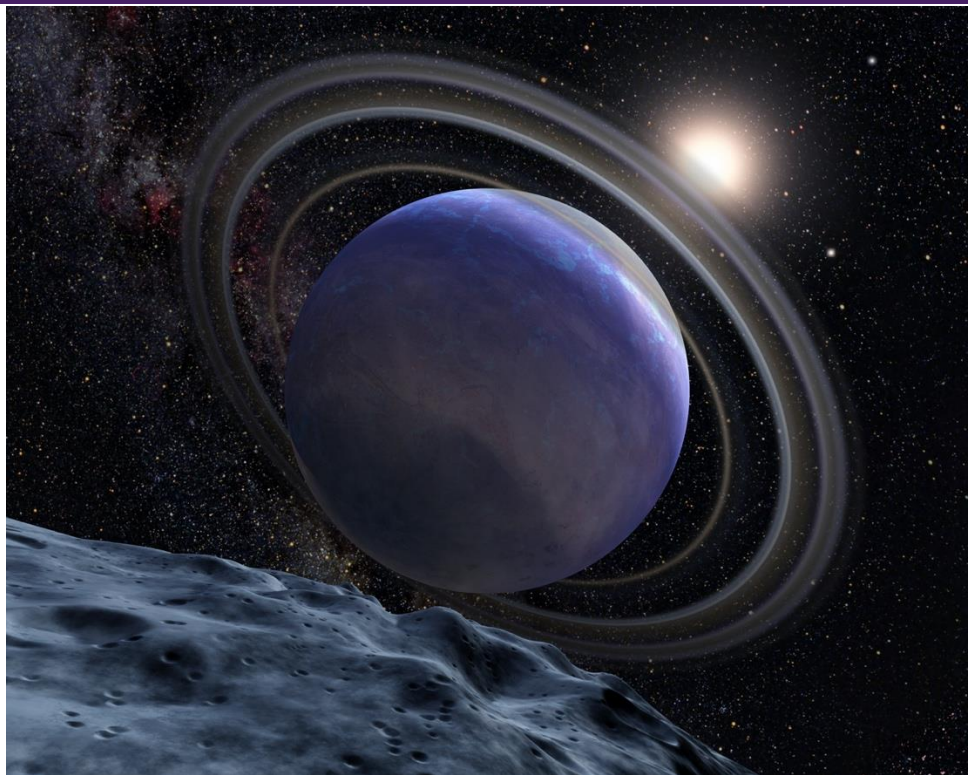


What's Beyond Pluto?



What's Beyond Pluto?

- Sizes, compositions, and orbits of objects beyond the Kuiper Belt
- Search for and characterize rogue planets and other objects not bound to our Sun
- Continue to identify and characterize exoplanets and the diversity of planetary systems in our galaxy



Even further out...

- What makes up the fabric of interstellar space?
- How could we survive long-term away from Earth?
- What conditions are necessary for life to arise, and how quickly might it arise once those conditions are met?
- Do all solar systems have habitable planets?
- How is a habitable planet built?