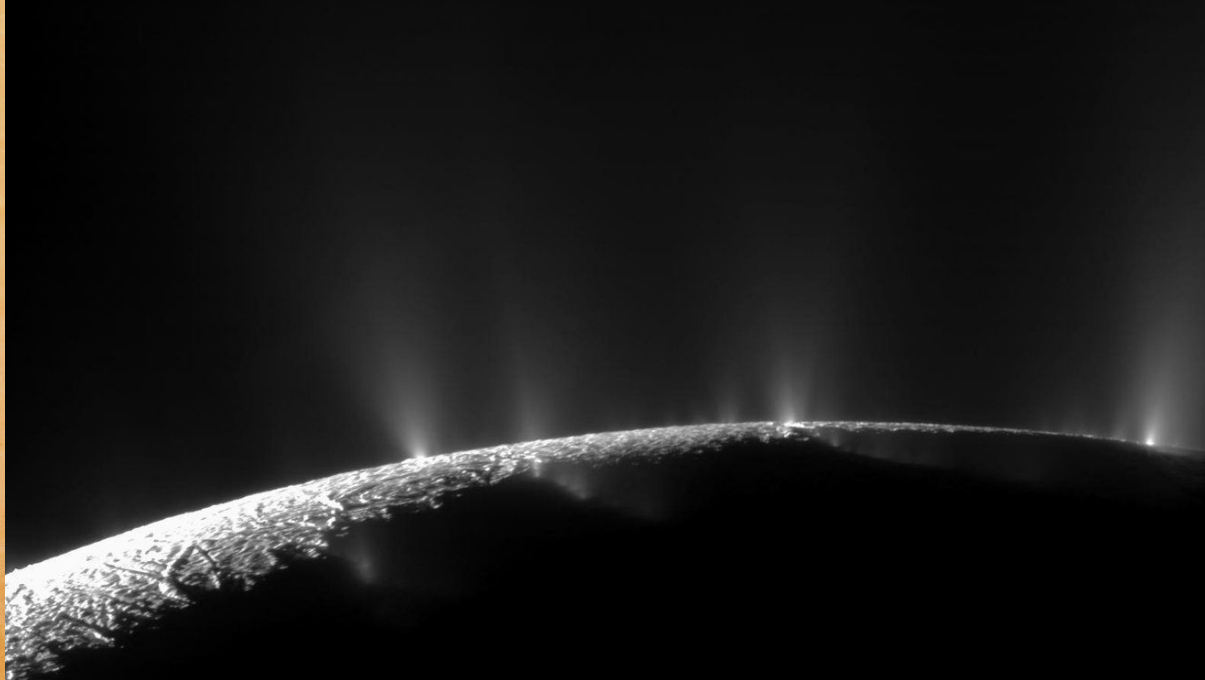


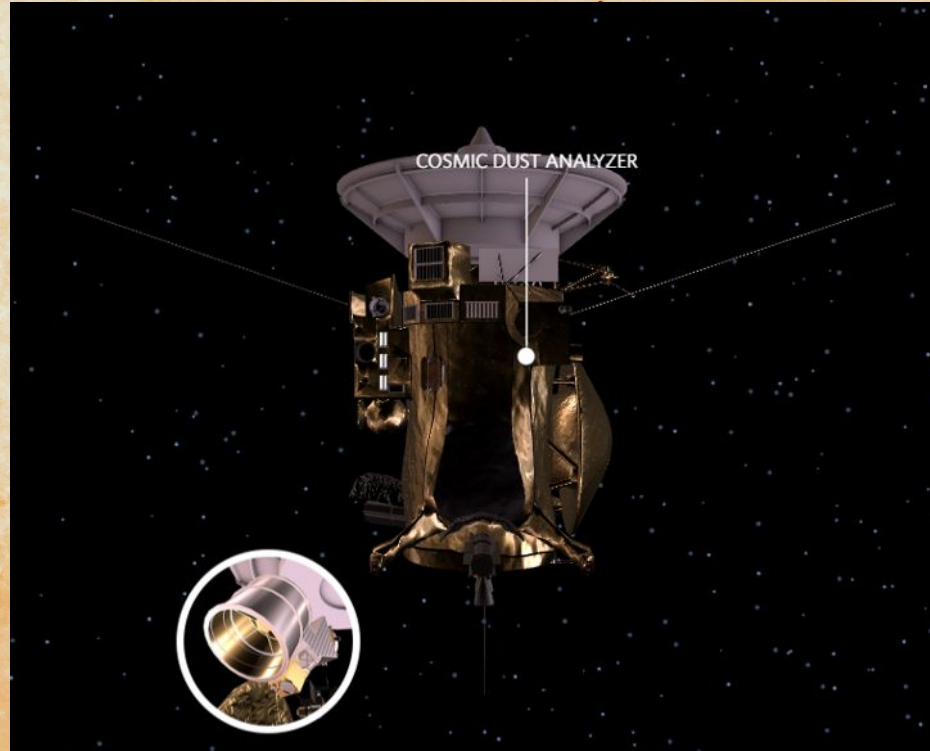
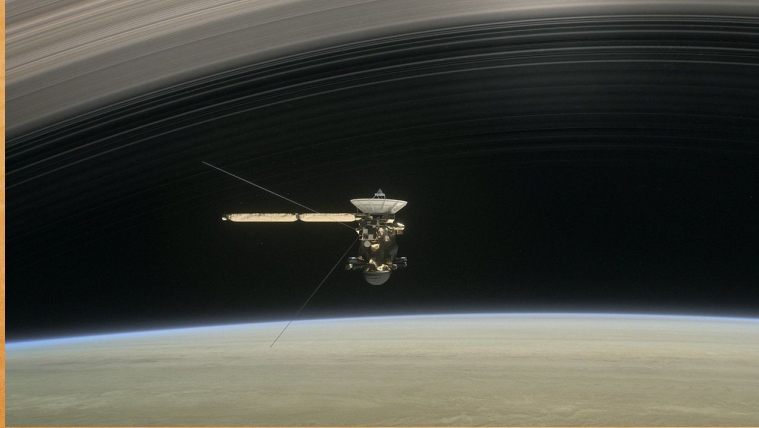
Show Notes – Phosphates from Enceladus's Ocean



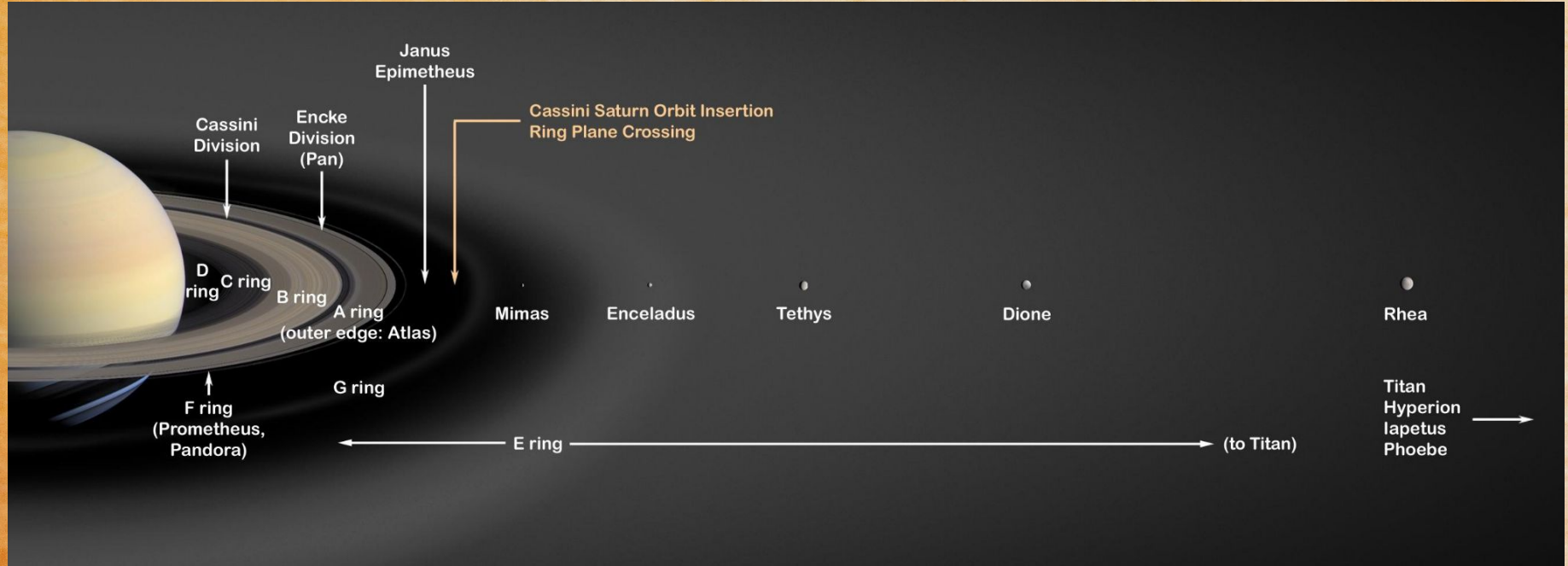
[Watch the YouTube Video](#) | [Blog Post](#) | [Research Paper](#)

Cassini Spacecraft Overview

- Launched in 1997
- Arrived at Saturn in 2004
- Sent data back until 2017
- Grand Finale - Crashed into Saturn's atmosphere in 2017



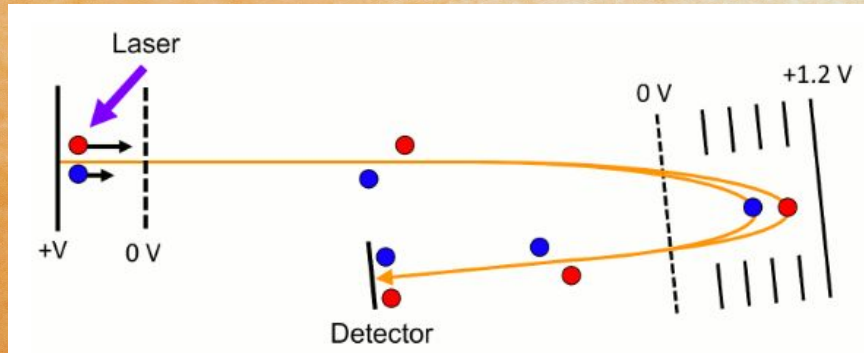
Study Focussed on Particles from the E Ring



"The E-ring of Saturn is formed by ice grains escaping Enceladus's plume into orbits around Saturn."

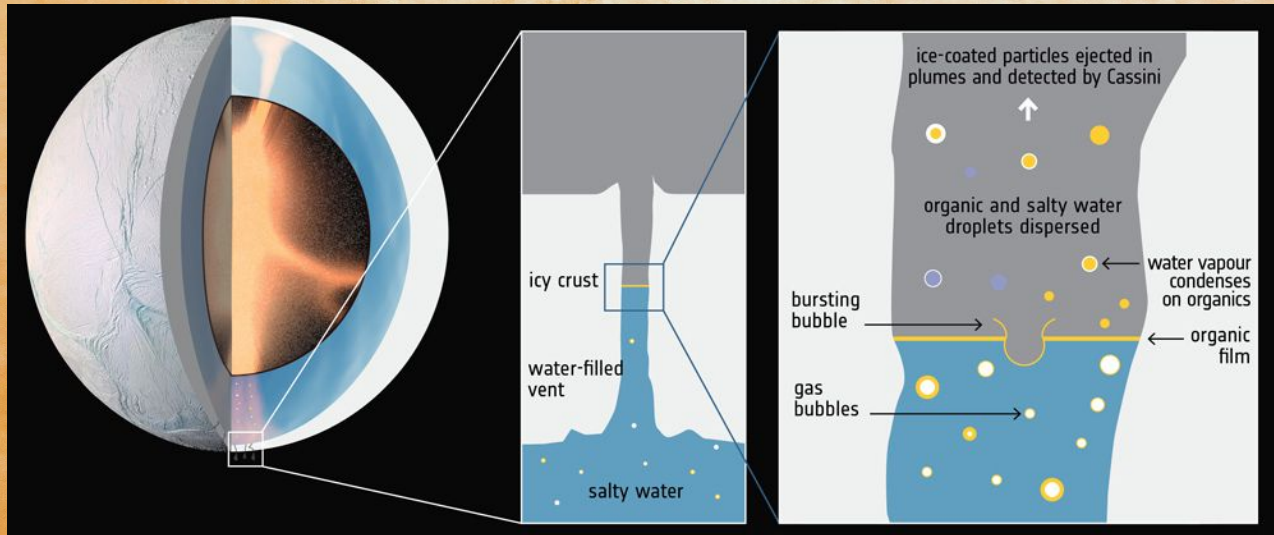
Grains Collected by Cassini's Cosmic Dust Analyzer

- Bucket shape was used to catch dust particles
- Particles were analyzed by mass spectroscopy
 - Laser detects new particles
 - Charged particles deflected by an electric field
 - Rhodium detector notes impacts
 - Time of flight is inversely correlated with particle mass



Volcanic Activity on Enceladus

- Interior of Enceladus is heated through tidal forces from the pull of Saturn and its other moons
- The hot rocky core melts water ice into liquid
- Organic-rich liquid percolates up to the frozen surface

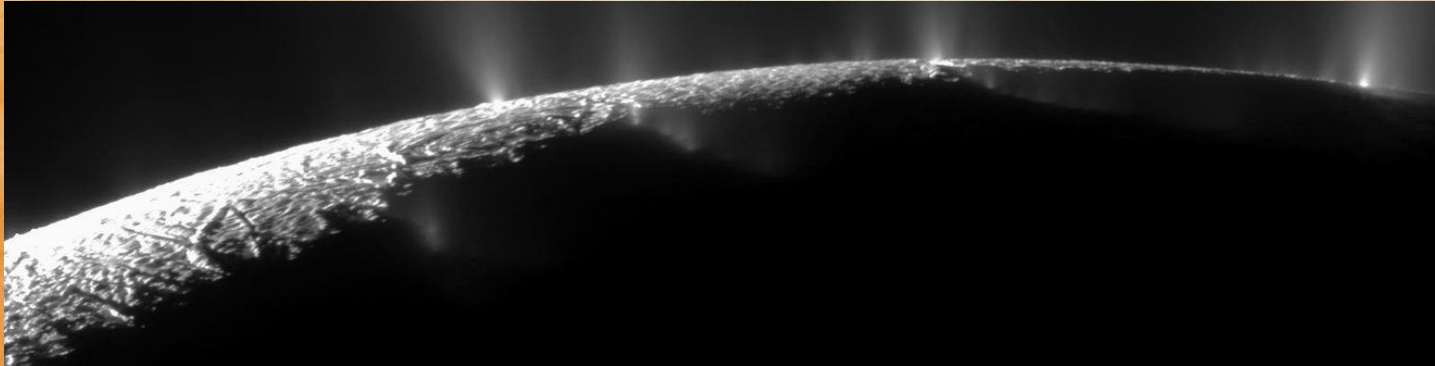


Primary Constituents of the E Ring

- The constituent atoms of Saturn's rings were previously characterized by their EM absorption spectra

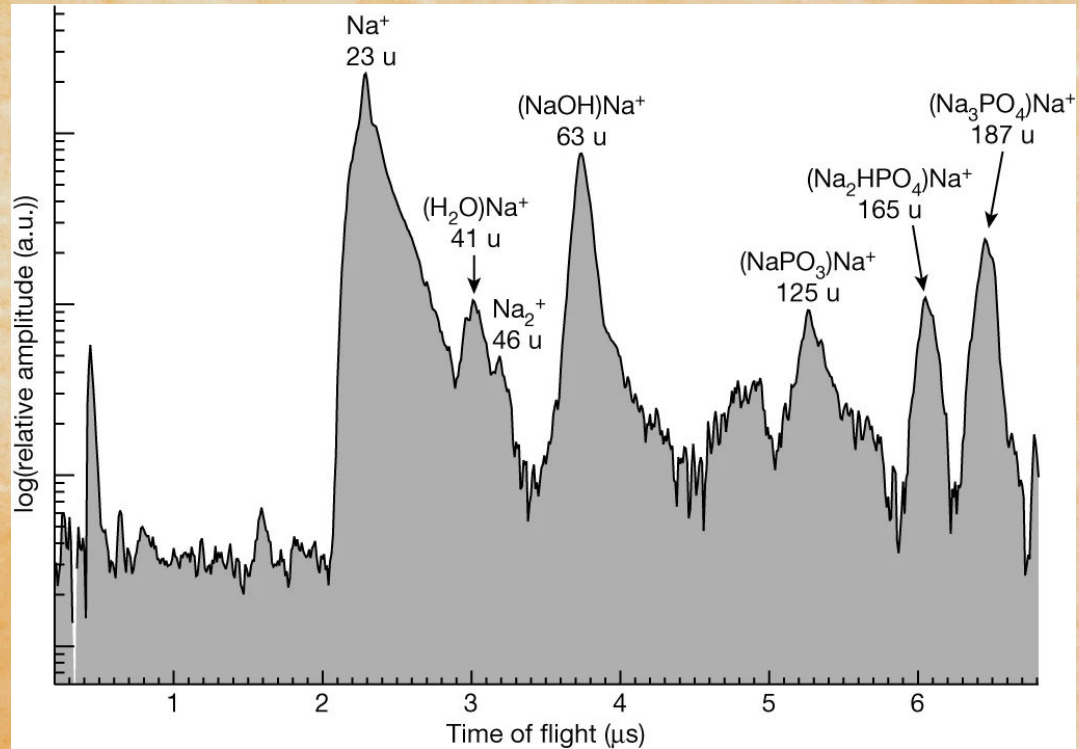


- The absorption spectra of the E Ring matches the spectra of material coming from Enceladus's geysers

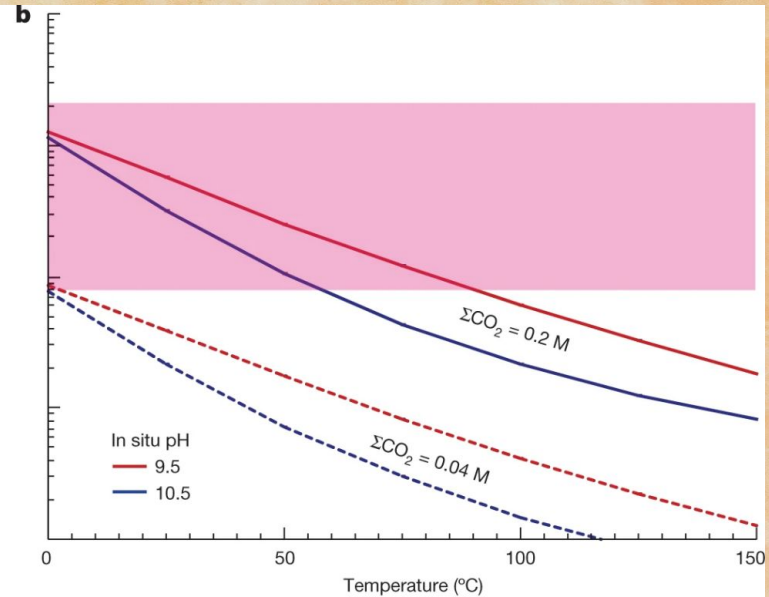
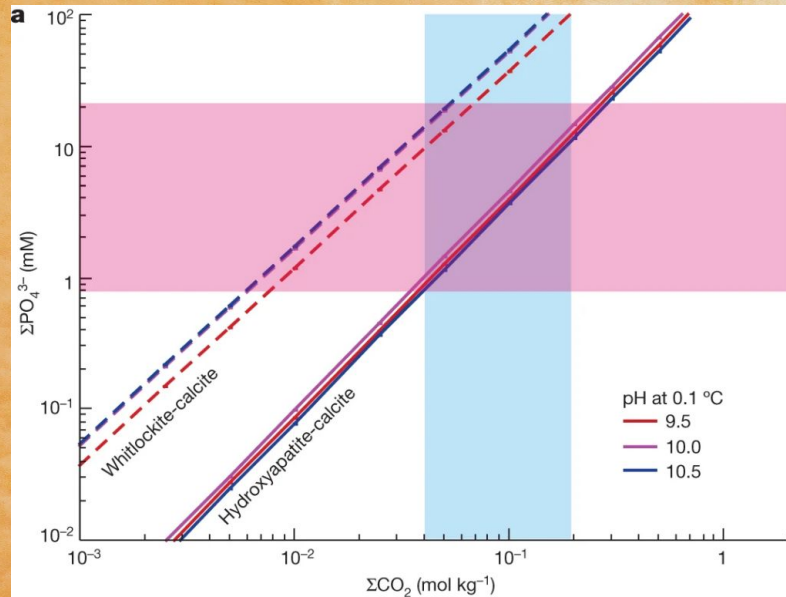


Dust Compositions Analyzed by Mass Spectra

- 345 particles were analyzed
- 9 were found to contain Sodium Phosphates
- The other 336 mostly consisted of Sodium Carbonates and Chlorides
- Researchers assumed the composition of the ice crystals matched Enceladus's ocean



Possible Ocean Compositions Were Hypothesized

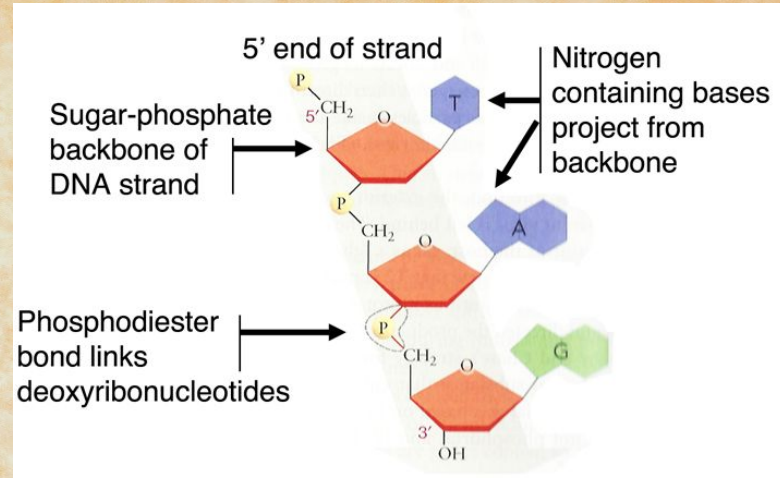
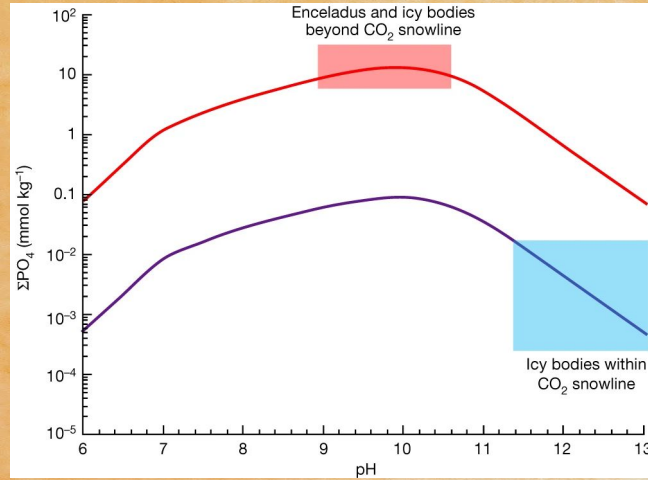


Pink corresponds to potential phosphate concentrations and blue to carbonate concentrations. Solubility is related to temperature. The graph on the right shows possible pH states relative to temperature above 0 °C.

Phosphates are Abundant in Enceladus's Ocean

- “Even with a conservative margin, our estimate indicates concentrations in the order of at least hundreds of micromolar, several 100-fold the average phosphate abundance in Earth’s oceans”
- “Of the six elements—C, H, N, O, P and S—that are generally considered to be critical ingredients for life based on water and organic chemistry, phosphorus is cosmochemically the least abundant and has not previously been detected at any of the ocean-bearing moons in the Solar System.”
- “However, the results presented here demonstrate that Enceladus instead has a high availability of dissolved P, which is thus extremely unlikely to be a limiting factor in the survival of putative life on Enceladus—and perhaps also on other ocean worlds that reside beyond the CO₂ snowline in the Solar System.”

Wider Implications



- DNA and ATP require phosphates
- Solar System bodies that form beyond the CO_2 snowline are expected to have higher phosphate concentrations due to having lower pH
- “Regardless of these theoretical considerations, with the finding of phosphates the ocean of Enceladus is now known to satisfy what is generally considered to be the strictest requirement of habitability.”

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