Sample Return from Europa & Enceladus using Ares V

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Ares V

Adds mass, not dollars, to planetary missions

Cheap, but useful, mass

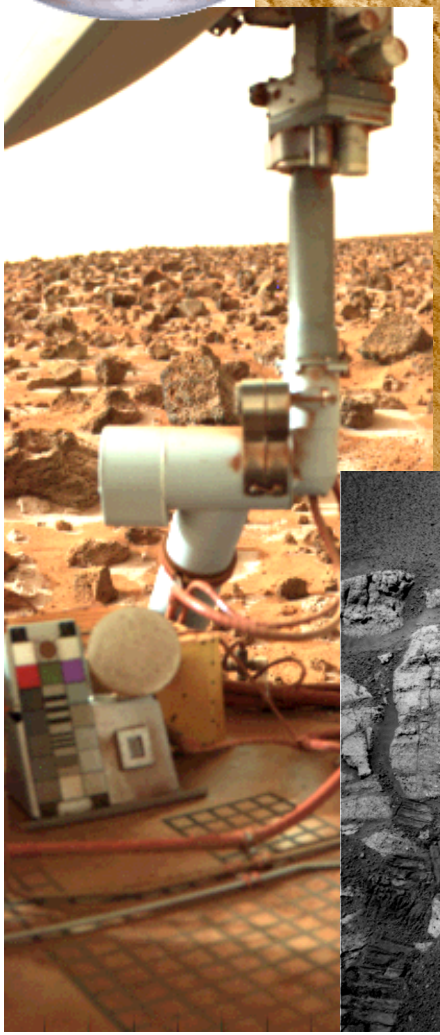
1. Fuel for ΔV
2. Shielding (lead)
3. Drill string and casing
4. Duplicates (~30) of a small lander

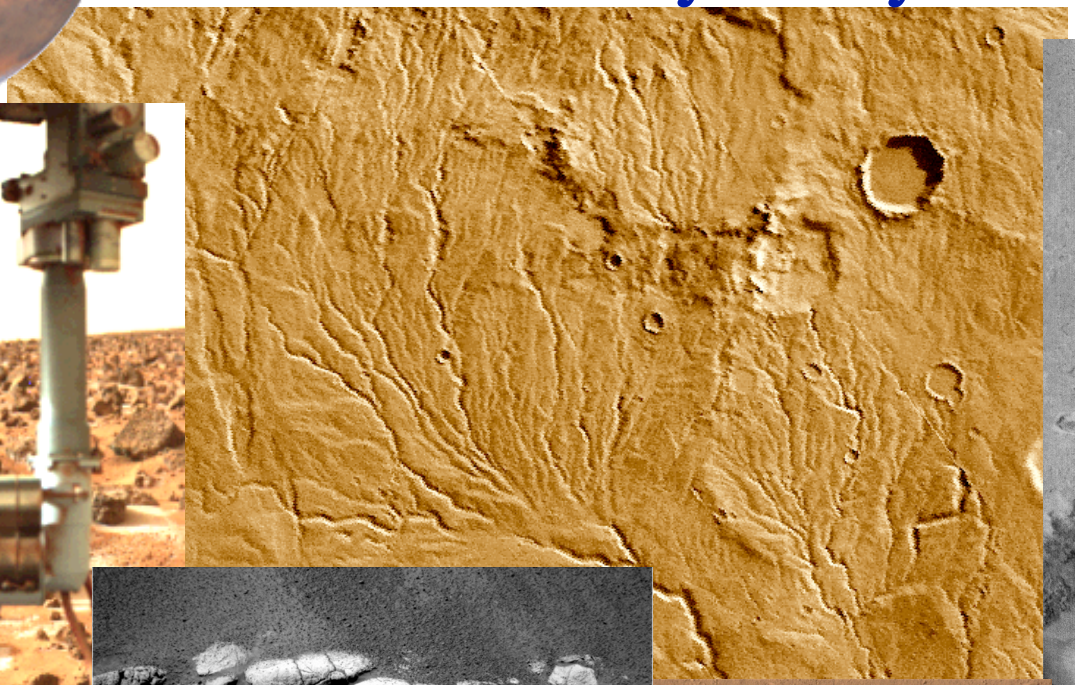
Why is Life on other Worlds Interesting?

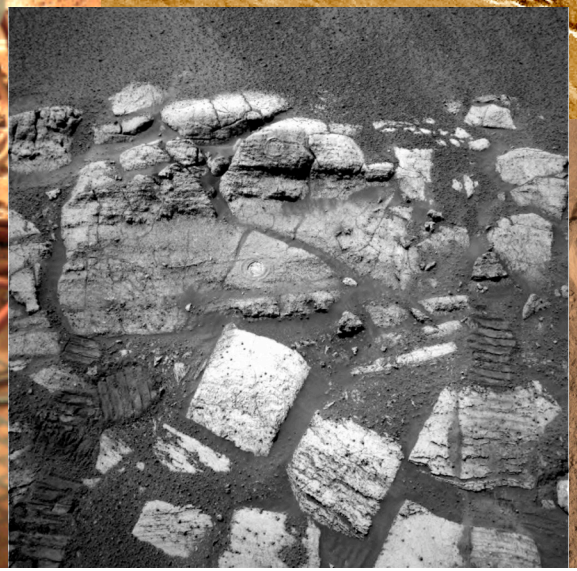
- The possibility of a second genesis of life:
  $\Rightarrow$ comparative biochemistry
  $\Rightarrow$ life is common in the universe (yeah!)

- Information about the early planetary environment
- Relevant to the origin of life on Earth

Mariner 9 discovers evidence for water and past flow on Mars. Confirmed and rediscovered by many following missions.

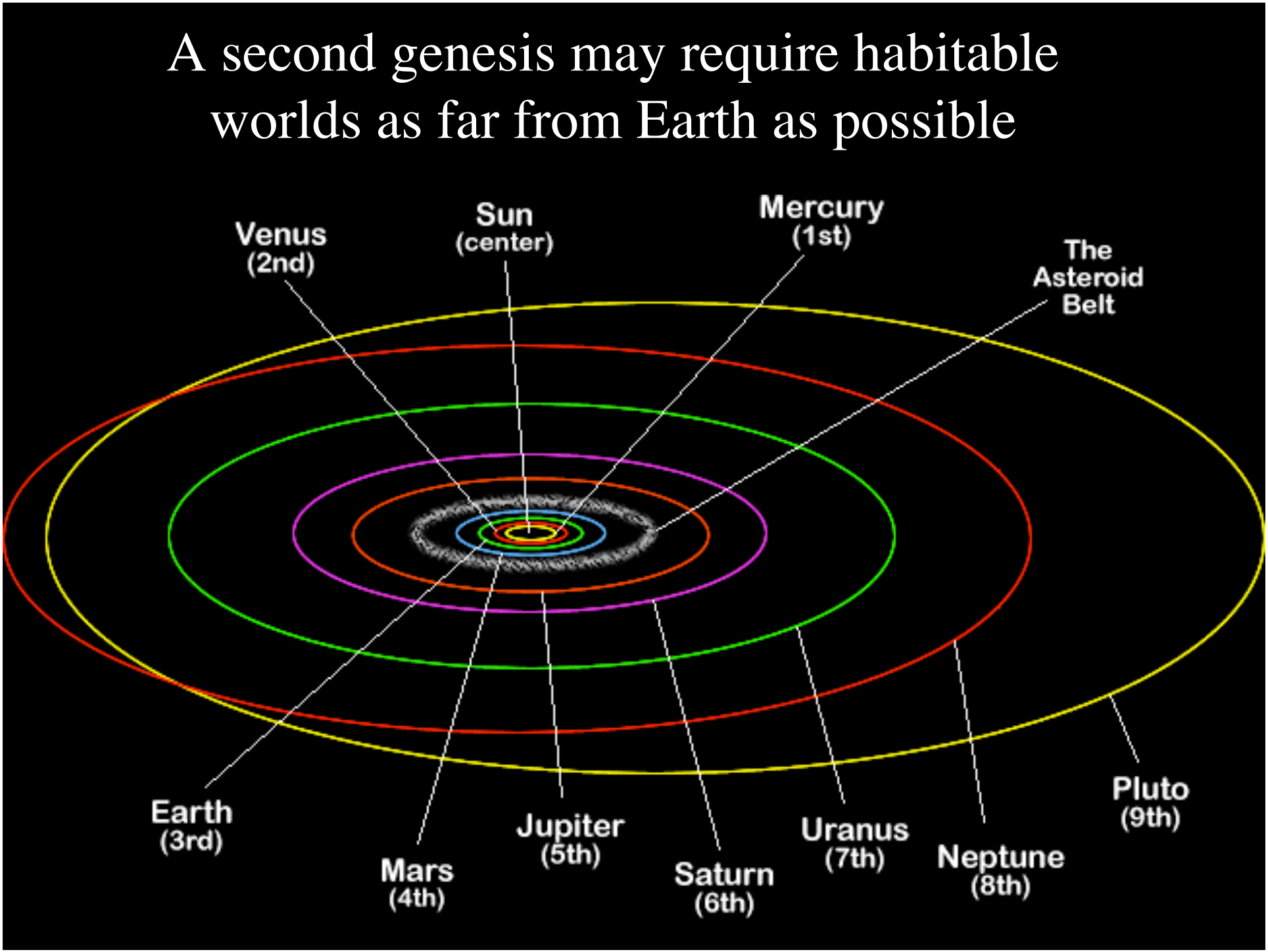


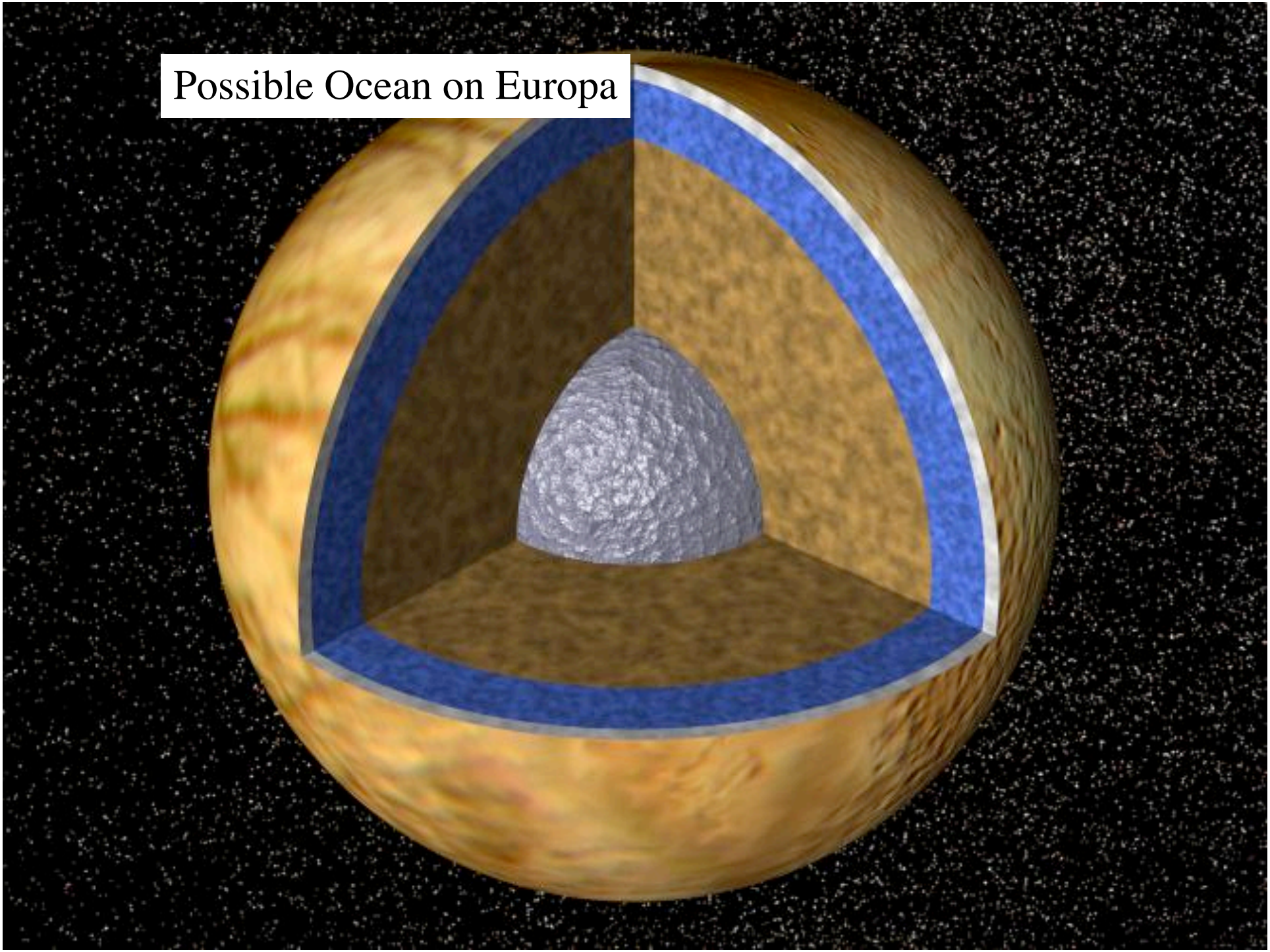


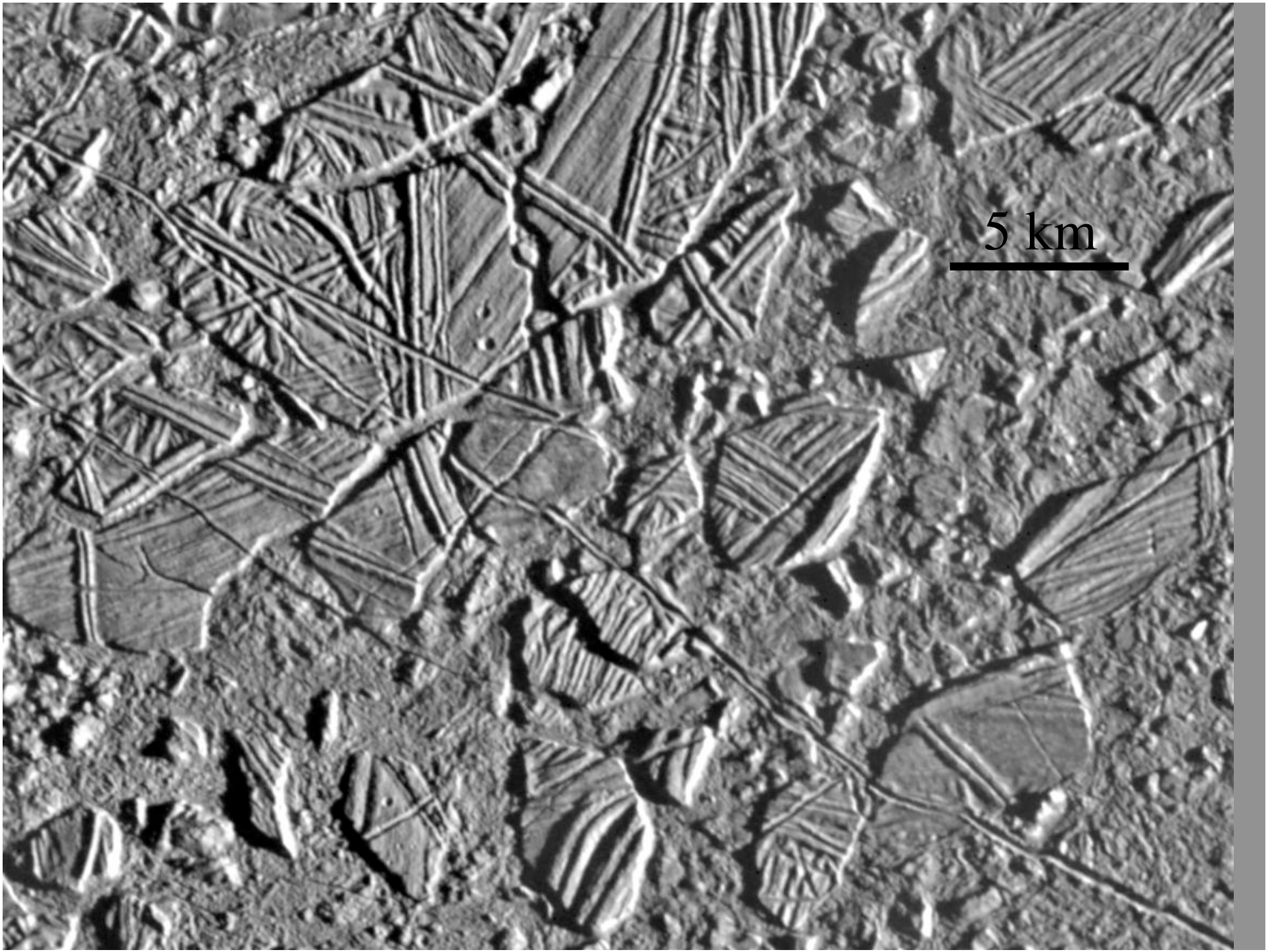



ALH84001,0
1 cm
E
Image by Don Davis
© NASA, courtesy of the Lunar and Planetary Institute

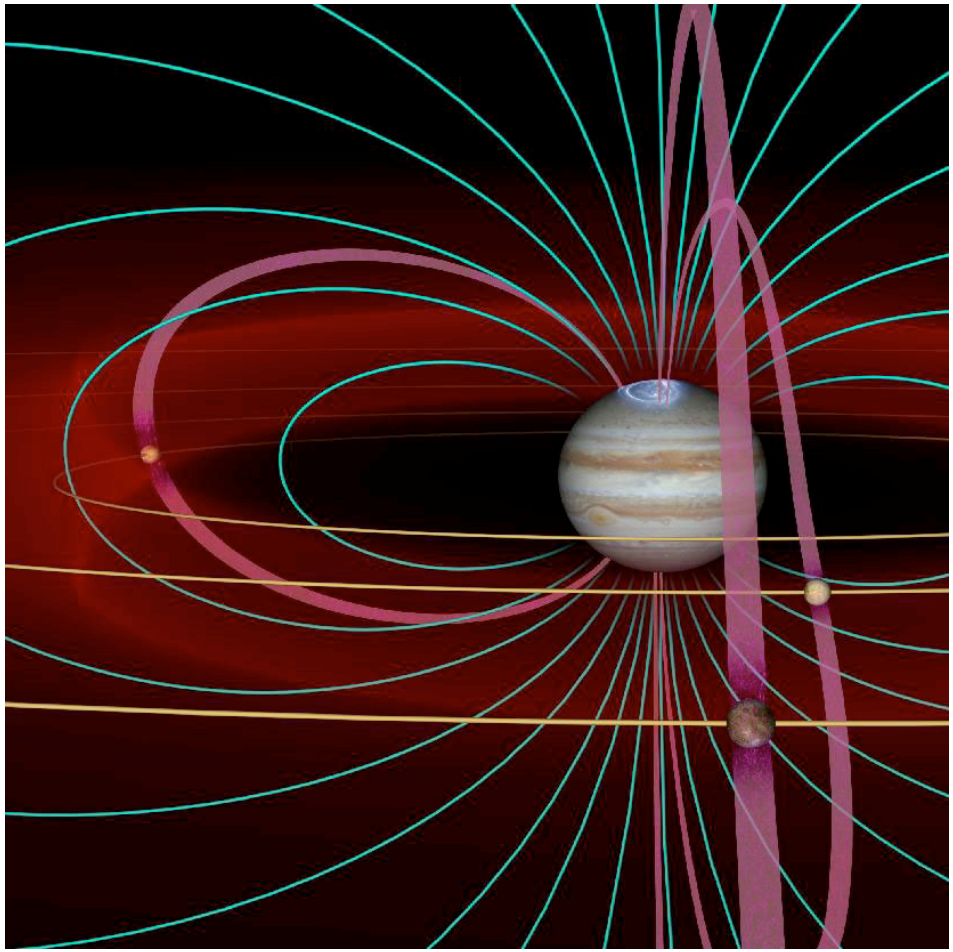
A second genesis may require habitable worlds as far from Earth as possible

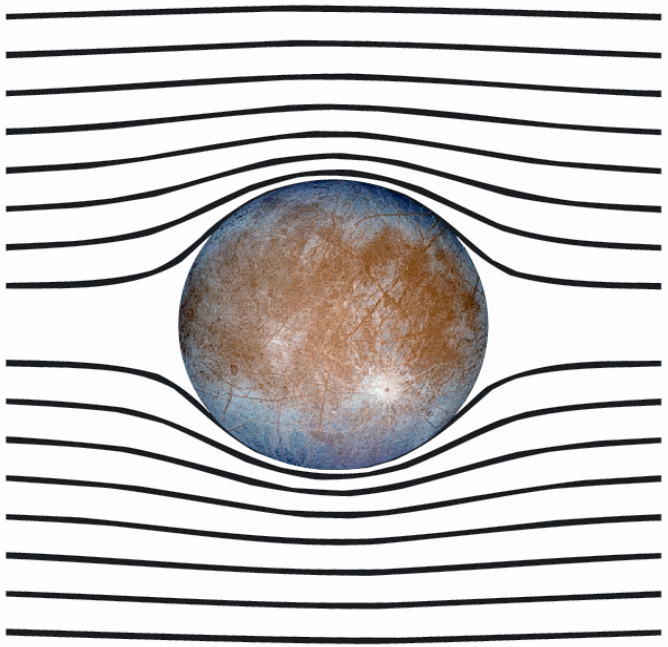



Possible Ocean on Europa

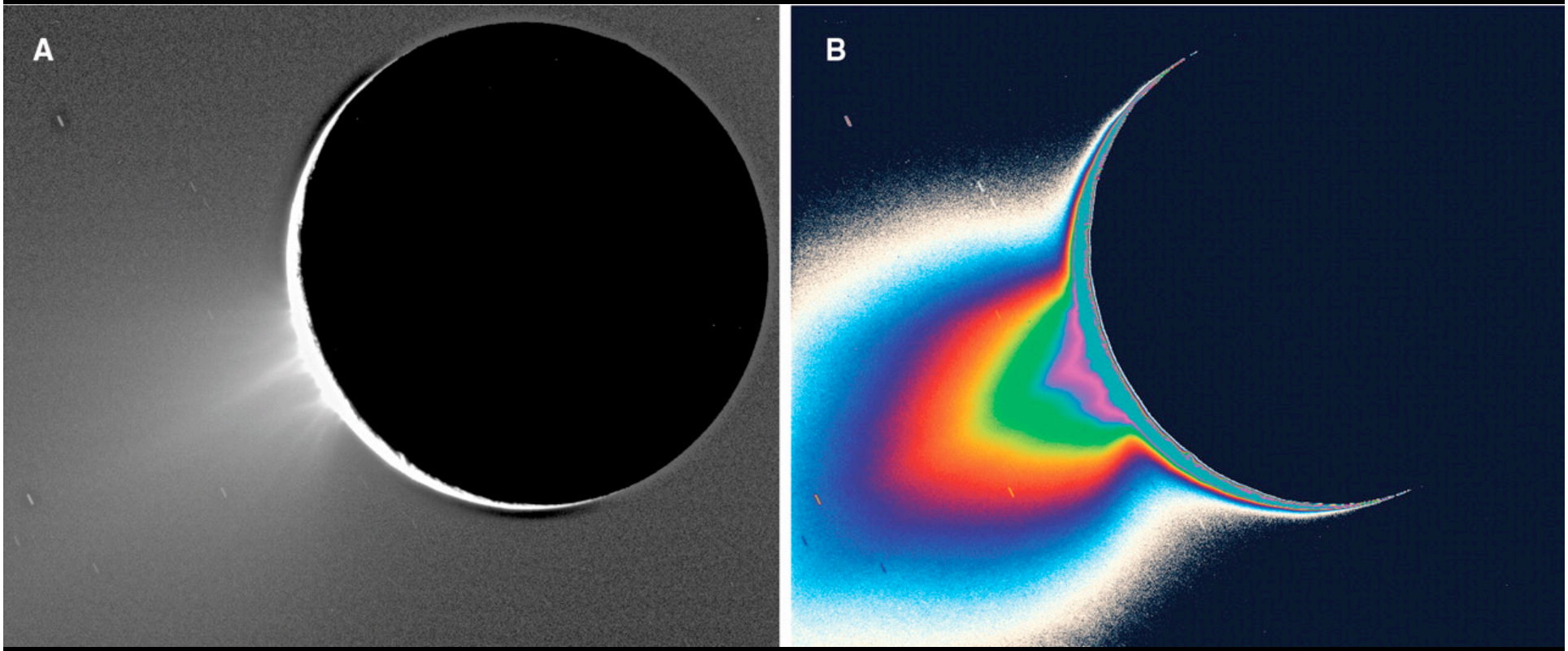

5 km

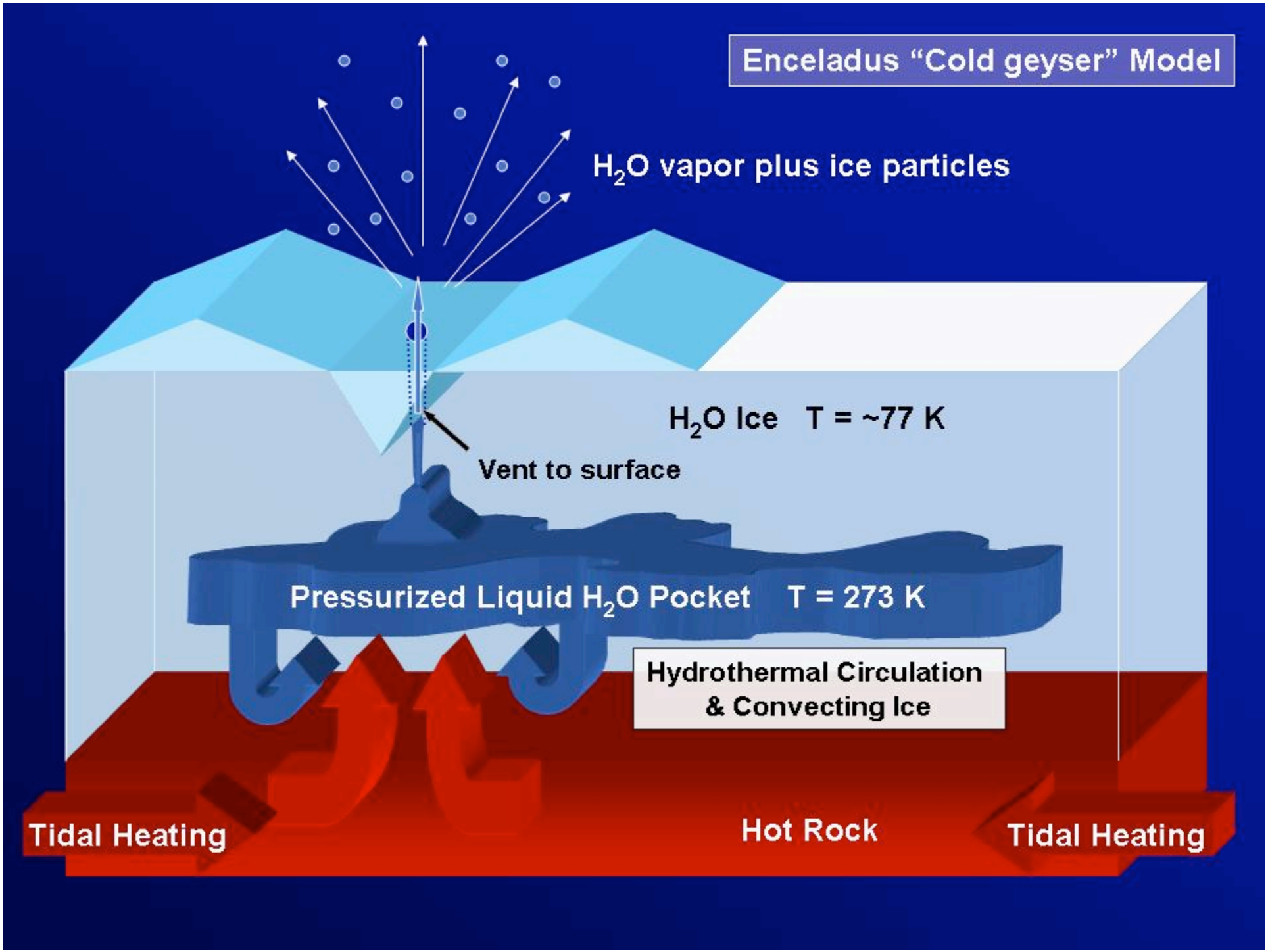
Evidence for global salty water (conductor) is the most compelling evidence for an ocean on Europa <u>today</u>.





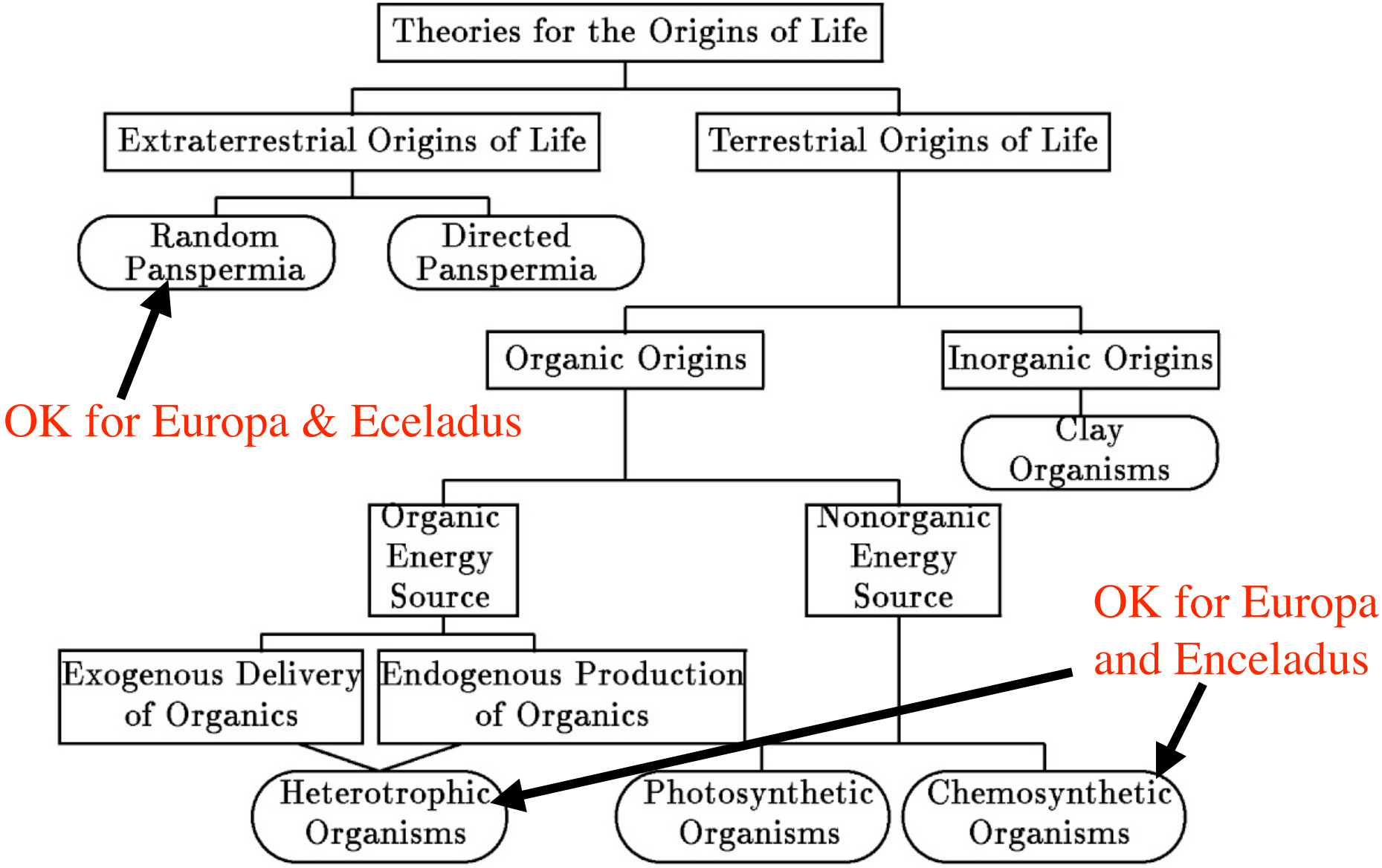
Jets of H_2O on Enceladus




Enceladus "Cold geyser" Model
H_2O vapor plus ice particles
H_2O Ice T = ~77 K
Vent to surface
Pressurized Liquid H_2O Pocket T = 273 K
Hydrothermal Circulation & Convecting Ice
Tidal Heating
Hot Rock
Tidal Heating

Given liquid water on
Europa & Enceladus
is there:

- a plausible origin of life?
- a plausible ecology?



Davis & McKay, *Origins Life Evol. Biosph.* **26**, 61-73, 1996.

Examples of ecologically isolated microbial ecosystems (no O_2, no light, no organic input)

Only three examples are known:

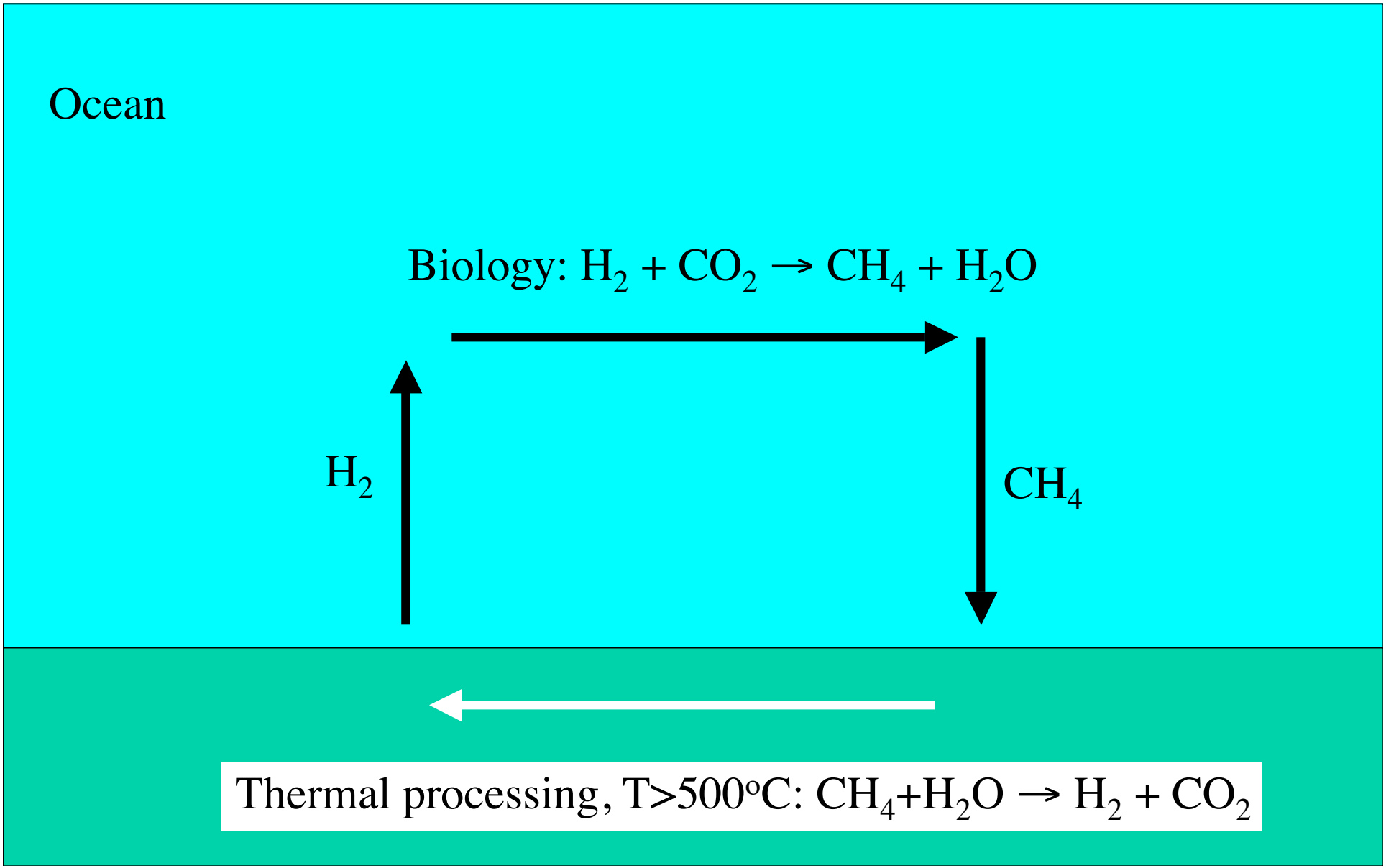
Two are are based on H_2 from rock reactions
($H_2 + CO_2 \rightarrow CH_4 + H_2O$)

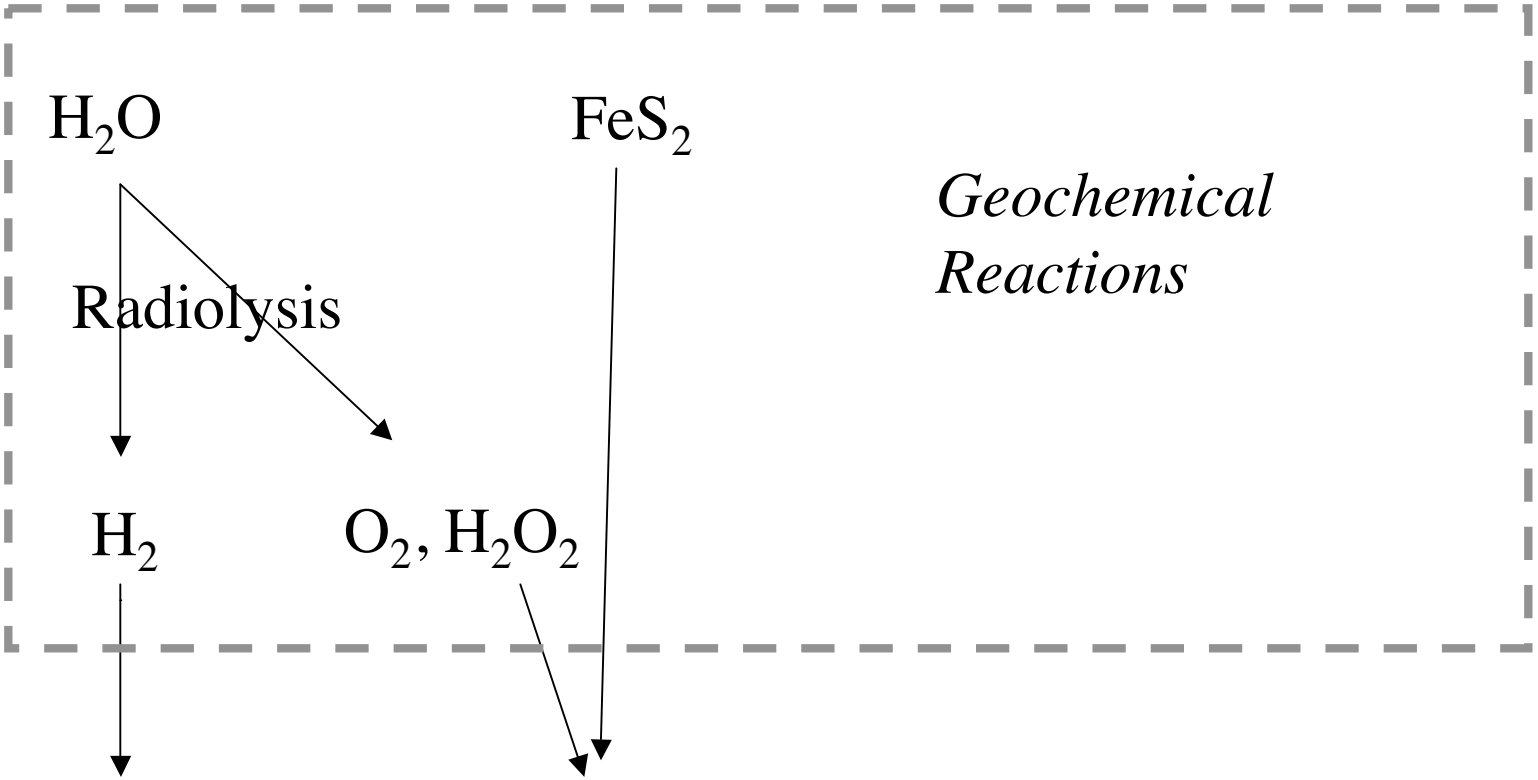
- Stevens, T.O. and J.P. McKinley 1995. Lithoautotrophic microbial ecosystems in deep basalt aquifers, Science 270, 450-454.
- Chapelle, F.H., K. O'Neill, P.M. Bradley, B.A. Methe, S.A. Ciufo, L.L. Knobel, and D.R. Lovley 2002. A hydrogen-based subsurface microbial community dominated by methanogens, Nature 415, 312-315.

One based on radioactive decay

- Lin, L.-H., et al. 2006. Long-Term Sustainability of a High-Energy, Low-Diversity Crustal Biome, Science 314, 479-482

Ice Cover


Ocean
Biology: $H_2 + CO_2 \rightarrow CH_4 + H_2O$
H_2
CH_4
Thermal processing, T>500°C: $CH_4+H_2O \rightarrow H_2 + CO_2$

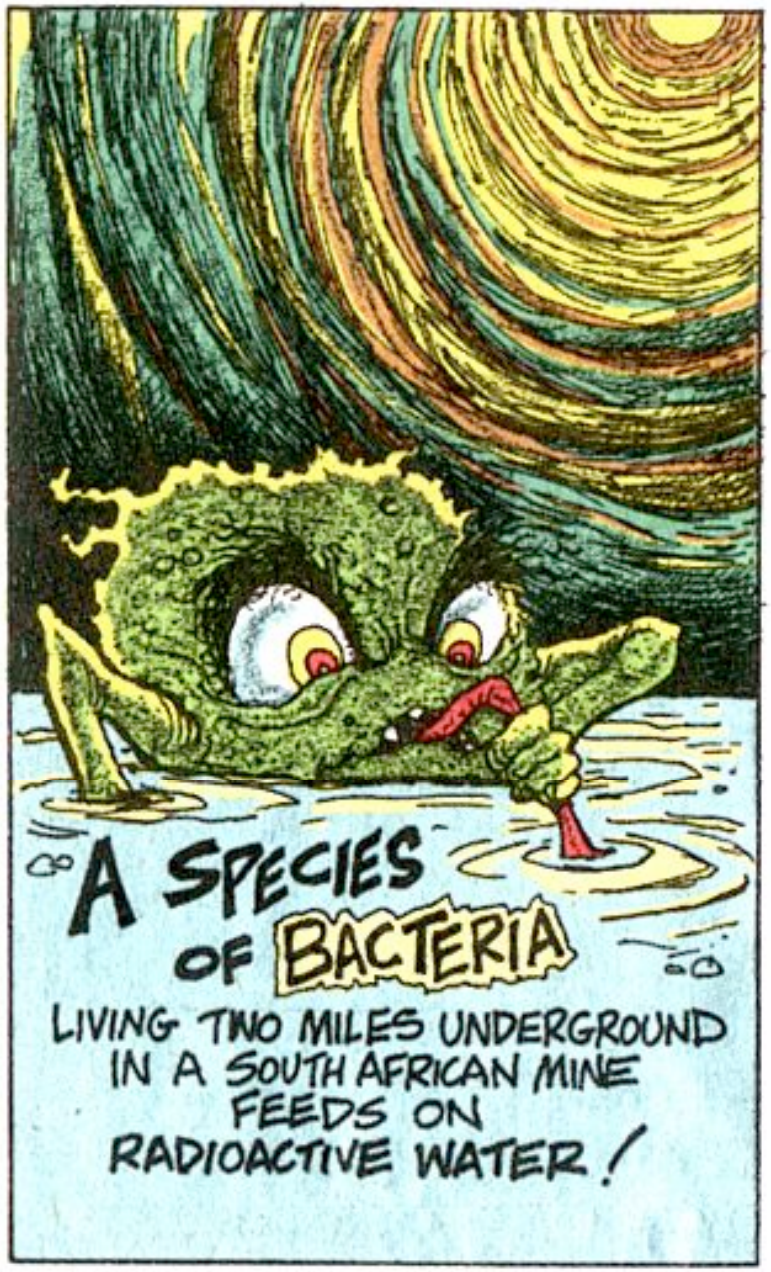


$$4H_2 + H^+ + SO_4^{2-} \xrightarrow{SRB} H_2S + 2H_2O + 2OH^-$$

Desulfoprofundis tokoloshe

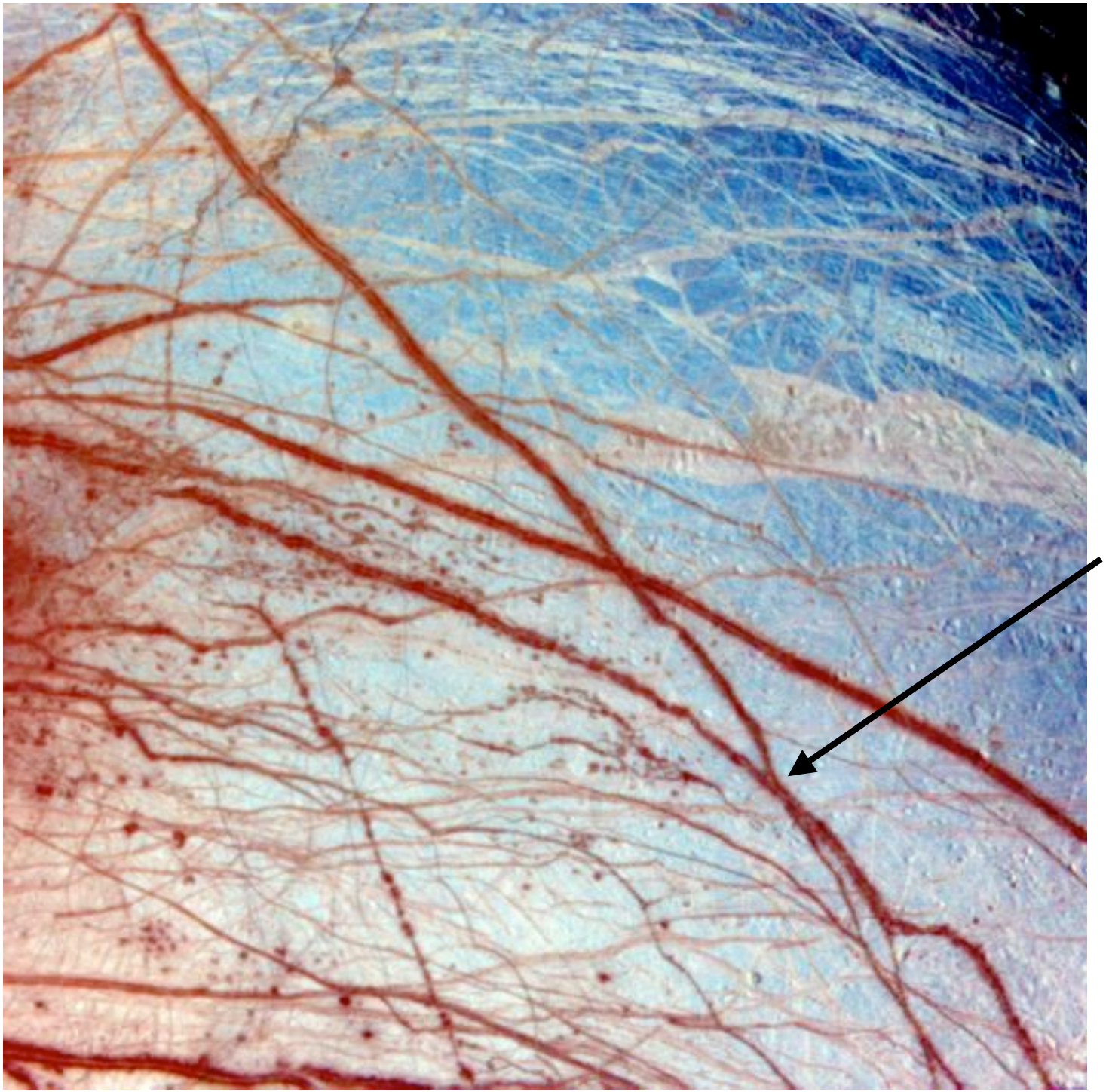
Lin et al. 2006, slide courtesy of T. Kieft

Ripley's — **Believe It or Not!**



$H_2S + O_2$ is the metabolic basis of deep sea vents.

Anaerobic chemoautotrophic ecosystems may be present below the surface.



Europa's surface

If there is an ocean

If the ocean has life

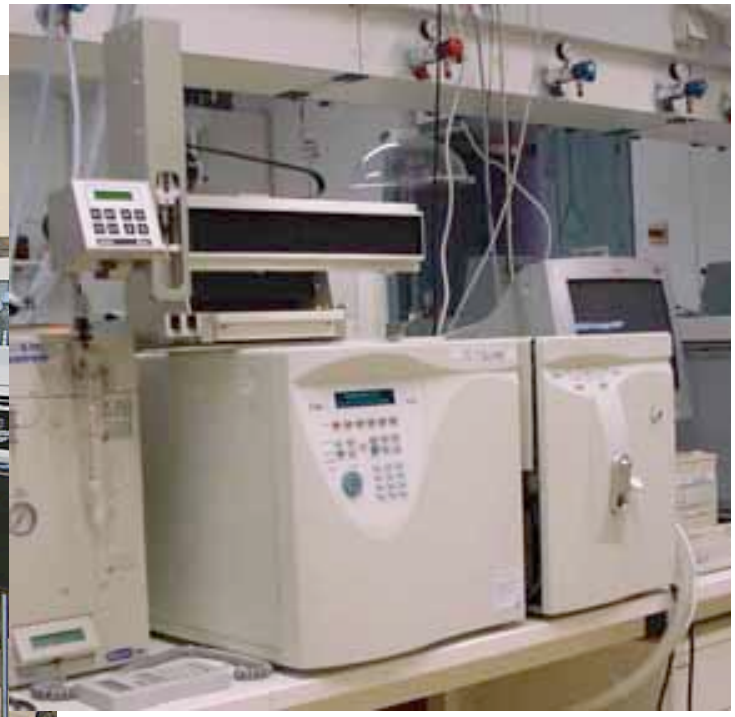
Then these surface features may contain biogenic organic material

Analysis for a second genesis needs samples in the lab

-we don't know what we'll find

-state-of-the-art capabilities

-analysis changes based on results



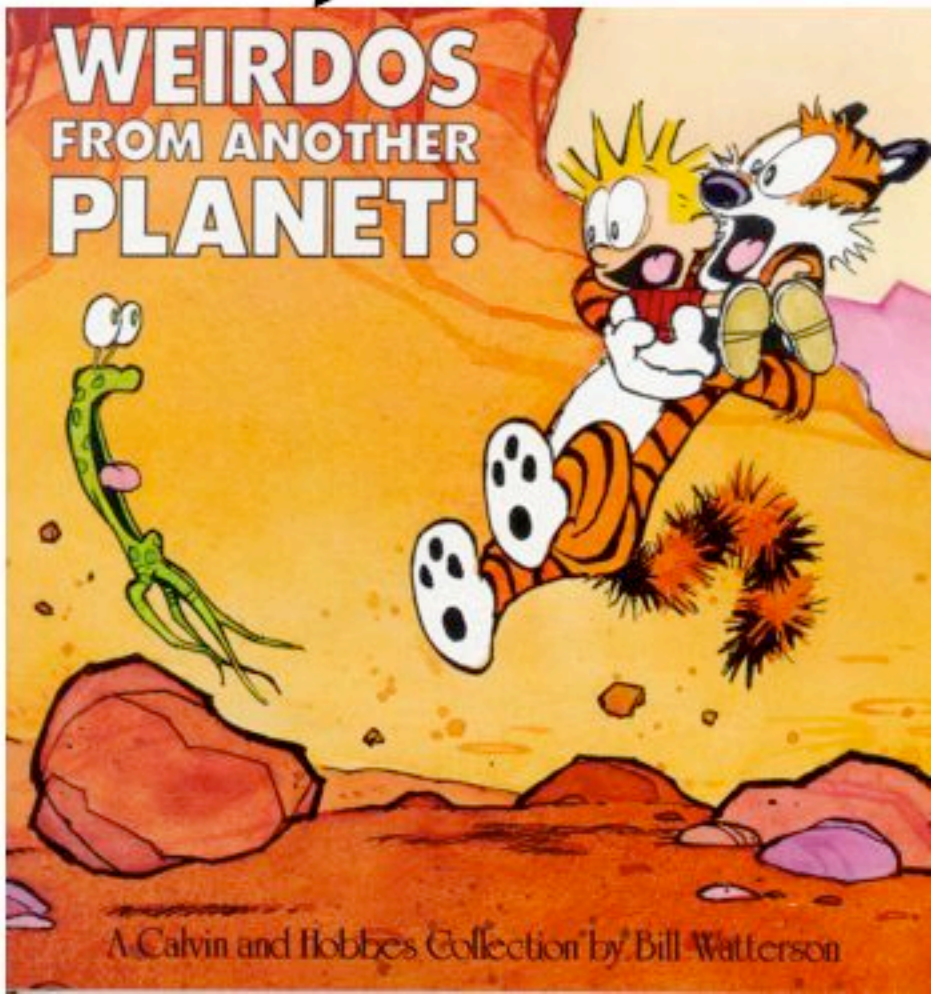
If we find organic material on Europa, or Enceladus how can we tell if it was ever alive?

If its like us then easy, less interesting
If its alien then hard, but interesting

How do we recognize alien life?

use a tricorder!

we'll know it when we see it!



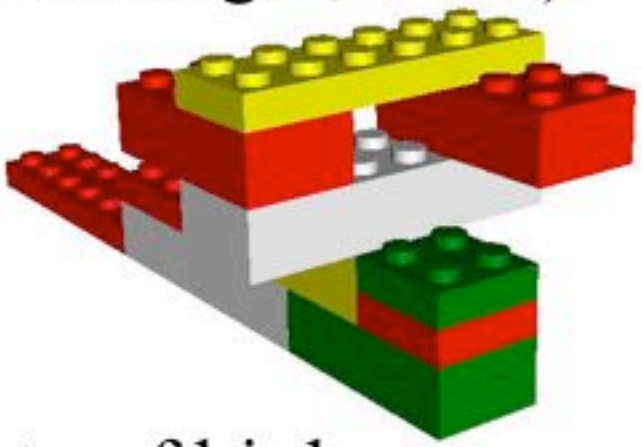
The Lego® Principle

•Biology is largely built from on a small number of components (Lehninger, 1975):

-20 L amino acids

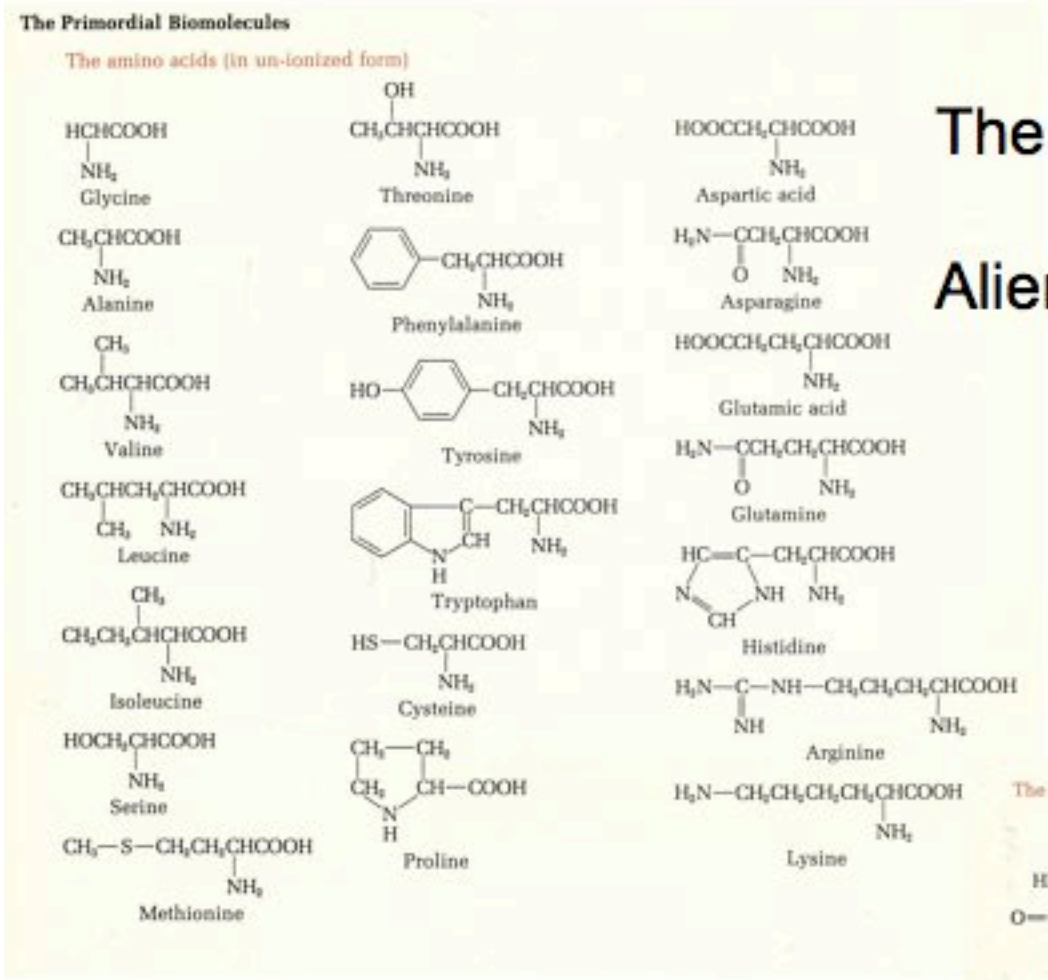
-5 nucleotide bases

-few D sugars, etc.



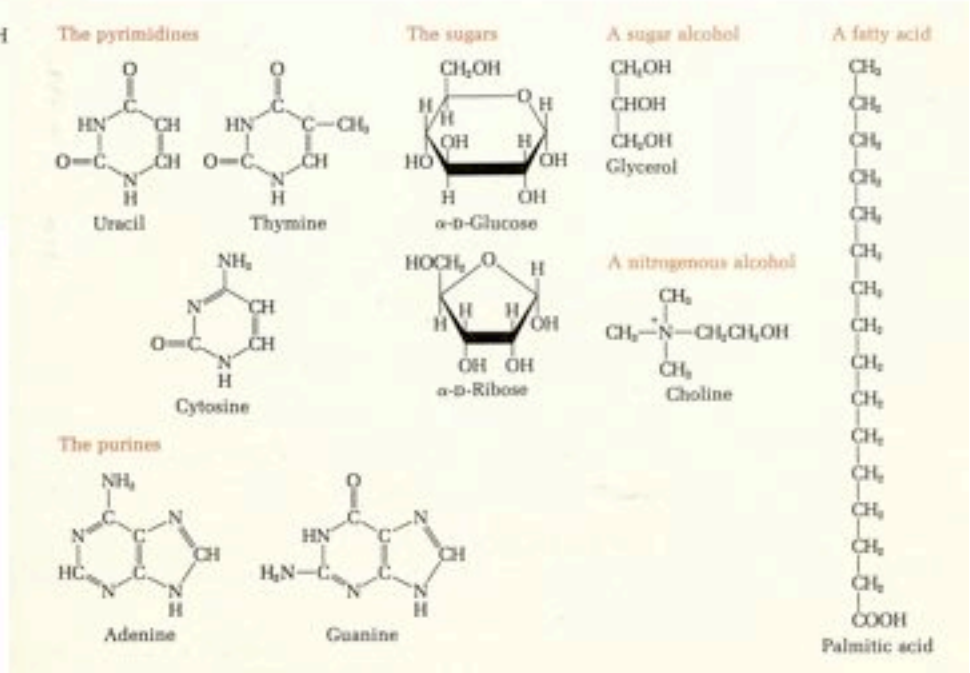
•Likely a common property of biology (and mass-produced children's toys) throughout the universe.

McKay 2004 *PLoS Biol* 2(9)1260-12623

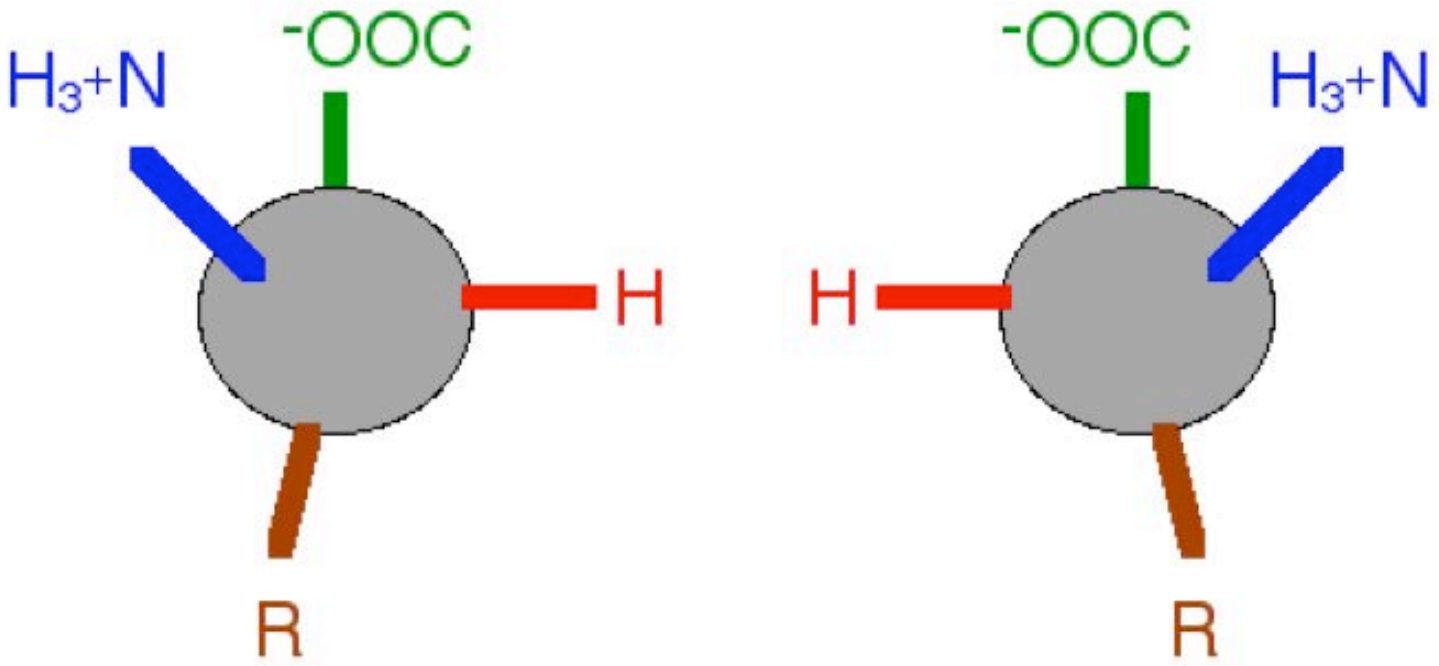


The building blocks of Earth life

Alien life could use a different set



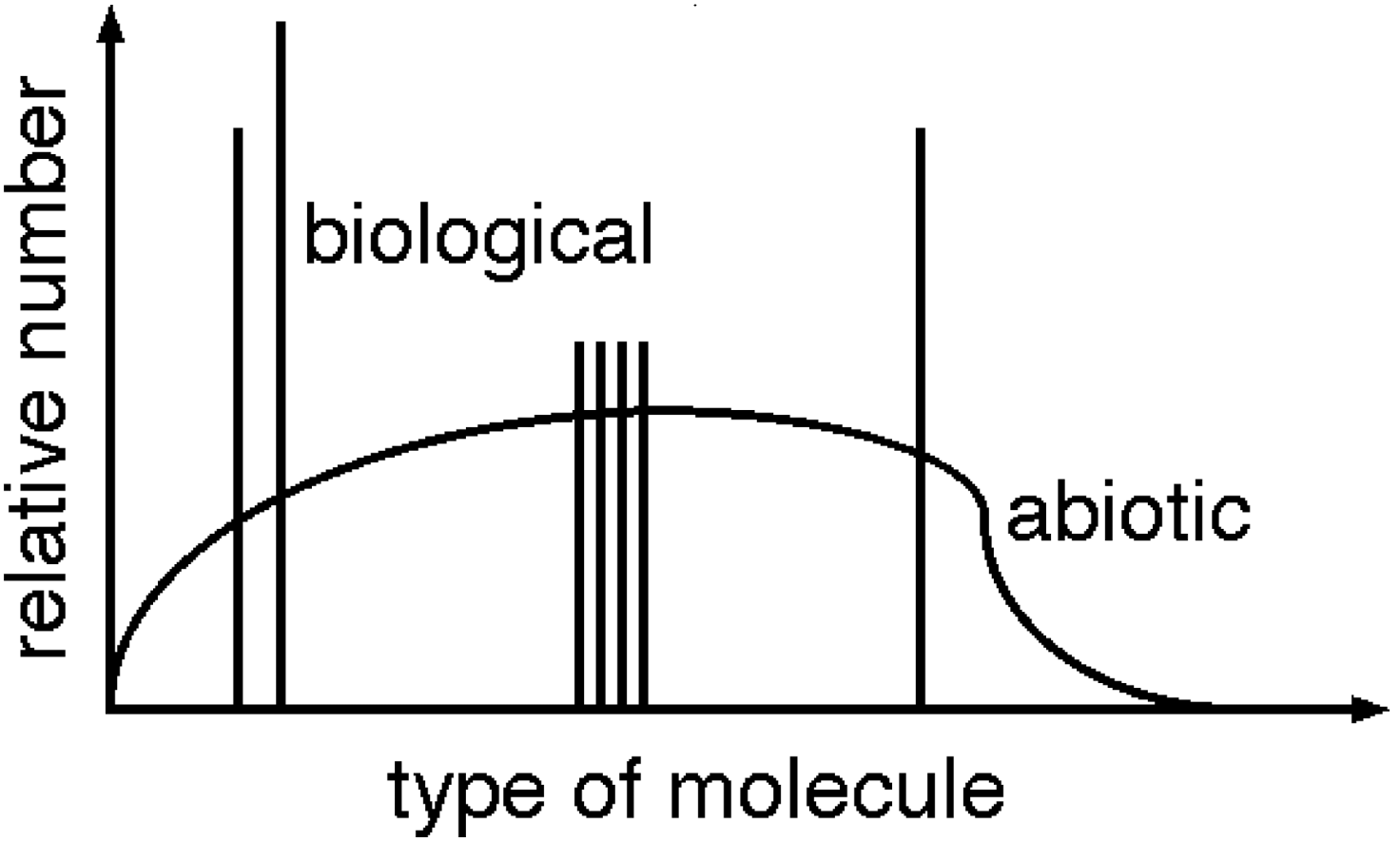
From Lehninger, 1975



L - amino acids
used in proteins

D - amino acids
not in proteins

Abiotic distributions are smooth
Biotic distributions are spiked



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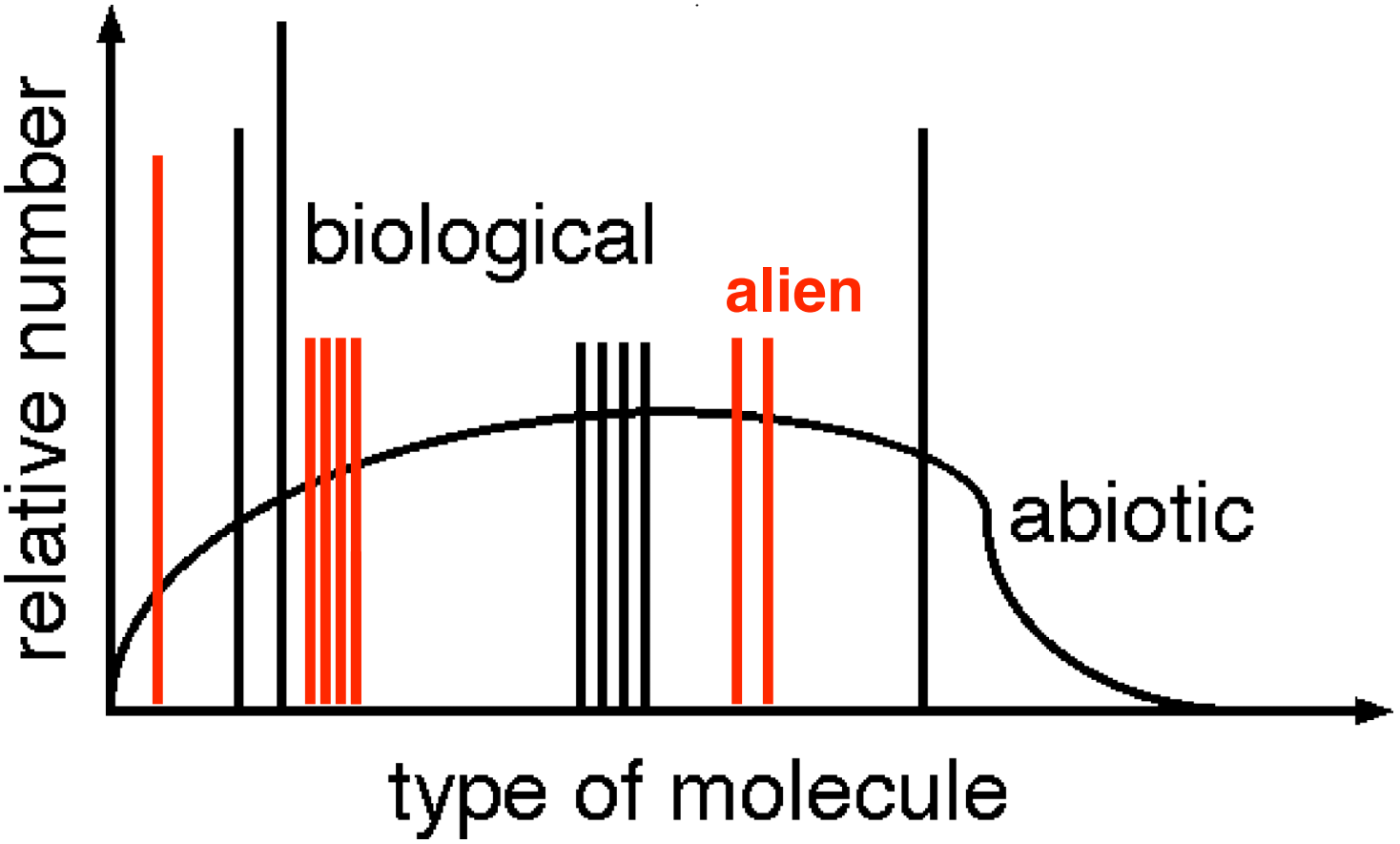


McKay 2004 *PLoS Biol* 2(9)1260-12623

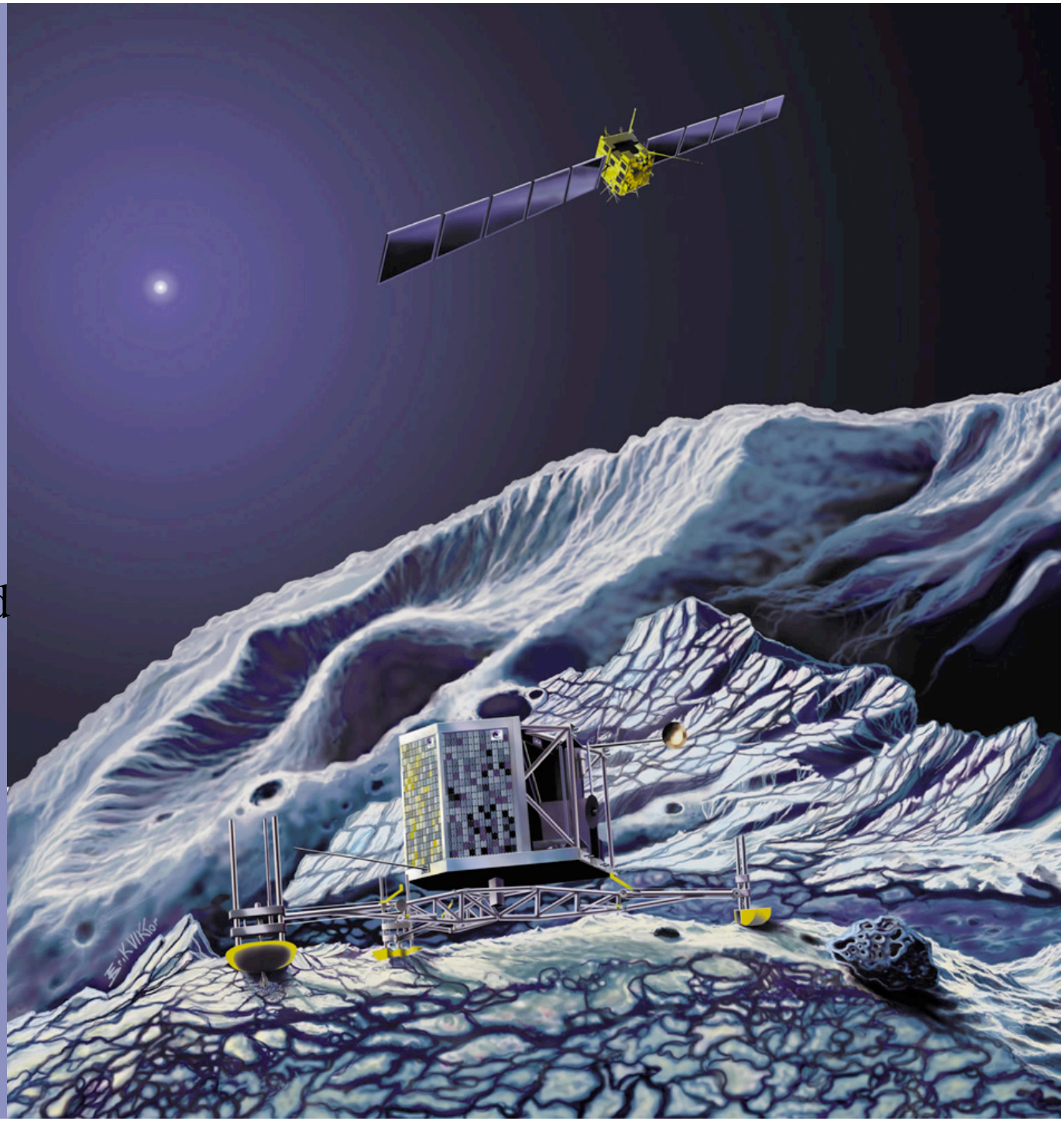
Possible Sample Return Missions
Europa & Enceladus

1. Landers
   - mass for shielding
   - mass for Δv
2. Flyby
   - mass for Δv

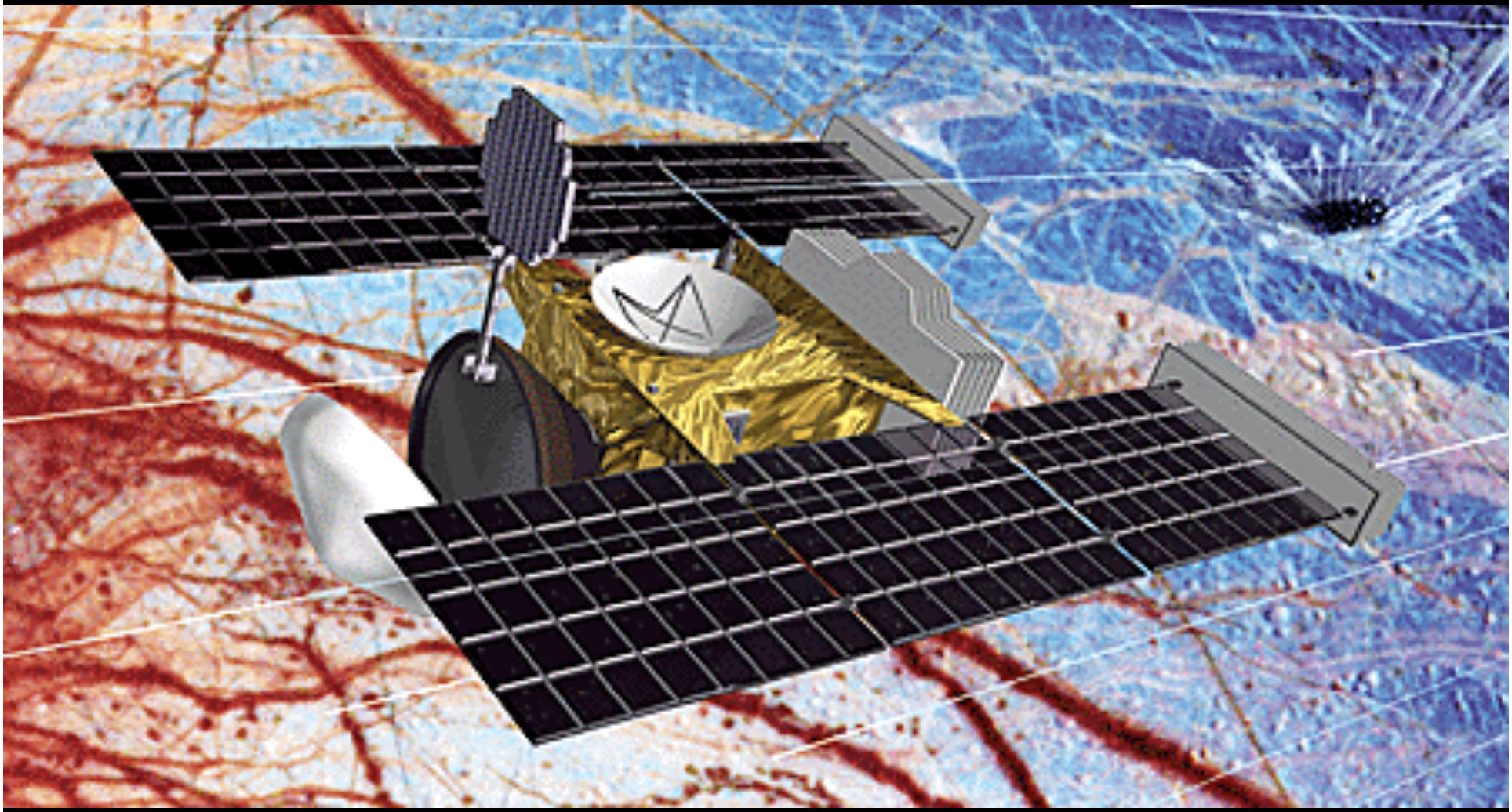
A lander on Europa faces significant radiation.

Easy answer is lots of shielding.

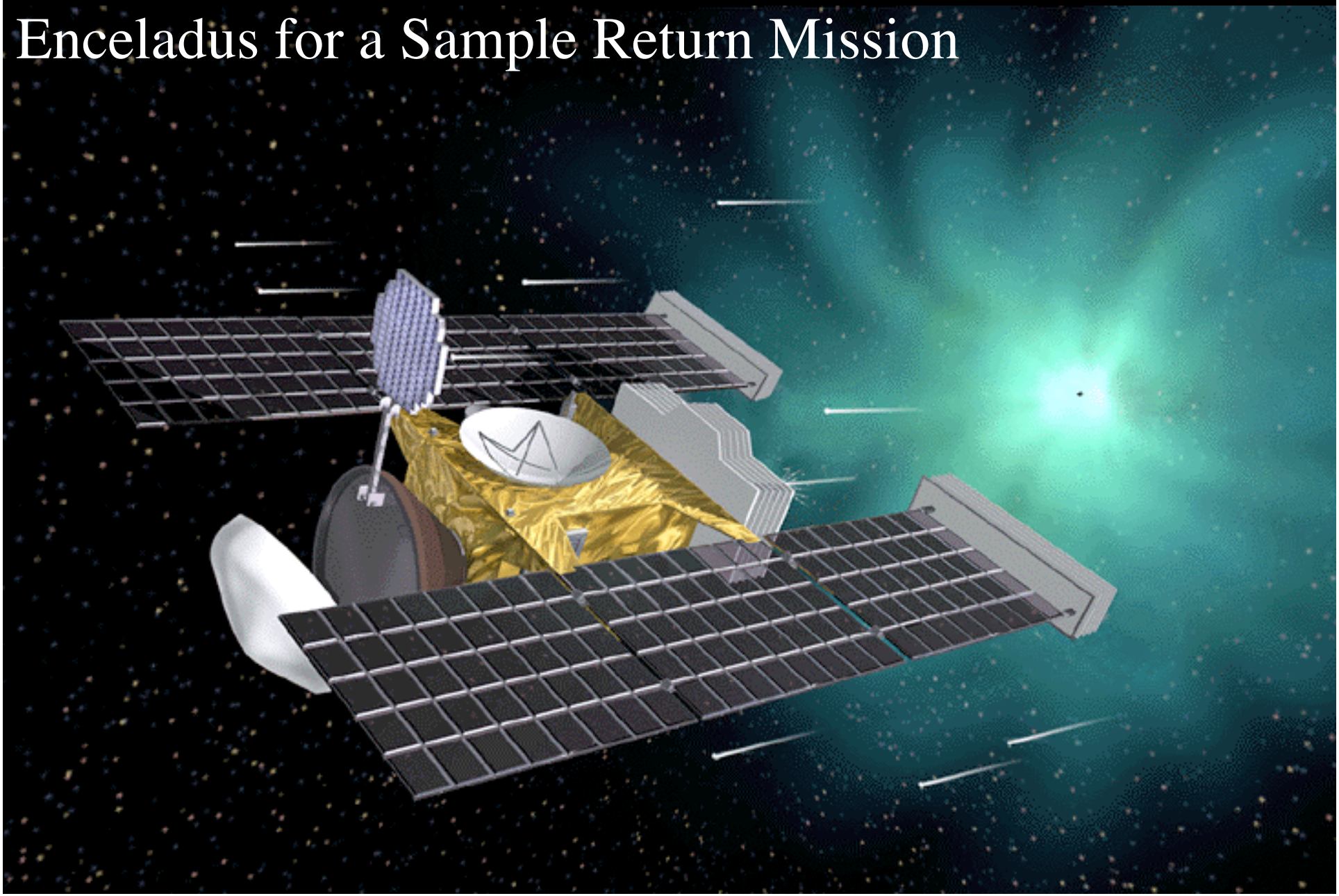
For both Europa and Enceladus, landers require large Δv.



Ice Clipper: A Europa Sample Return Mission based on Stardust spacecraft flying through impact cloud produced by a copper inpactor



Stardust flys through the Plume of Enceladus for a Sample Return Mission



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