UNIVERSITÀ POLITECNICA DELLE MARCHE
DIPARTIMENTO SCIENZE DELLA VITA E DELL'AMBIENTE
Corso di Laurea in Scienze Biologiche L-13

Life in the exo-ocean on Europa
Vita nell'eso-oceano su Europa

A.A. 2025-2026 sessione autunnale

Tesi di Laurea di: Tommaso Pallotti

Docente Referente Chiar.ma Prof.ssa Cinzia Corinaldesi

Juice, April 2023

Clipper, October 2024

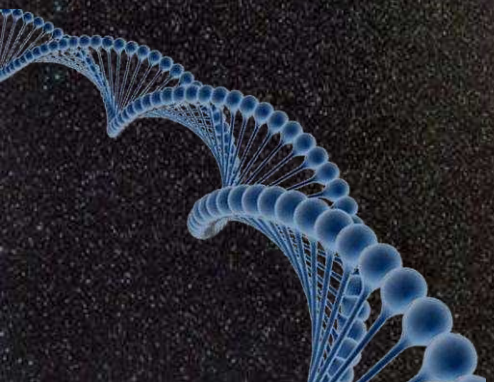
JUICE launch, april 2023

CLIPPER launch, october 2024

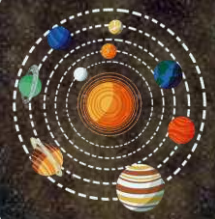
What is life?

Life is a self-sustained chemical system capable of undergoing Darwinian evolution (Pier Luisi 1998).

Life is a chemical system based on a liquid water solvent, a suite of “biogenic” elements (most famously carbon, but others as well), and a source of free energy (Cleland, C. E. & Chyba, C. F. 2002).



Some informations about Europa...



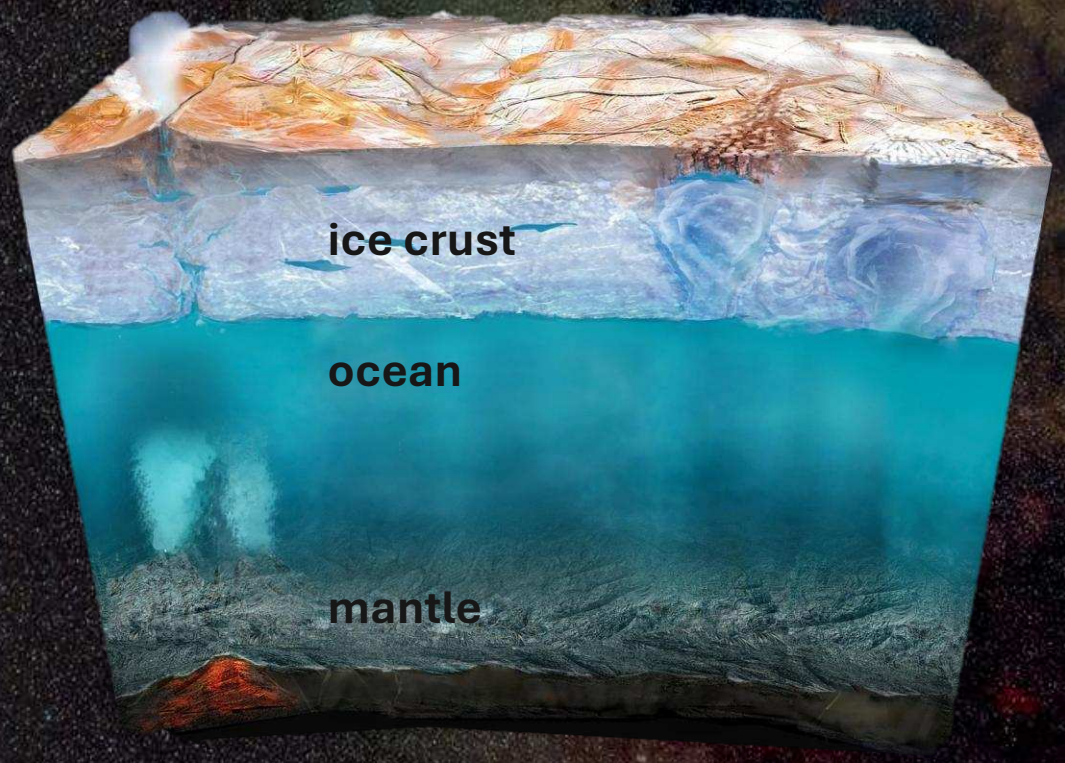
The smallest and closest moon to Jupiter.

≈80–170 km thick overlying water-ice shell.

Thin atmosphere composed of oxygen.

Smoothest surface of the solar system.

Proofs of liquid water



Models indicate sufficient geothermal and tidal heating to maintain much of the ice shell as liquid water beneath an outer ice layer ≈10 km thick.

Fractures on the icy surface may have formed due to elastic forces generated by the asynchronous rotation of the ice crust relative to the planet's core

Magnetic field results show the signal of an induced field. This field requires a near-surface global conducting layer, for which the most probable explanation is a salty ocean.

Biogenic elements

It is supposed that Europa has the same composition of a carbonaceous chondrite meteorite, in which case biogenic elements would be abundant.

Comet impacts over solar system history should have provided Europa with a supply of biogenic elements enough to support life.

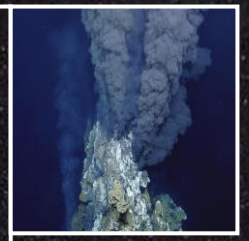
Source of free energy

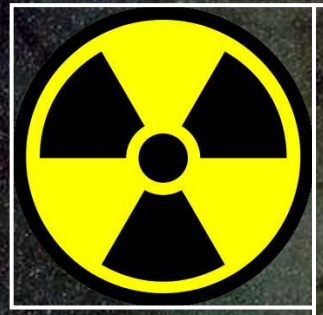
Sun light

Photosynthesis on Europa is unlikeable both because of the distance from the sun and the thick layer of ice covering the European ocean.

Hydrothermal vents

Although ecosystems sustained by deep hydrothermal vents can exist, their detection would be extremely difficult.





Radiations

Radiation due to charged-particle acceleration in the Jovian magnetosphere should simultaneously produce oxidants (H_2O_2) and simple organics ($HCHO$) at Europa's surface.

Two processes compete in the radiation-driven formation of organic elements: gardening and sputtering.

Gardening

Gardening is predominantly a vertical mixing process of the uppermost layer surface of a celestial body granted by small micrometeorites impacting the surface.

Sputtering

Sputtering is defined as the erosion that occurs when charged particles impacting a celestial surface eject material.

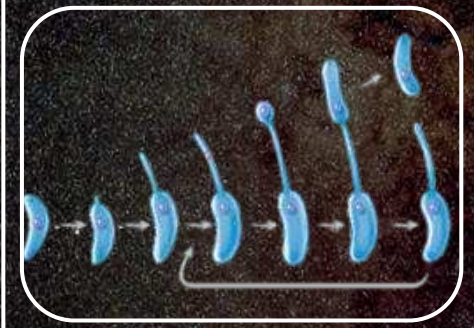
$= X$

Cell density estimation

I. $\approx 8 \times 10^{13} g\ HCHO$ and $\approx 7 \times 10^{17} g\ H_2O_2$ enter the ocean each 10 million years.
II. Once reached the ocean, $2H_2O_2 \rightarrow 2H_2O + O_2$.
III. Energy is produced by cells with the reaction $HCHO + O_2 \rightarrow H_2O + CO_2$.
IV. If $2 \times 10^{-14} g$ is the mass of an aquatic cell, each year 3×10^{20} cells are produced.
V. Adopting a turnover of $t = 1 \times 10^{3} yr$, $3 \times 10^{23} cells$ are present each moment.
VI. Given the European ocean volume, cell density is $0.1 - 1\ cells/cm^3$.

The estimated cell density is even lower of the one detected in earth deep ocean areas ($5 \times 10^{4} cells/cm^3$).
It is logical to predict a much higher cell density in waters close to surface fractures.

Earth analogue, *Hyphomicrobium spp.*



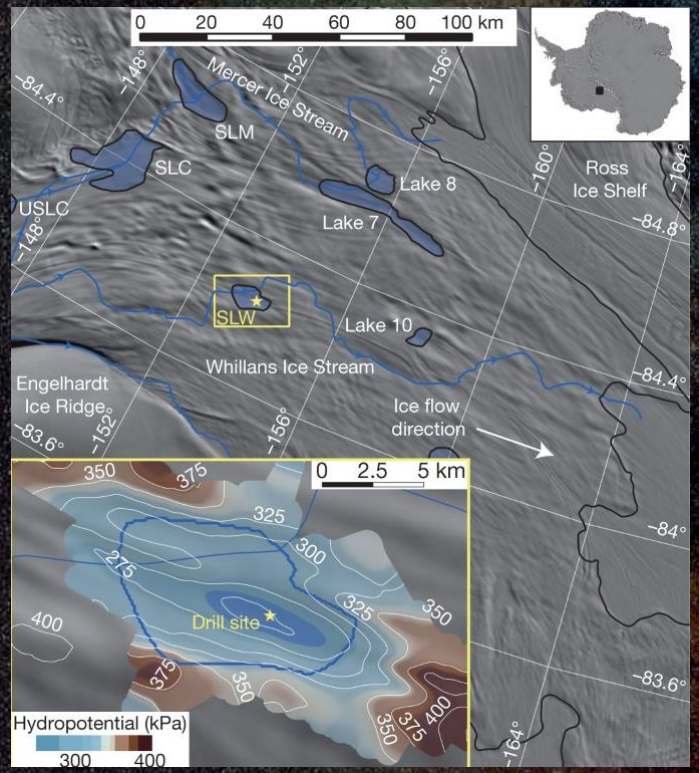
Hyphomicrobium spp.

- Metabolism = facultative methylotrophs
- Morphology = strains provided with prosthecae.
- Reproduction = prosthecate budding
- Habitat = ubiquitous, mostly concentrated in oligotrophs soils

Experiments on Europa

- Considering geological factors and the gardening process, a future probe destined for Europa should ideally land near the surface fractures.
- Given the low estimated cell concentration, enough ice needs to be melted and filtered

Experiments on Earth - Antarctic-subglacial lakes



Lake Whillans

- Located under an 800 meters thick ice layer in western Antartica.
- Water cell density of $1.3 \times 10^5 cells/mL$
- Chemolithoautotrophs and methylotrophic heterotrophs bacteria

Thank you for your attention!

Bibliography 

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