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The Search for Signs of a Second Origin of Life in Ocean Worlds of the Outer Solar System

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Introduction: The question of whether or not we live in a 'biological universe' is, in large part, a question of whether or not the origin of life is easy or hard: Are the conditions for life's origin so unique that life occurs very rarely, or does life arise 'easily' through one – or several – modalities? Arguably the best places to test the 'biology hypothesis' are the ocean worlds of our outer solar system – moons such as Europa and Enceladus [1, 2].

Two specific modalities and locales for the origin of life within ocean worlds are: 1) within hydrothermal systems on active seafloors, and 2) within, or beneath, the ice shells of ocean worlds (regions in which a liquid water and solid ice interface exist). These two options serve as useful points of comparison with respect to life's origin on Earth; were no life to be found on worlds like Europa or Enceladus would such results implicate terrestrial/continental environments (tide pools, hot spring, etc.)? While origins in hydrothermal systems have received considerable attention, less work has been done on origins in ice. Here I detail laboratory experiments relevant to surface and subsurface chemistry on and with Europa and Enceladus, and describe possible pathways for the origin of life as we know it. I will then described the mission concept for the Europa Lander and how that mission could serve to detect and distinguish a second, independant origin of life in our solar system.

References: [1] Hand KP (2009) *Europa (UA Press) 589-629*. [2] Lazcano A and Hand KP (2012) *Nature*, *488*(7410), 160-161. [3] Hand KP and Carlson RW (2012) *JGR*, 117:E03008, doi:10.1029/2011JE003888.

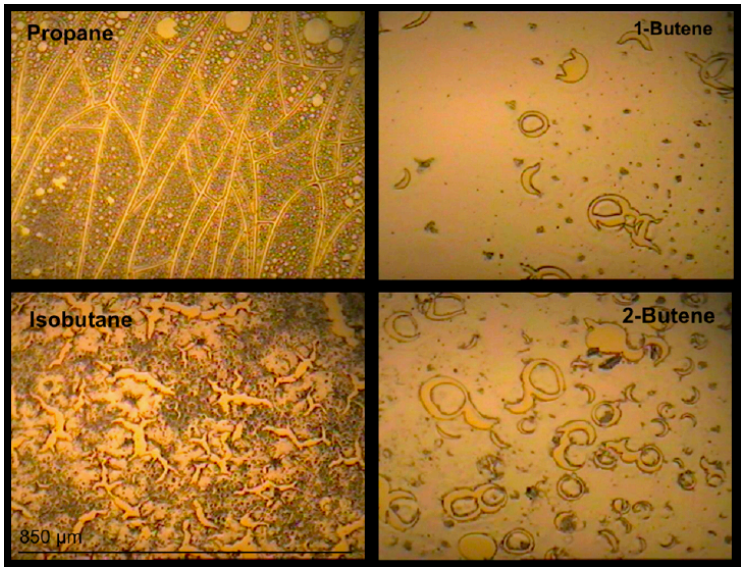

Figure 1 – Residues of electron irriadiated short-chain organics created under cryogenic, vacuum, and irradiation conditions comparable to that of Europa's surface [3].