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# DEFINING ASTROBIOLOGICAL SCIENCE OBJECTIVES FOR THE EUROPA AND ENCELADUS EXPLORER MISSION DESIGNS

**Abstract**

Future advanced exploration efforts in the outer solar system, especially of Jupiter's moon Europa and Saturn's Enceladus, will be focused on assessing the in situ presence of extant biological activity or past signatures thereof on icy planetary bodies with subsurface water reservoirs. The core technologies needed for such missions are autonomous melting and underwater probes. Melting devices could be deployed near the active regions of Enceladus, for example, and melt their way through towards water-bearing crevasses where the measurements were to be performed. A similar approach could be employed on Europa should the existence of recently observed water plumes be confirmed. Exploration of Europa's global subsurface ocean, however, can only be realized by using a robotic submersible. Two DLR funded projects, the "Enceladus Explorer" (EnEx) and "Europa Explorer" (EurEx) mission designs are aiming at demonstrating the feasibility of future planetary exploration with a subglacial melting probe and an autonomous underwater vehicle (AUV) respectively. Firmly astrobiologically oriented mission concepts encompass science objectives that go beyond those of preceding orbiter or lander scenarios which are rather concerned with further constraining habitability of a given planetary environment. Hence, the payload for melting probes and submersibles must be chosen according to the dedicated science goal of finding extant or past biosignatures. The design of adequate instrumentation for the envisioned probes should consequently be guided, first, by ongoing exploration of extreme environments on Earth such as polar under-ice and deep-sea habitats and, second, theoretical considerations pertaining to possible degrees of biological complexity originating and evolving within extraterrestrial environments. Here it is argued that evolutionary convergence, the independent and repeated emergence of similar adaptive traits in analogous planetary environments, between terrestrial and putative alien life forms on Europa and Enceladus might present an important factor in the process of instrument selection. A common hypothetical evolutionary trajectory for both moons leading from the possible origin of life at hydrothermal serpentinizing systems towards chemoautotrophic organisms is described. Minimal convergent traits (MCTs) potentially found in life across analogous planetary habitats could be represented by 1) molecular replication and inheritance, 2) cellularization via membrane systems and 3) metabolic networks coupling energetically favorable biochemical reactions. Europa might harbor organisms with even more complex adaptations. Different kinds of instrumentation are associated with individual minimal convergent and more complex traits. This paper presents a science traceability matrix of astrobiological objectives for both the EnEx and EurEx mission designs.