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## COSMIC CONVERGENT EVOLUTION OF BIOLUMINESCENCE ON EUROPA

**Abstract**

Within the solar system Jupiter's moon Europa is a prime candidate for harbouring extraterrestrial life. Its subsurface ocean is thought to be analogous to terrestrial deep-sea habitats. In an environment devoid of sunlight ecosystems might be fueled by hydrothermal circulation systems located on the seafloor. In terrestrial oceans one of the most widely distributed adaptations among marine organisms is bioluminescence, ecologically functional light. A striking feature of the evolution of bioluminescent species on Earth is its convergent nature. It has emerged more than forty times independently, employing a disparate range of chemical systems, and hence is a powerful example of convergent evolution, the phenomenon that similar adaptations can arise in distantly related organisms. This paper will argue for the relevance of convergent evolution to astrobiology. Just like intelligence might be a common trait of life in the universe, an idea which is actively pursued by the SETI enterprise, bioluminescence could have evolved on distant ocean planets multiple times. It is conceivable that evolution converges on a planetary or even cosmic scale. This concept will be discussed under the term cosmic convergent evolution (CCE). The theory of CCE has, in principal, falsifiable implications and can thus be assessed experimentally. The hypothesis presented here states that European organisms have evolved bioluminescence since the environment of Europa's subsurface ocean strongly favours its emergence. CCE might encompass a wide range of features of life as we know it. Bioluminescence can be classified as a new type of biosignature. A future lander mission to Europa should take this into consideration by including a probe that is capable of emulating bioluminescent light patterns known from terrestrial organisms. This could assist in the attraction and eventual detection of responsive European fauna. CCE might not only expand evolutionary conceptions in the age of astrobiology but also provides a new theoretical framework in which falsifiable implications about the origin and development of extraterrestrial life forms can be formulated.