Probabilities of Earth-like evolution by easy and hard steps

Ferluga S.[1], Bisesi E.[2]

The concept of *life* in the cosmic context (as well as *evolution* and *intelligence*) is mostly referred to earth-like models, in order to be scientifically investigated. This implicitly constrains the discussion within an anthropomorphic framework. Moreover, since we know only the case of biological evolution on Earth, our planet is supposed to be representative of biological evolution on the planets in general, for any stellar system. There is a wide consensus about the Copernican idea that the Earth, populated by intelligent life, should not be a special case.

Expectations for widespread life in the universe are theoretically supported by the *easy-life* scenario, which considers biological evolution as a sequence of highly probable transitions, occurring on any habitable planet. On the opposite side, a less popular scientific point of view (yet Copernican) is the *hard-life* scenario, which supposes the Earth to be still a random case of planetary evolution, but of low probability, brought in evidence by the (anthropic) selection effect of allowing the presence of observers. The number of critical evolutionary steps considered in the literature [1] [2], according to biological and paleontological issues, is generally small (from 5 to 7).

A complete conception admits the possibility that the sequence of evolutionary transitions, leading to intelligent life, might include *hard* and *soft* steps as well. In principle, the correct model should be recognizable on experimental basis, but in the framework of current knowledge there are few elements for a decision. The Fermi paradox (despite its possible explanations) and the failure in observing traces of life in space, if persisting in future research, may reduce the appeal of the *easy-life* idea. On the other side, the *hard-life* model may be immediately falsified by the detection of evolved life beyond Earth; moreover, we show that it poses a surprising mortgage on the future of the Earth.

The present work proposes a generalized mathematical approach, by numerical computation, which treats together (for the first time) both *hard* and *easy* evolutionary steps, best according with the actual observational knowledge. The purpose is to study the probability functions for single transitions in a general *hard + easy* scenario, with special attention to the last critical step leading to consciousness. Finally, an attempt is made to estimate the probabilities of transitions and expectations of biological evolution – from the appearance of the first living forms, to the rise of consciousness, up to the end of planetary habitability.

[1] Carter, 2008, Int. J. Astrobiology, **7**, 177
[2] Watson, 2008, Astrobiology, **8**, 175

[1] Trieste University, Trieste, Italy
[2] Graz University, Graz, Austria