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Systems astrobiology for a reliable biomarker on exo-worlds

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Although astrobiology is a science midway between biology and astrophysics, it has surprisingly remained largely disconnected from recent trends in certain branches of both of these disciplines. Aiming at discovering how systems properties emerge has proved valuable in chemistry and in biology and should also yield insights into astrobiology. This is feasible since new large data banks in the case of astrobiology are of a geophysical/astronomical kind, rather than the also large molecular biology data that are used for questions related firstly, to genetics in a systems context and secondly, to biochemistry. The application of systems biology is illustrated for our own planetary system, where 3 Earth-like planets are within the habitable zone of a G2V star and where the process of photosynthesis has led to a single oxygenic atmosphere that was triggered during the Great Oxidation Event some 2,5 billion years before the present. The significance of the biogenic origin of a considerable fraction of our atmosphere has been discussed earlier (Kiang et al., 2007). Bonding of O_2 ensures that it is stable enough to accumulate in a world's atmosphere if triggered by a living process. The reduction of F and Cl deliver energy release per e+-transfer, but unlike O_2 the weaker bonding properties inhibit large atmospheric accumulation (Catling et al., 2005). The evolution of O_2-producing photosynthesis is very likely on exo-worlds (Wolstencroft and Raven, 2002). With our simplifying assumption of evolutionary convergence, we show how to probe for a reliable biomarker in the exo-atmospheres of planets, or their satellites, orbiting stars of different luminosities and ages (Chela-Flores, 2013). We treat the living process as a system of exo-environments capable of radically modifying their geology and atmospheres, both for exo-planets, and especially for exo-moons, the presence of which can be extracted from the Kepler data (Kipping et al., 2012). What we are learning about the moons of our solar system (Chela-Flores, 2010), and will learn in the foreseeable future with the JUICE Mission will be relevant to systems astrobiology. The distribution of systems of habitable worlds with their biomarkers will be testable in the short term with forthcoming space missions: FINNESSE, EChO and TESS. This would justify subsequent use of quantitative systems biology methods that are available from its repertoire of analytic approaches.

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