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# Biosignatures for Astrobiology

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This issue of Origins of Life and Evolution of Biospheres contains a series of articles on Biosignatures, the theme of the 2014 meeting of the European Astrobiology Network Association (EANA) meeting, entitled "Signatures of Life: From Gases to Fossils", held in Edinburgh October 13–16, 2014. The meeting took place at the University of Edinburgh and was hosted by the UK Centre for Astrobiology (UKCA). It was sponsored by the UK Space Agency, EANA and ESA.

The title "Signatures of life, from gases to fossils" neatly and succinctly sums up the multifarious aspects of astrobiology and the search for traces of life on other planets and satellites. The main potential biosignature on exoplanets is their atmospheric composition, hence "atmospheres" while, although the ability of identifying extant life may be somewhat easier than identifying fossil traces of life – at least there would be a biochemical response – the likelihood of finding extant life on a planet in the Solar System in the next 10 years is perhaps lower than the likelihood of finding fossil traces of life on Mars (although the latter depends of course on the challenge of landing in the right place).

The signatures of life (biosignatures) cover very many aspects of living beings from metabolic gases, e.g., oxygen or methane; spectral signatures of biology, e.g., the red edge of vegetation in Earth-light reflected from the Moon; complex molecules, such as DNA, RNA, lipids, proteins etc. and their degradation products; metabolic influence on chemical disequilibria; chiral organic molecules; isotopic fractionation of important bioelements, such as C, S, N, Fe and others; leaching of important transition metals (reduction/oxidation); biominerals formed as a result of microbial metabolisms, e.g., carbonate, phosphate, iron oxides and sulphides; morphological features produced by microorganisms and their activities, such as

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biolaminations, stromatolites, mud mounds, microbially-induced sedimentary structures (MISS), and corrosion features. Apart from specialised molecules and strong chirality, most of these phenomena can be produced or imitated by abiotic processes. Hence, the onus is on demonstration that a particular feature or assemblage of features cannot have been produced by abiotic means. On Earth, such demonstrations sometimes require the use of highly sophisticated instrumentation and even then, clear demonstration of biogenicity may be difficult. This is particularly the case where biosignatures occur in rocks that have undergone significant degradation or metamorphism, or in extremely ancient rocks produced and the period on the Earth when life was still very primitive.

Interest in the earliest preserved traces of life on Earth is increasing apace. Likewise, new instrumental developments for observation and spectroscopic analysis of other planets (also *in situ* in the case of Mars) and satellites in the Solar System or exoplanets in other star systems open the prospect of making significant discoveries in the next decade or so. The finding of Kepler-186f in the Cygnus constellation reveals the most Earth-like planet discovered to date. Europa, a Jovian satellite with an icy crust over a probably liquid ocean, continues to excite the imagination and two new missions are planned to examine her icy surface in the next decade (JUICE from the European Space Agency and NASA's Mission to Europa). Saturn's moon Enceladus is spewing out tantalising jets of briny water, indicating the existence of liquid water beneath her icy crust. The lobby for a mission to return to the saturnian system is strong. Finally, the first step in a series of missions to return samples from Mars, NASA's Mars 2020 mission slated for 2020, additionally will increase the necessity of being able to determine biogenicity of features in specifically-chosen extraterrestrial rocks.

The manuscripts in this issue cover just a few of the vast array of biosignature subjects. Their themes range from exposure experiments of extremophile microorganisms on the International Space Station with corresponding ground based experiments in laboratory exposure experiments (Baqué et al., Brandt et al.….) to the influence of a martian $CO_2$-rich atmosphere on the metabolism of cyanobacteria (Murukesan et al.), to use of Raman spectroscopy in the search for biosignatures on other planets, such as Mars (Parnell et al.; Rolfe et al.).