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ASTROBIOLOGY

Introduction to the Special Issue - Habitability in the Universe: from the Early Earth to Exoplanets

Muriel Gargaud[1] · **Wolf Dietrich Geppert**[2] · **Nigel J. Mason**[3]

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European astrobiology is in the midst of great change, emerging as a recognised independent interdisciplinary field that is distinct yet complementary to the more well-established disciplines such as astrochemistry, planetary sciences, Earth sciences, chemistry and life sciences. The European Astrobiology community is a strong one with over 70 laboratories and groups identifying astrobiology as their dominant research topic. Astrobiology research has been recognised by the European Research Council (ERC) in its award of both Starting and Advanced grants and several Marie Curie Fellowships from Framework 7 and Horizon 2020 specify astrobiology as their prime discipline. The European Astrobiology research community has developed a range of state of the art research facilities both in the laboratory and at field sites which through European funding (e.g. Europlanet Research Infrastructures) have supported transnational access and fostered collaborative research programmes. Indeed Europe has some unique field sites that are accepted as global resources for astrobiology research (e.g. Iceland, Svalbard, Rio Tinto in Spain). European involvement in the International Space Station (ISS) has further broadened the range of Astrobiology research conducted with EU ISS researchers having explored the survival and growth of microorganisms in real

✉ Muriel Gargaud
Muriel.Gargaud@obs.u-bordeaux1.fr

Wolf Dietrich Geppert
wgeppert@fysik.su.se

Nigel J. Mason
n.j.mason@open.ac.uk

[1] Laboratoire d'Astrophysique de Bordeaux, 2 rue de l'Observatoire, 33270 Floirac, France

[2] Stockholm University Astrobiology Centre, Stockholm University/Stockholms Universitet, Roslagstullbacken 21, S-10691 Stockholm, Sweden

[3] Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK

space conditions. Europe is also the base of a flourishing exoplanet research community, building on the first discoveries made by European researchers. Thus after more than two decades of research and discussion European Astrobiology has 'come of age' and in 2016 will launch its Astrobiology roadmap (www.astromap.eu) which complements that of NASA (astrobiology.nasa.gov/roadmap) and provides a vision for Europe to be a leader in this still new and emerging discipline.

In 2014 two new Astrobiology programmes were launched to coordinate and harmonise European astrobiology research: the COST supported TD1308 action 'Origins and evolution of life on Earth and in the Universe (ORIGINS) http://life-origins.com/ and, for training and education, the European Astrobiology Campus (http://astrobiology-campus.eu). In March 22–27th, 2015, these programmes organised a conference on "Habitability in the Universe: From the Early Earth to Exoplanets" at Porto, Portugal (http://www.iastro.pt/research/conferences/life-origins2015/). The meeting was to be the first in a series led by COST Origins to bring researchers together from across Europe to review the state of the art and discuss future directions. The meeting was attended by over 100 researchers and from their contributions the 17 papers of this volume are compiled.

This special issue of OLEB entitled '"Habitability in the universe" provides a 'snapshot' of the field as it is developing in 2015/16. Papers represent the five thematic areas of the COST action;

- Understanding the formation and evolution of planetary systems and habitable planets.
- Searching for the origins of the building blocks of life.
- Tracing the origin and evolution of life on Earth and finding its limits.
- Detecting life on other planets and satellites
- History and Philosophy of science.

The paper by Gallet et al. entitled 'Host star evolution for planet habitability' and that of Figueira et al. 'A pragmatic Bayesian perspective on correlation analysis: The exoplanetary gravity - stellar activity case' discuss the complex relationship between stellar properties and the planetary systems they may support. Adibekyan et al. in their paper 'Which type of planets do we expect to observe in the Habitable Zone?' proceed to explore how the chemical composition of a planet is dependent on that of the host star and thus also the likelihood of 'habitable' planets in different solar systems.

Assembling the chemical building blocks of life and exploring the nascent chemistry in the InterStellar Medium (ISM) and during planet formation (including Earth) are discussed in the experimental paper by Saladino et al. 'First evidence on the role of heavy ions irradiation of meteorites and formamide in the origin of biomolecules' and the theoretical analysis on 'Proton-induced Collisions on Potential Prebiotic Species' by Bacchus-Montabonel. The chemistry of planetary atmospheres as a precursor for prebiotic life is discussed using Titan as model by Hrušák and Paidarová in their paper 'A Step towards modelling the atmosphere of Titan; state-selected reactions of O^+ with methane' and Zymak et al. in their paper 'A pilot study of ion - molecule reactions at temperatures relevant to the atmosphere of Titan,' as well as Mazankova et al. in the paper 'The influence of CO_2 admixtures on the product composition in a nitrogen-methane atmospheric glow discharge used as a prebiotic atmosphere mimic". Titan may therefore provide a fascinating template for early Earth chemistry.

Recent and planned missions to Mars provide the European astrobiology community with the opportunity to explore a planet where it is speculated life may have originated at the same time as Earth. The search for signatures of such life and identification of early Martian atmospheric chemistry is through the collection and analysis of Martian Meteorites. Kereszturi and

Chatzitheodoridis in their paper 'Searching for the source crater of nakhlite meteorites' provide insight into where such samples may originate and be found. Future in situ studies of Martian geology providing clues as to past Martian climate are discussed by Kereszturi et al. in their paper 'Indicators and methods to understand past environments from ExoMars rover drills'.

Defining the parameters of planetary habitability is central to the development of astrobiology and the search for life beyond Earth. In this special issue the current state of knowledge and the need for further research to define these parameters is reviewed in two papers: Kereszturi and Noack's 'Review on the role of planetary factors on habitability' and Dehant and co-workers in their report on 'PLANET TOPERS: Planets, Tracing the Transfer, Origin, Preservation, and Evolution of their Reservoirs' a programme to explore habitability in our solar system http://iuap-planet-topers.oma.be.

Since Earth provides our only example of a confirmed inhabited planet, the question of how prebiotic molecules assembled to form self-replicating macromolecular systems and how life itself was then able to evolve are central to Astrobiology. Strbak et al. in their paper 'Proton gradients as a key physical factor in the evolution of the forced transport mechanism across the lipid membrane' address the critical phase in the transition from prebiotic chemistry to biological evolution through study of asymmetric ion flow across the lipid membrane. Kaye et al. develop the cellular biochemistry in their study of the 'Selective phosphonylation of 5'-adenosine monophosphate (5′-AMP) via pyrophosphite [PPi(III)]'. Both papers reveal that we still have to resolve a lot of details on how living systems were constructed on early Earth and whether such conditions exist elsewhere in our solar system and beyond.

The possibility of identifying signatures of life on exoplanets is now entering an exciting stage with the first probes of chemical signatures of such planets but the opportunity to view the surface and hence look for minerals (and perhaps vegetation, e.g. the 'red edge') is now being discussed as observational tools develop. Martin et al. provide an update in their paper 'Reflected light from giant planets in habitable zones: Tapping into the power of the Cross-Correlation Function'.

Panspermia as a mechanism for transport of life between planetary systems (and their moons) has been widely discussed and requires study of the survival of life-bearing species under such extreme conditions. Such an understanding is also essential if we are to avoid contamination of solar system bodies (planets, moons and asteroids) through our own probes. Experimental studies on the ISS are therefore providing valuable data and such study is reported by Gomoiu et al. in their paper entitled 'Fungal spores viability on the International Space Station'.

Astrobiology must be seen as a cultural as well as a scientific discipline. Humanity has wondered about its place in the Universe since the earliest civilizations and discussion of the origins of life have been a central part of philosophical debate for millennia. The COST Action has provided a forum for interlinking scientific studies with the history and philosophy of science, perhaps in a novel way. This interdisciplinary approach will be a feature of the European Astrobiology Roadmap and is encouraged by the H2020 programme. The paper by Pascal and Pross on 'The Logic of Life' is an example of this discussion that the Porto meeting and Cost Action is developing between the sciences and humanities.

In conclusion this special issue gives a unique insight into the breadth and novelty of European Astrobiology research at a time when the community is emerging as a new interdisciplinary research field, capable of providing international leadership in addressing some of the most challenging (and exciting) questions of modern science. Where, when and how did life emerge and evolve on Earth? What are the conditions under which life can exist? and Does life exist elsewhere in the Universe and, if it does, how can it be detected and identified?