

NExSS/NAI JOINT ExoPAG SAG 16 REPORT ON REMOTE BIOSIGNATURES FOR EXOPLANETS.

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Introduction: Future exoplanet observations will soon focus on the search for life beyond the Solar System. Exoplanet biosignatures to be sought are those with global, potentially detectable, impacts on a planet. Biosignatures occur in an environmental context in which geological, atmospheric, and stellar processes and interactions may work to enhance, suppress or mimic these biosignatures. Thus biosignature science is inherently interdisciplinary. Its advance is necessary to inform the design of the next flagship missions that will obtain spectra of habitable extrasolar planets.

The **NExSS/NAI Joint Exoplanet Biosignatures Workshop Without Walls** brought together the astrobiology, exoplanet, and mission concept communities to review, discuss, debate, and advance the science of remote detection of planetary biosignatures. The multi-meeting workshop began in June 2016, and was a process that engaged a broad range of experts across the interdisciplinary reaches of NASA's Nexus for Exoplanet System Science (NExSS) program, the NASA Astrobiology Institute (NAI), NASA's Exoplanet Exploration Program (ExEP), and international partners, such as the European Astrobiology Network Association (EANA) and Japan's Earth Life Science Institute (ELSI). These groups spanned expertise in astronomy, planetary science, Earth sciences, heliophysics, biology, instrument/mission development, and engineering.

The workshop report is a set of review chapters and thought pieces covering: 1. The published state of the science of exoplanet biosignatures. 2. An in-depth analysis of lessons learned from the changing understanding about O₂ as a biosignature. 3. A generalized

framework for searching for biosignatures and identifying false positives. 4. Exploration of recently emerging ideas, and the current debates over them, for development of biosignature science conceptual frameworks and discovering novel biosignatures. And 5. A roadmap for the parallel path for development of both observation technology and science (Fig. 1).

Major consensus themes running throughout these report sections are the importance of environmental, evolutionary, and biology-planet co-evolutionary context, to constrain confidence in identifying an observed phenomenon as a sign of life or not.

The draft workshop report papers have been open for community review since earlier this year through April 31, 2017. The report will be a product of the Exoplanet Exoplanet Exploration Program Analysis Group (ExoPAG) Study Analysis Group 16 (SAG16), and is intended for an audience of students through senior researchers, to serve as a guide for conducting interdisciplinary research in biosignature science, and to inspire further advances in the science of the search for life elsewhere in the universe.

References: [1] Seager, S., Bains, W., and Petkowski, J. J. (2016) *Astrobiology*, 16(6):465. [2] Parenteau, M. N., *et al.*, (2015) *AbSciCon 2015*, Abstract #7693, *Oral*. [3] Sara Walker, *pers. comm.* [4] Barnes, R., *et al.* (2015) *ApJ*, 814(2). [5] Way, M. J., *et al.* (2016) *GRL*, 43. [6] Masumoto, H. *et al.*, *pers. comm.*

Workshop website: <http://nexss.info/community/workshops/exoplanet-biosignatures-workshop>

