To: Exoplanet Program Analysis Group (ExoPAG) Executive Committee

From: ExoPAG Study Analysis Group (SAG) 16 Co-Chairs

Date: 18 June 2018

Subject: ExoPAG SAG 16 Topic: Exoplanet Biosignatures

Dear ExoPAG Executive Committee:

Below and attached please find a summary of the products from the SAG 16 Topic: Exoplanet Biosignatures Workshop Without Walls (EBWWW). The EBWWW encompassed a series of online and in-person activities, with participation from the international exoplanet and astrobiology communities, to assess the state of science and future research needs for the remote detection of life on planets outside our Solar System.

These activities culminated in six manuscripts featured in a special Open Access collection in *Astrobiology* to be published on June 23, 2018 (see links below). These respectively cover: 1) an executive summary (Kiang et al., in press); 2) a review of known and proposed biosignatures (Schwieterman et al., in press); 3) a review of O_2 as a biosignature as an end-to-end example of the contextual knowledge required to rigorously assess any claims of life on exoplanets (Meadows et al., in press); 4) a generalized statistical approach to place qualitative understanding and available data in a formal quantitative framework according to current understanding (Catling et al., in press); 5) identification of needs to advance that statistical framework, and to develop or incorporate other conceptual frameworks for biosignature assessment (Walker et al., in press); and 6) a review of the upcoming observatories - both planned and possible - that could provide the data needed to search for exoplanet biosignatures (Fujii et al., in press).

Kiang, N.Y., Domagal-Goldman, S., Parenteau, M.N., Catling, D.C., Fujii, Y., Meadows, V.S., Schwieterman, E.W., Walker, S.L. (2018) Exoplanet biosignatures: At the dawn of a new planetary era. *Astrobiology*, 18(6).
https://www.liebertpub.com/doi/10.1089/ast.2018.1862

Schwieterman, E.W., Kiang, N.Y., Parenteau, M.N., Harman, C.E., DasSarma, S., Fisher, T.M., Arney, G.N., Hartnett, H.E., Reinhard, C.T., Olson, S.L., Meadows, V.S., Cockell, C.S., Walker, S.I., Grenfell, J.L., Hegde, S., Rugheimer, S., Hu, R., Lyons, T.W. (2017). "Exoplanet Biosignatures: A Review of Remotely Detectable Signs of Life," *Astrobiology*, 18(6).
https://www.liebertpub.com/doi/10.1089/ast.2017.1729

Meadows, V.S., Reinhard, C.T., Arney, G.N., Parenteau, M.N., Schwieterman, E.W., Domagal-Goldman, S.D., Lincowski, A.P., Stapelfeldt, K.R., Rauer, H., DasSarma, S., Hegde, S., Narita, N., Deitrick, R., Lyons, T.W., Siegler, N., Lustig-Yaeger, J. (2017). "Exoplanet Biosignatures: Understanding Oxygen as a Biosignature in the Context of Its Environment," *Astrobiology*, 18(6).
https://www.liebertpub.com/doi/10.1089/ast.2017.1727

Catling, D.C., Krissansen-Totton, J., Kiang, N.Y., Crisp, D., Robinson, T.D., DasSarma, S., Rushby, A., Del Genio, A., Bains, W., Domagal-Goldman, S., 2017. "Exoplanet biosignatures: A framework for their assessment," *Astrobiology*, 18(6). https://www.liebertpub.com/doi/10.1089/ast.2017.1737

Walker S. I., Bains W., Cronin L., DasSarma S., Danielache S., Domagal-Goldman S., Kacar B., Kiang N. Y., Lenardic A., Reinhard C. T., Schwieterman, E.W., Shkolnik, E.,L., Smith, H.B. (2017). "Exoplanet Biosignatures: Future Directions," *Astrobiology*, 18(6). arXiv preprint 1705.08071.
http://arxiv.org/abs/1705.08071

Fujii, Y. , Angerhausen, D., Deitrick, R., Domagal-Goldman. S., Grenfell, J.L., Hori, Y. , Palle, E., Siegler, N., Stapelfeldt, K., Rauer, H. (2017). "Exoplanet Biosignatures: Observational Prospects," *Astrobiology*, 18(6). arXiv preprint 1705.07098.
https://arxiv.org/abs/1705.07098

In addition, two white papers were submitted to the National Academies of Sciences Astrobiology Science Strategy and Exoplanet Science Strategy panels.

Domagal-Goldman. S., et al. (2018) Life Beyond the Solar System: Remotely Detectable Biosignatures. This is a white paper that was submitted to the National Academies of Sciences Study: Astrobiology Science Strategy for the Search for Life in the Universe.
https://arxiv.org/abs/1801.06714

Domagal-Goldman. S., et al. (2018) Life Beyond the Solar System: Remotely Detectable Biosignatures. This is a white paper that was submitted to the National Academies of Sciences (NAS) Study on an "Astrobiology Science Strategy for the Search for Life in the Universe," and to another NAS study on an "Exoplanet Science Strategy." The NAS Exoplanet Science Strategy white paper is appended to this report.

Sincerely,

Shawn Domagal-Goldman, Nancy Kiang, Niki Parenteau