Dear Dr. Glaze,

In response to your recent request, here we provide a list of "Big Questions" as developed by the OPAG community. The OPAG community drew from its Scientific Goals documents, the Roadmap to Ocean Worlds, previous Planetary Science Decadal Surveys, Europa Lander and Ice Giant System mission concept studies, and community discussion at the 20-21August 2019 OPAG meeting. The resulting ideas were combined and curated by the OPAG Steering Committee to produce a final set of three "Big Questions" and one planetary-science-wide, cross-divisional theme.

You also requested big science questions the OPAG community perceives to be of importance for the other AG communities. We believe that our three Big Questions are also responsive to your second request, as our community discussion strived to formulate the most fundamental questions that encompass all of planetary science relevant to all of the AGs.

These "Big Questions" are listed below along with example bulleted, high-level, OPAG-specific sub-questions:

Big Question #1: What is the distribution and history of life in the solar system?
- Does life or do habitable conditions exist beyond the Earth?
- What controls the habitability of ocean worlds?
- Do ocean worlds host life now, or did they in the past?
- What is the potential for prebiotic chemistry in ocean worlds, and how far towards life has this progressed?
- What role did the giant planets play in the emergence of life on Earth or elsewhere in the solar system?

Big Question #2: What is the origin, evolution, and structure of planetary systems?
- What was the initial chemical profile of the protoplanetary disk as informed by noble gas content in the giant planets, and how did this profile impact the overall formation and evolution of our solar system?
- What are the possible architectures of planetary systems, and how do these different configurations affect planet formation and evolution (e.g., giant planet migration, tidal evolution, etc.)?
- What controls the formation, evolution and internal structures of gas giants, ice giants, planetary satellites (particularly ocean worlds), rings, and small bodies in the outer solar system?
- How do planetary crusts/cryospheres, oceans, atmospheres, and magnetospheres form and evolve in the outer solar system, and how do they influence the evolution of bodies in those systems?

Big Question #3: What present-day processes shape planetary systems, and how do these processes create diverse outcomes within and across different worlds?
- How do the chemical and physical processes in the solar system scale between planet size and location within the solar system?

- What is the dynamic relationship between the planets, rings, and moons of giant planet systems, and how do these relationships influence their constituent members?
- How do the magnetospheres of gas and ice giants influence the dynamics, composition and structure of the atmospheres, rings, and moon surfaces?
- How do the aurorae and induced magnetic fields of ocean worlds characterize the coupling between planets, moons, and magnetospheres?
- What are the mechanisms, drivers, and rates for transporting heat and materials within, and ejecting them from, (cryo-)volcanically active worlds?
- How does coupled orbital evolution and tidal heating affect the interior structures and activity of satellites, and how does the interior evolution of the primaries affect this evolution (e.g., resonance locking)?
- What drives the transport of energy and materials within the deep interior of the giant planets?
- How do the atmospheric dynamics, cloud microphysics, radiative transfer, and chemistry interact to form stable and transient features observed in outer planet and satellite atmospheres?
- How do the ice giant magnetospheres and atmospheres respond to the impulsive solar wind forcing created by their unusual geometries, and what effect does solar insolation play on weather and upper atmospheric structure?

Cross-Divisional Theme: How can knowledge of the solar system advance our understanding of the Earth, Sun, and Exoplanets?

- How does knowledge gleaned from studying the outer solar system make us better stewards of our own planet?
- How does the study of our planet inform our understanding of the outer planets and their moons?
- How do studies of the diverse present-day oceans in the solar system advance biological, chemical and physical oceanography?
- How does the study of the solar wind interaction at bodies in the outer solar system improve our understanding of the Sun and the propagation and evolution of its dynamic atmosphere?
- How can solar system bodies inform our understanding of bodies in exoplanetary systems?

Lastly, the OPAG community also discussed the critical importance of equity, diversity, and inclusion in formulating the statement of task for the Decadal Survey and in the composition of the Survey leadership (especially in the chair(s) and steering committee). OPAG suggests that the statement include language such as the following:

> *"The composition of the Decadal Survey panels - particularly the Chairs and Steering Committee - should take full advantage of the diversity of the planetary science community in factors such as area of expertise, gender, race, ethnicity, career stage, types and sizes of institutions, geographic distribution, and disability status."*

We note that Astro2020 has two co-chairs, rather than a chair and a vice-chair; many members of OPAG believe this would be a good approach for the Planetary Decadal Survey as well, particularly given the wide range in topics and targets covered.

Please let us know if you have any questions or would like any clarification.

Jeff Moore and Kunio Sayanagi for the OPAG Steering Committee
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