【International Leading Research】

Understanding of the diversity of prebiotic chemistries and emergence of molecular systems in various planetary environments in the Solar System

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Purpose and Significance of the Research

How did Earth and Earth's life form? Are there any planets in the universe that harbor life? - These are simple questions that everyone may have asked, and they are simple but fundamental in natural science that lead to the ultimate question of "who are we? In fact, it is expected that major progress will be made within the next decade on this question of the origin of Earth and life. The Hayabusa2 spacecraft has brought back samples from an asteroid, which is a building material for Earth and other planets, providing information on the earliest era of the Solar System. On Mars, NASA's rovers are driving over muddy sediments that once accumulated in ancient lakes to collect samples containing organic materials. These samples will be brought back to Earth in the 2030s.

However, these space explorations will not immediately answer the above questions concerning the origins of Earth and life, and life in the universe. To understand what these observations mean, theories based laboratory experiments and numerical calculations on "the formation and evolution of the surface environment of planets and prebiotic chemical evolution" are indispensable. To make such a theoretical interpretation, it is necessary to know what kind of material materials Earth and other planets in the Solar System are made of, how surface environments such as atmospheres and oceans were formed, and how these surface environments differ among the planets. We also need to know what kind of organic matter is produced in these diverse environments, and what kind of materials are used to create "possible life" beyond Earth.

Our goal is to develop scenarios for the origin of Earth and life, to understand the meanings of extraterrestrial samples and observations, and to approach the question of extraterrestrial life, through establishing a tight link between theories and space

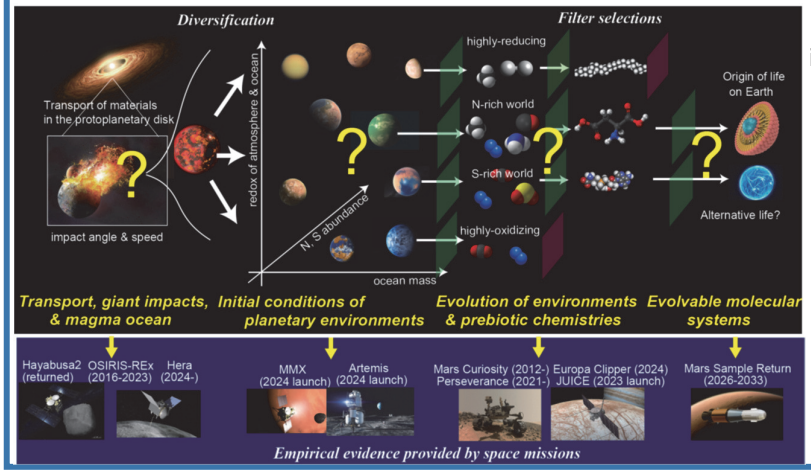

Fig. 1. Schematic image showing how different conditions during the formation of a planet create diverse surface environments, where organic matter is produced. For each stage, a solar system exploration is planned to demonstrate it.

Organization of the Project Team

In this research, an international joint research framework (Fig. 2) will be established to build a tight link between theories and space explorations. First, Earth-Life Science Institute (ELSI) of the Tokyo Tech., a World Premier International Research Center (WPI), will be the core of the theoretical research, and international collaboration will be established with top overseas centers (Observatory of the Cote d'Azur, Niels Bowa Institute, etc.) to reinforce this framework. ELSI has an outstanding achievement of fostering fusion of fields ranging from astronomy to biology. On the other hand, as for space explorations, JAXA has been leading exploration of asteroids, including Hayabusa2. We will build strong international collaborations with NASA's Jet Propulsion Laboratory and other overseas space agencies for the exploration of Mars and the ice satellites of Jupiter and Saturn, creating a major international research network.

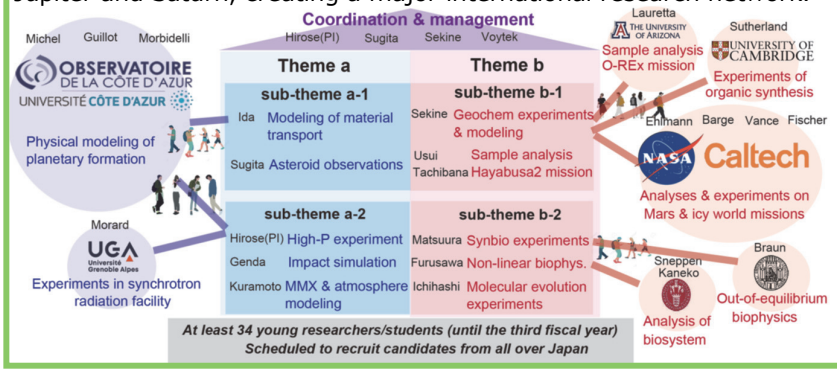

Fig. 2. Schematic image of domestic and international collaborations for this research project. The core researchers and themes are noted for each of the themes.

Plan for Fostering Early-career Researchers

In addition to the 11 principal investigator and co-investigators, 34 young researchers will participate in this research by the second year of the project, and an average of 30 young researchers will participate thereafter. They will be dispatched to overseas corresponding to the research topics (a-1)-(b-2) in Figs. 2 and 3 for a long period.

To internationalize the field as a whole, this research plan will gather excellent young researchers from all over Japan, and dispatch them to overseas on a long-term basis. We have also prepared tenure-track faculty positions (at ELSI, Tokyo Tech., and ISAS, JAXA). This post will be used to establish a system to foster researchers who will play a central role in the international research community over a long term. This will lead to the establishment of research groups that link from astronomy and earth and planetary sciences to chemistry and life sciences (Fig. 3), and to the development of researchers capable of breaking the discipline boundaries and pioneering new horizons of knowledge.

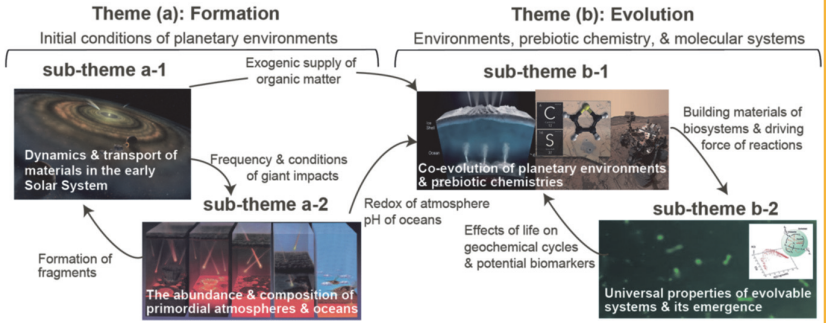

Fig. 3. Schematic image showing themes of this research and the linkages. By linking these themes, we will develop researchers that transcend the discipline boundaries.

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