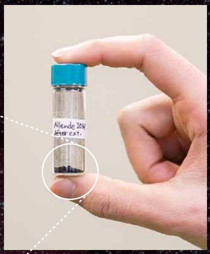
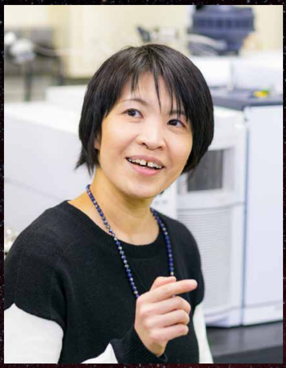
Unveiling the chemical evolution of life's building blocks in space

Organic macromolecular solid isolated from carbonaceous meteorites





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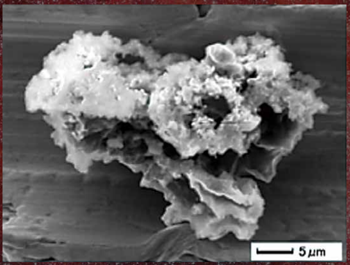
Major research fields

Geochemistry/Cosmochemistry, Astrobiology



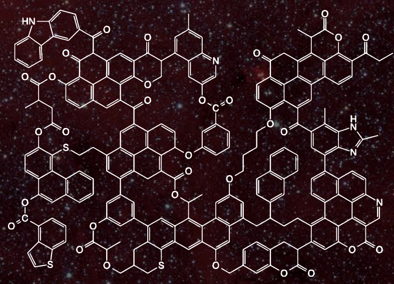
Cosmic dust collected from Antarctic surface snow

My research focuses on investigating the origins, formation, and transport of the building blocks of life in the Solar System. We analyze organic molecules in extraterrestrial materials, such as meteorites and cosmic dusts, using a number of techniques.

Organic molecules consist of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), and sulfur (S). These are the primary elements that make up living organisms and the most abundant elements in the universe. About 4.6 billion years ago, in interstellar molecular clouds, chemical reactions occurred in gas phase and on dust surfaces at very low temperatures, producing various molecules. Afterward, the first molecules produced in the interstellar clouds chemically evolved through repeated synthesis and decomposition into complex organic molecules in the protoplanetary disk and planetesimals, and they were then incorporated into primitive small bodies such as asteroids and comets. Thus, these primitive small bodies are "time capsules" which retain the pristine materials in the early Solar System. Organic molecules in the small bodies are one of the important materials that formed the planets and life.

Meteorites and cosmic dust are pieces of asteroids or comets that have fallen to Earth. Carbonaceous meteorites with high organic carbon content (2-5 weight-percent) contain a significant amount of organic macromolecular solids as well as a low amount of biochemically relevant molecules of extraterrestrial origin, such as amino acids, carboxylic acids, and sugars. For many years I have been intrigued by the question of how these macromolecules were formed in the history of the Solar System and how it could have contributed to the origin of life. A number of previous studies of carbonaceous meteorites have revealed that the chemical compositions of organic macromolecules are modified by aqueous alteration and thermal metamorphism on the meteorite parent body, that is, the macromolecules sensitively record the chemical history of the early Solar System. In addition, a comparison of the molecular compositions of organics in meteorites (asteroids) and cometary dust has enabled tracing back the origin and evolution of organic matter in space.

The asteroid explorer Hayabusa2 is scheduled to return to Earth with samples collected from the asteroid Ryugu at the end of 2020. Detailed observations by the spacecraft have found that Ryugu does not perfectly match any meteorites that have been investigated to date. I expect that the unknown type of extraterrestrial matter brought back by Hayabusa2 will give us a new clue for unveiling the questions on the origins of life. In the Hayabusa2 initial analysis team, I will serve as a leader of the organic macromolecules analysis sub-team. I hope we will discover something new that will help future planetary explorations undertaken by next-generation scientists.



Molecular structure model of organic macromolecule (Glavin, Yabuta et al. 2018)

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*HiSIM (Hiroshima-University STARC IGFET Model) is a transistor model used in circuit design that has been developed by Hiroshima University in collaboration with the Semiconductor Technology Academic Research Center (STARC).

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