

## NINS ASTROBIOLOGY CENTER

The Astrobiology Center (ABC) in NISS was established in 2015 to promote interdisciplinary studies that include astronomy, earth science, and biology by organizational adaptation between National Astronomical Observatory of Japan (NAOJ) and National Institute for Basic Biology (NIBB). In the 2021 fiscal year, ABC stayed active to encourage interdisciplinary studies and grow the research community as the hub institute of astrobiology despite social constraints under the COVID-19 pandemic. ABC symposium was held online on Jan 28th, 2022, inviting speakers from diverse research fields including an observatory mission by James Webb Space Telescope. Life in the Universe Workshop was also held online on Feb 17th-18th, 2022 to present the latest results from ABC-subsidized research.

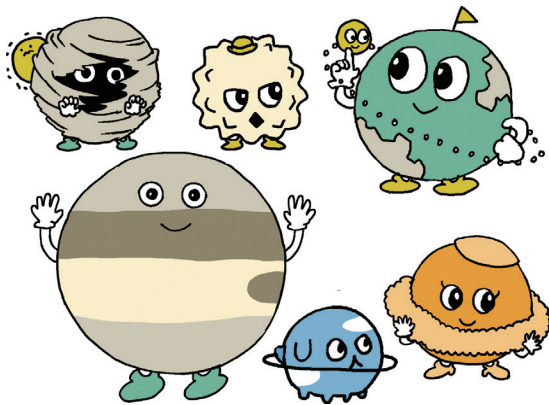


Figure 1. ABC mascot characters: “Exoplanet Friends” (Credit: Hayanon Science Manga Studio)

Three project offices in ABC are working together to find a habitable exo-planet and a sign of life on said planet. Exo-Planet Search Project Office and Astrobiology Instrument Project Office which are located in the Mitaka campus of NAOJ are preparing direct-imaging surveys of “Another Earth” by next-generation, 30m-scale telescopes. To support future observation projects, three groups from NIBB in Okazaki, the Takizawa, Johzuka, and Fujita groups, are participating in the Exo-Life Search Project Office to investigate life on Earth utilizing three different approaches: 1) assessing the biosignature of various photosynthetic organisms to predict biosignatures of hypothetical life on exoplanets, 2) evaluating the effects of cosmic radiation on living cells, and 3) elucidating mathematical principles in the formation of self-organizing structures in organisms.

## LABORATORY OF BIOLOGICAL DIVERSITY

### TAKIZAWA Group



Specially Appointed Associate Professor  
TAKIZAWA, Kenji

The Takizawa group operating out of ABC is currently studying the environmental responses of photosynthesis in order to predict photosynthetic apparatus of so-called ‘Alien’ plants under extreme conditions on the aforementioned ‘Another Earth’.

### Light adaptation mechanisms of photosynthesis

We investigated the flexible molecular mechanisms of light harvesting and following photosynthetic reactions in cooperation with the division of environmental photobiology. In photosynthesis research, we are specialized in spectroscopic analyses which can be applied to astrobiology studies.

### Characterize hypothetical plants in exo-planets

One of the most plausible biosignatures detected by the exo-planet observations is a specific reflection pattern on the land surface named ‘vegetation red edge’ or VRE. VRE arises from strong absorption of red light by photosynthetic pigments and high reflectance of near-infrared radiation (NIR) by the developed leaf tissue structure. The wavelength position and amplitude of VRE could be different on another planet. We studied the light reflection spectrum of various plants and predicted that substantially large VRE could be observed even on the ocean planets if floating plants cover the water surface (Figure 2). We also predicted the possibility of red-sift in VRE on the planets exposed to NIR rather than visible light. We have revealed that several metal-containing pigments can be functional in reaction centers under NIR radiation conditions via quantum chemical calculations.

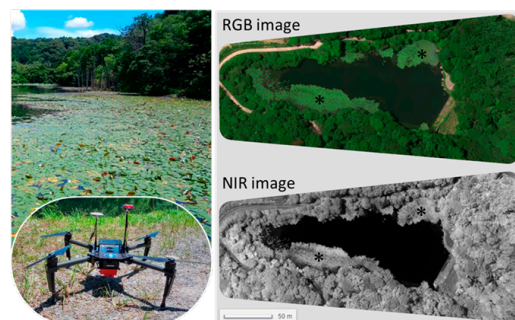


Figure 2. Remote sensing of light reflectance of floating leaf of waterlily. Light reflectance in visible light (RGB) and NIR were obtained by the drone-based multiband sensor.

### Publication List:

#### [Original papers]

- Komatsu, Y., and Takizawa, K. (2021). A quantum chemical study on the effects of varying the central metal in extended photosynthetic pigments. *Phys. Chem. Chem. Phys.* 23, 14404–14414. DOI: 10.1039/d1cp00760b
- Pan, X., Tokutsu, R., Li, A., Takizawa, K., Song, C., Murata, K., Yamasaki, T., Liu, Z., Minagawa, J., and Li, M. (2021). Structural basis of LhcbM5-mediated state transitions in green algae. *Nat. Plants* 7, 1119+. DOI: 10.1038/s41477-021-00960-8