
EARTH-LIFE SCIENCE INSTITUTE
Tokyo Institute of Technology

Message from the President

Kazuya Masu

President
Tokyo Institute of Technology

The Earth-Life Science Institute (ELSI) was launched in 2012 with generous support from the World Premier International Research Center Initiative (WPI), MEXT*. In just a few years, ELSI has grown into a fully formed and mature institution. We at Tokyo Tech are proud of the accomplishments of ELSI, which include a highly successful recruiting strategy, the establishment of a global collaborative network of world-leading scholars, and a genuinely international environment that welcomes researchers from all over the world. ELSI is intended to be a role model for the university as a whole, and forms a key part of my vision for Tokyo Tech to become a top global university.

Diversity is one of the key factors in making new discoveries, tackling new fields of study, and surmounting challenges in research. ELSI is leading Tokyo Tech with its diversity in members that address a wide range of research topics.

ELSI is now established as a permanent independent institute, and operates directly under the Tokyo Tech president. ELSI's scientific leadership has been rewarded with both a large amount and a variety of foreign and domestic funding. ELSI's future is bright and it will continue to grow and enhance its vigorous research activities long after the initial WPI grant period expires.

Seeing how far ELSI has come in these years, I am excited by our shared future. Let's continue to rise together.

*MEXT: Ministry of Education, Culture, Sports, Science and Technology

Exploring the Origins of the Earth and Life

Kei Hirose

Director
Earth-Life Science Institute
Tokyo Institute of Technology

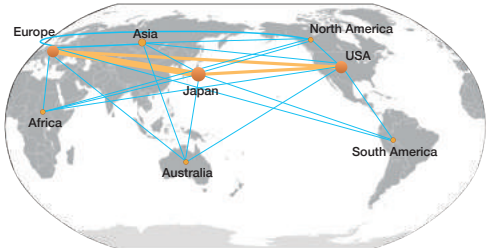
How did the Earth form and what was the early Earth like, how did life emerge and evolve in its early environment, and what does the answer imply for the possibility of life elsewhere in the universe? The Earth-Life Science Institute (ELSI) is a one-of-a-kind, internationally recognized, world-class research institute established in 2012 to address these questions.

As a World Premier International Research Center (WPI Center) based at Tokyo Institute of Technology, our mission is to facilitate breakthroughs at the frontier of science by attracting and interacting with the best minds from around the world, to promote interdisciplinary research in Origins of Earth and Life Science, and to play a leading role in implementing and promoting administrative innovation and organizational excellence among universities in Japan.

ELSI has cultivated a multidisciplinary international community of researchers, integrating disciplines to study the Origins of Life within the context of the Origin of the Earth and other planets. ELSI hosts dozens of short- and long-term visitors to develop innovative ideas. We are committed to science education and also sharing our research with the general public. All are welcome to visit ELSI and join our quest to understand the origins of Earth and the life it supports.

Global Research Network

ELSI is continuing to expand its global network and research is conducted under close coordination with 5 satellite institutions at home and abroad. Many papers have been published as a result of international research cooperation.



The figure indicates the level of interactions between other institutions in the world and ELSI based on the number of joint publications.

Satellite Centers

- Geodynamics Research Center (GRC), Ehime University
- Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo
- Interdisciplinary Program, Institute for Advanced Study (IAS) in Princeton
- Origin of Life Initiative, Harvard University
- Columbia Astrophysics Laboratory, Columbia University

About WPI

The World Premier International Research Center Initiative (WPI) was inaugurated in 2007 by the Ministry of Education, Culture, Sports, Science and Technology with a mission of establishing "globally visible research centers" within Japan, where researchers on the frontline of science gather from all over the world. WPI centers are required to fulfill the following criteria of "advancing cutting-edge research," "creating interdisciplinary domains," "establishing international research environments," and "reforming research organizations." ELSI was selected to be a member institution of this prestigious initiative in 2012.

wpi
World Premier International Research Center Initiative

ELSI: Unraveling the Wonders of the Earth and Life

The Earth-Life Science Institute (ELSI) raises the following four questions as part of its mission to investigate the origin of the Earth and life.

(A) How was the Earth formed in our Solar System? (the formation of planet Earth)

(B) When, where, and how did the Earth-Life system come into existence? (early Earth-Life system)

(C) How did life on Earth evolve? (evolution of life on Earth)

(D) Through our research on early Earth-Life systems and unraveling the secrets of this planet's ability to support life, we aim to suggest new search criteria for life on extrasolar planets and moons in order to establish a field of study called "bioplanetology." (life in the universe)

Life exists on Earth because of its unique environment. Our institute would first (A) determine the structure of the Earth, (B) identify the kind of life that first appeared and when its birth took place, and (C) investigate how those early life forms evolved, through multiple perspectives and procedures. Then, by applying our discoveries on genetic information of primitive life forms, we aim to further explore (D) "whether life would arise in environments entirely different from Earth."

A The Formation of Planet Earth

Why is there water on Earth?
What was the Earth's first atmosphere comprised of?

- Reestablishing the first-principles theory of planet formation (planetary physics)
- Defining the composition of the Earth's primitive crust, mantle, and core (high pressure experiment)
- Recreating hydrothermal environments in the Hadean eon to observe chemical energy (hydrothermal experiment)

B Early Earth-Life System

When, where, and how did life form?
What were the Earth's first ecosystems like?

- Estimating genomic information of primitive ecosystems (database, sampling)

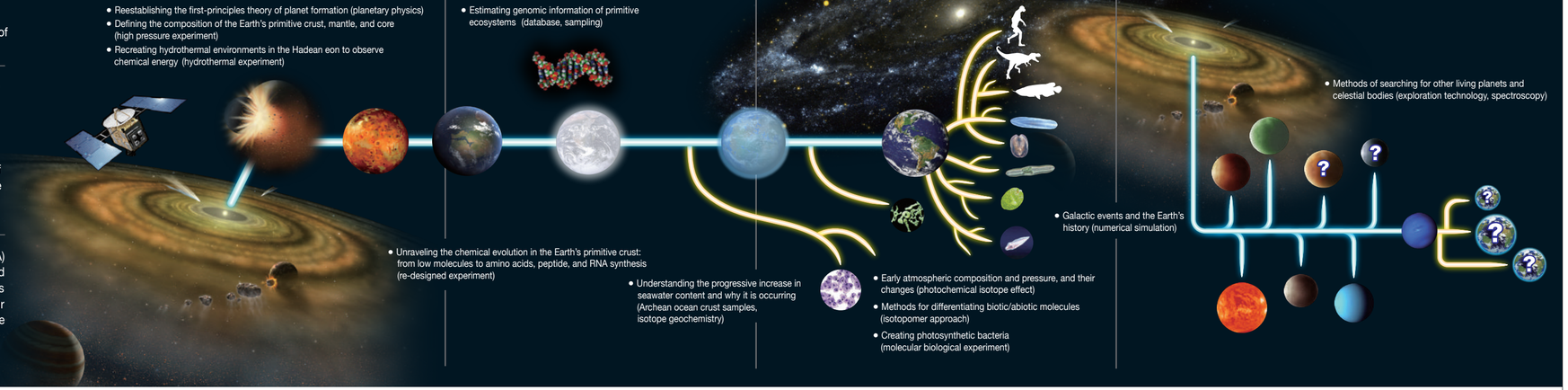
C Evolution of Life on Earth

How did changes in the solid Earth and the galaxy affect the evolution of life?
Why is there oxygen in the atmosphere?

D Life in the Universe

Is the Earth a special planet in the universe for harboring life?
Or is it a universal phenomenon? How do we find extraterrestrial life?

- Methods of searching for other living planets and celestial bodies (exploration technology, spectroscopy)



- Unraveling the chemical evolution in the Earth's primitive crust: from low molecules to amino acids, peptide, and RNA synthesis (re-designed experiment)
- Understanding the progressive increase in seawater content and why it is occurring (Archean ocean crust samples, isotope geochemistry)
- Early atmospheric composition and pressure, and their changes (photochemical isotope effect)
- Methods for differentiating biotic/abiotic molecules (isotopomer approach)
- Creating photosynthetic bacteria (molecular biological experiment)
- Galactic events and the Earth's history (numerical simulation)

International Research Hub for the Origin of Earth and Life

About half of the researchers at ELSI are foreign nationals, and approximately two-thirds of applications are from abroad when we recruit new researchers; hence, our institute is home to various projects in an international environment. We also welcome many visiting researchers from across the world and will continue to pursue building a research hub without borders, fulfilling our role as an international hub for researching the origin of Earth and life.

Approaches in Fostering Multidisciplinary Research

Exchanges between researchers of different fields of study are essential in order to realize ELSI's mission, which is to understand the origin of the Earth and life. Hence, our institute takes a multi-layered approach to introduce various opportunities for social exchange.

For instance, we provide opportunities to share new knowledge and hold discussions among researchers of different disciplines through our frequent intramural seminars. Our daily 3PM coffee break is also a special moment for researchers to chat and exchange ideas in a relaxed environment.

An Efficient Environment for Research

ELSI-1, completed in 2015

For the purpose of building a well-equipped environment worthy of a WPI member institution, our new research laboratory building (ELSI-1) was completed in 2015 in addition to ELSI-2, which is housed inside an existent university building. ELSI-1 is equipped with laboratories, seminar rooms, an entire floor designated for experiments, a community lounge named the "Agora", an information center (ELSI Gallery), and a lecture hall with a seating capacity of over 100 (Mishima Hall). Various research projects are efficiently conducted in these two neighboring facilities.

Various ELSI Activities

As the world's first research institute themed around the origin of Earth and life, ELSI manages various activities for discussing and publicizing research achievements. In addition to an annual international symposium where researchers attend from all over the world, ELSI hosts a range of workshops targeted to researchers, as well as summer schools and winter schools for students in related fields of study. Furthermore, our institute holds lectures that are open to the general public and publicizes information through newsletters and the website as part of our outreach activities, for the purpose of familiarizing the public with research conducted by ELSI.

Research Facilities

High Resolution Isotope Ratio Mass Spectrometer (Thermo Scientific™ 253 Ultra™)

Molecular information regarding a molecule's origin is contained in the stable isotopes of its bioelements, which ranges from hydrogen to sulfur. This device enables the measurement of molecules that consist of multiple heavy isotopes and is applied to create new indicators for the study of early Earth, as well as extraterrestrial environments and biological activities.

Diamond Anvil Cell

Comprised of natural diamonds, the diamond anvil cell is a device that generates ultra-high pressures. It reenacts the conditions of the Earth's interior inside the laboratory through laser irradiation, creating an ultra-high pressure, ultra-high temperature environment; helping us elucidate the origin and evolution of the Earth's core and mantle from the early Earth to the present.

Liquid Chromatography-Mass Spectrometer (LC-MS)

Although molecules that are produced as a result of experiments cannot be seen with the naked eye, the mass spectrometer enables us to measure molecular mass, which is one of the characteristics of molecules. Through the application of LC-MS, we can measure molecular mass as the device separates the mixtures of molecules.

Cray XC30™ Supercomputer

This supercomputer is an XC30 from Cray with about 1000 Intel Xeon CPU cores. It is used to investigate a variety of research topics such as the formation of planets, moons, stars and galaxies; convection in planetary mantles; and first-principles simulations of deep earth materials.

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About the ELSI Logo

Designed by art director Ms. Naoko Fukuoka, the ELSI logo is versatile in its symbolism: the globes simultaneously represent a moon-forming giant impact, cell division, and planetary orbits. The lines branching out within the larger sphere create a phylogenetic tree that stands for the origin and evolution of life and, returning to the metaphor of planets, also symbolizes the origin and evolution of the Earth itself. In this manner, the logo embodies multiple fields of research at ELSI. Behind the letters of ELSI, semi-transparent infinity symbols are depicted. They signify both the infinite potential of ELSI's future research and the infinite knowledge awaiting discovery there.

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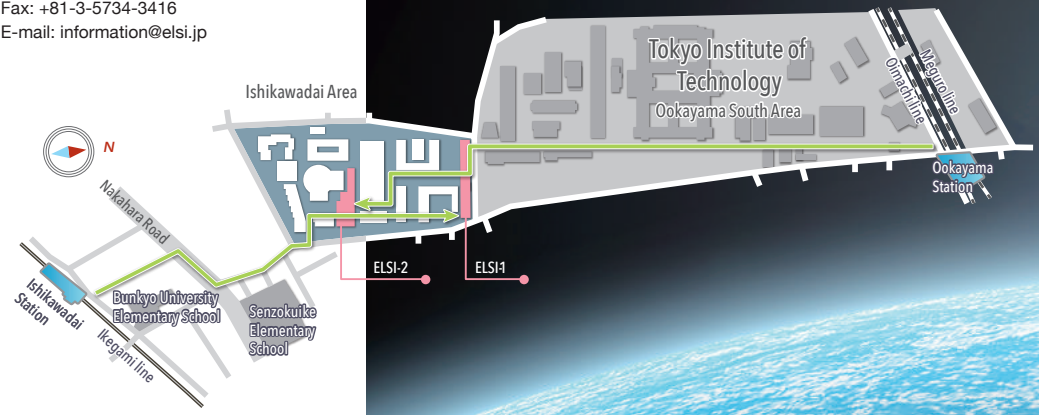

www.elsi.jp/en/

Designed by InterMAXIS inc.