ELSI

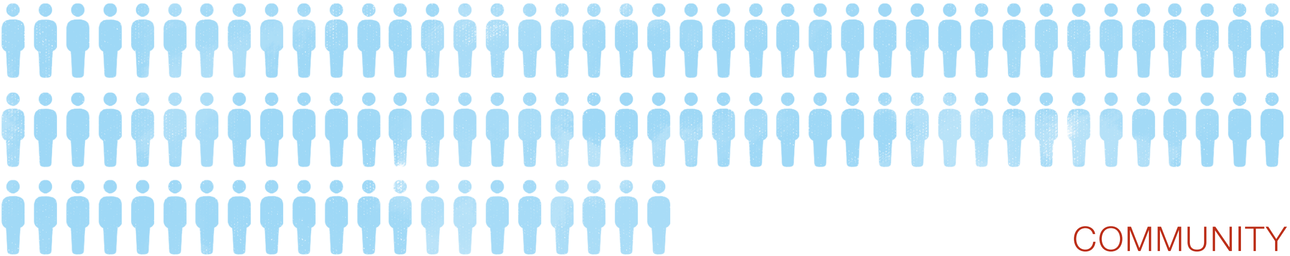
Earth-Life Science Institute

Tokyo Institute of Technology

ELSI AT A GLANCE

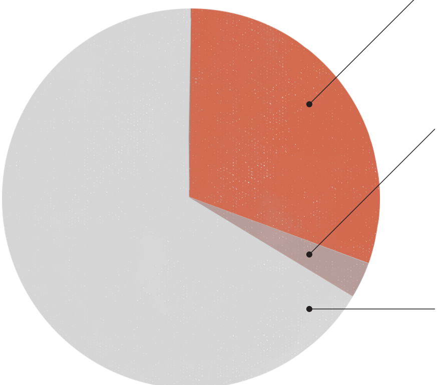
As of October 2019

101 is the total number of people working at ELSI



COMMUNITY

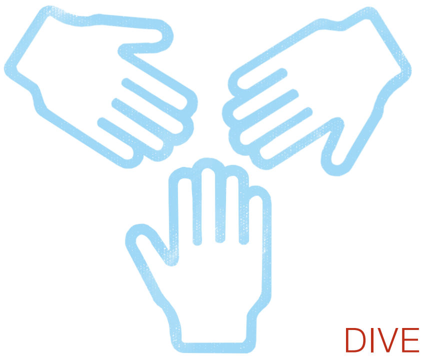
RESEARCHERS



19 Principal Investigators

2 Associate Principal Investigators

42 other researchers



DIVERSITY

29 out of the total are non-Japanese researchers (46%)

14 are female researchers (22%)

120 papers are published per year on average in refereed journals

PAPERS

SYMPOSIA

8 international symposia hosted by ELSI

23 research institutes and universities around the world have formal collaborations with ELSI

NETWORK

ENVIRONMENT

ELSI has an open and flat research environment

ELSI's community gathers for daily coffee break at 3:00 pm to catalyse interaction

INTERACTION

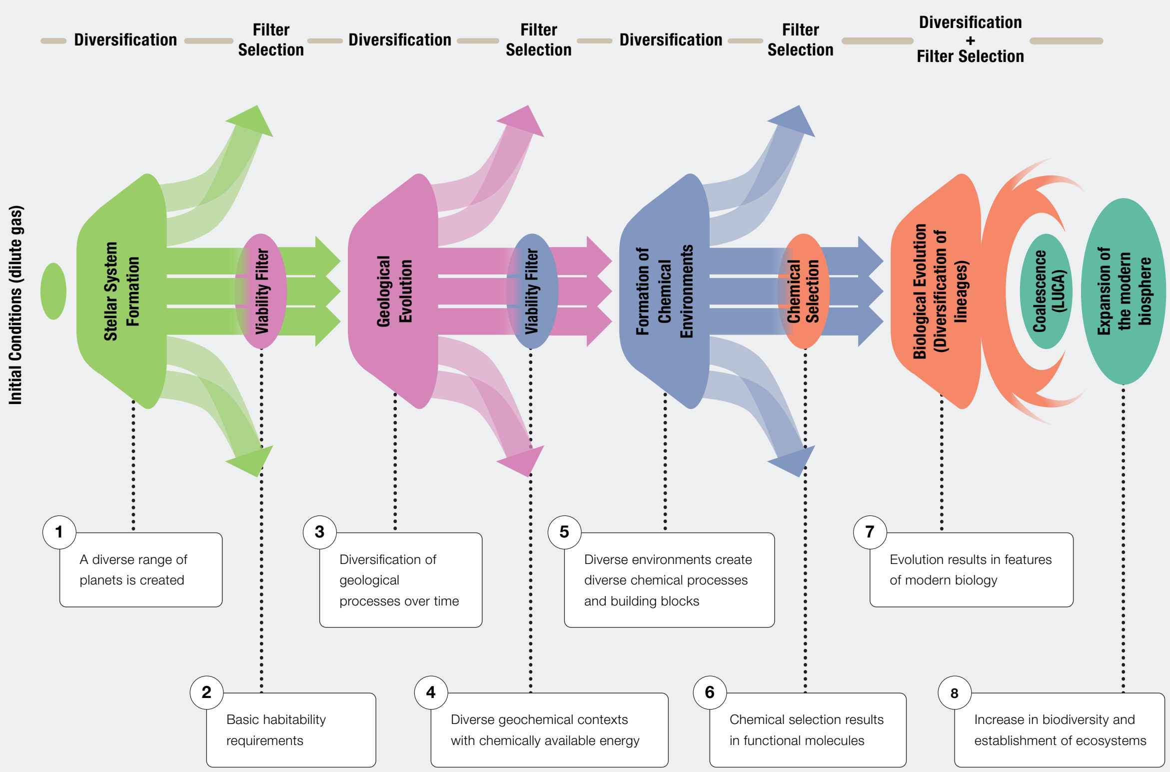
SOCIALISING

ELSI's community gathers on Friday evenings for 'izakaya': a social event to build rapport

ABOUT ELSI

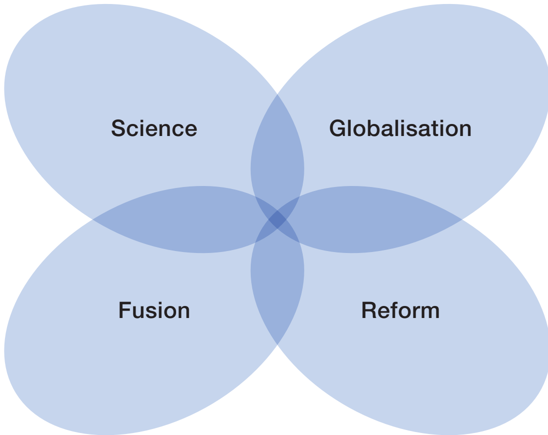
The great mystery of how life emerges from non-living matter has been solved at least once, not by humans but rather by naturally occurring processes on the early Earth, more than 3.8 billion years ago. Nature did not succeed in producing life by constructing artificial walls between astrophysical, geological, and chemical phenomena, but rather by drawing upon myriad resources and degrees of freedom that were available to our young planet. The Earth-Life Science Institute (ELSI) is inspired by nature's example, emulating this original successful strategy of open collaboration and diversity, creating a new culture that is better-suited to approach one of the great questions of all time.

'Only at ELSI' is a phrase that visiting colleagues use to describe their experience at our home in Tokyo. It beckons a conversation, a collaboration, an idea that could occur only at ELSI. It refers to the unique combination and enormous breadth of our researchers, the spontaneous discussions between astrophysicists, chemists, geophysicists, and biologists that occur daily in our Agora meeting space over tea and coffee, and the uniquely powerful new scientific concepts that are cultivated in an institute of unprecedented breadth and ambition. These impressions are amplified by the context of the institute, its position within Tokyo Institute of Technology (Tokyo Tech), and the dynamic synergy between Japan and the world that naturally emerges in our custom-designed environment that encourages and supports a new brand of science.



How do planets make life? ELSI's interests extend beyond specific origin scenarios involving particular environments on the early Earth. Our broader aim is to understand the more general strategies employed by nature, such as diversification and selection, that captures how life could arise anywhere in the universe. This is depicted in this diagram, which shows how evolutionary-like processes span astrophysical, planetary, and chemical scales to produce life.

ELSI is a research institute that was founded by a large grant from the government of Japan, as part of its top-level World Premiere International Research Center Initiative (WPI). The goals of WPI are to advance cutting-edge science, create new fusion science domains, provide a world-standard international research environment, and to adapt a research administration that is well-suited to accomplish this mission. These four pillars of WPI are woven deeply into the fabric of ELSI; our unwavering and total commitment to all of these aims has been our guiding light from the start. ELSI is one of 13 WPI institutes that have been installed at prominent national universities and institutes across Japan and uniquely devoted to interdisciplinary research in origins of Earth and life.



The WPI Programme has four basic objectives: advancing high-calibre research, creating interdisciplinary domains, establishing international research environments, and reforming research organisations.

World Premier International Research Center Initiative (WPI) consists of 13 research institutes around Japan.

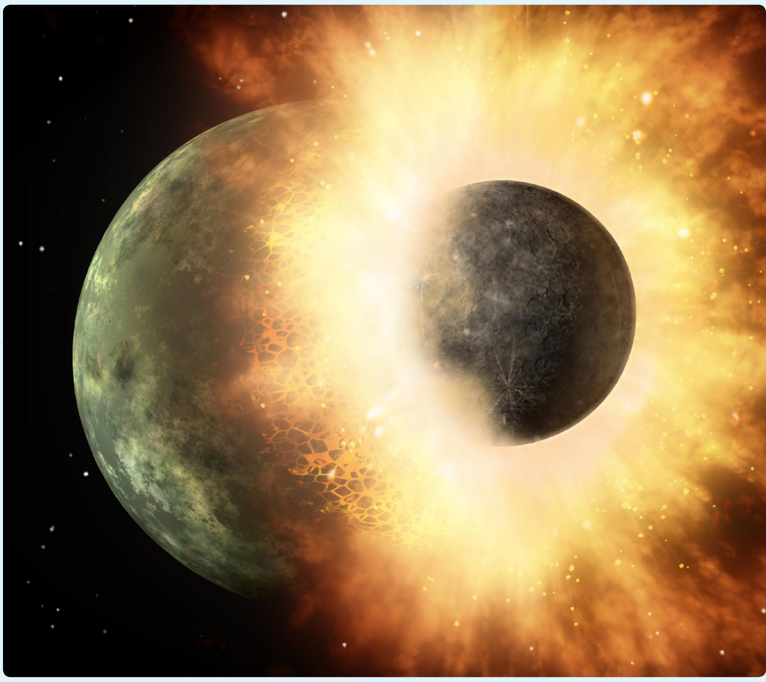
SCIENCE AT ELSI

ELSI is a unique institution, founded on the understanding that the origin of the Earth and the origins of life are aspects of the same scientific question. The stages and layers in which our planet formed are reflected in ELSI's major research domains. The formation of planets begins with the birth of their stars, which shapes the first

Origin of Planets

Stellar System Formation

We reconstruct key stages in Earth's formation, answering questions of where and how our planet formed, what determined its composition, how its internal state matured over time, how crucial chemical elements responsible for the atmosphere and oceans were delivered and retained, and how surface conditions responsible for life depended on these earlier stages. We have developed the first integrated models of accretion and transport in stellar discs across scales from gas and dust, through crucial intermediates known as 'pebbles', to the migrating orbits of early planets, and effects of giant impacts. By combining computer models with cosmochemical measurements, we can account for the diversity seen in planetary systems, and constrain the possible sources for light elements (C, O, Si, H, S, N) on early Earth. Our planet represents a delicate and probably rare balance between dry and completely ocean-covered worlds. We have begun a special programme on water worlds as the most common kind of planets thought likely to harbour life, with three representatives even in our own solar system.



We test models of planet formation against observations from Earth and other bodies in our Solar System and beyond.

Questions

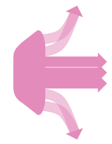
- How do planets form from gas and dust, and how fast do they form?
- What explains the great diversity of planets and of entire planetary systems?
- How do special events like the Moon-forming impact shape a planet's future evolution?
- How do early formation conditions affect a planet's possibility to create a biosphere?
- What role does the evolution of the Milky Way Galaxy play in the habitability of planets?

Tools & Techniques

We integrate the most current theories and models of gas and many-particle dynamics with evidence from meteor and comet isotope data and crater chronology to create an integrated understanding of early stages of solar system formation. Our domestic and international collaborations with space-mission and telescope projects anchor models of planetary diversity in extrasolar-planet data and enable ELSI to participate in mission planning. Laboratory geophysical models allow us to focus on select exotic cases such as water worlds.

KEYWORDS	*accretion - magma ocean - giant impact - moon formation - exoplanets - water worlds*

basis for their diversity. Planets constantly shift and evolve structurally and chemically, forming atmospheres and occasionally oceans and magnetic fields; with time, each planet develops along a unique geological track. Near-surface geochemistry on Earth, and perhaps elsewhere, underwent a burst of complexity that generated the first molecules and energy flows of life. This resulted in the intertwining of geological and biological chemistry, which has driven Earth's interaction and joint evolution with its biosphere throughout history. A common underlying dynamic of diversification and selection, which generates complexity in planets and in biospheres, allows us to understand the planetary foundation of life on Earth, and to explore the possibilities for complexity on extrasolar planets.



Planet Evolution

ELSI explores Earth and other bodies in our solar system from the inside out to reveal the connections among planetary processes. As planet accretion tapers off, one of the first stages in planet evolution is core-mantle differentiation, which may have proceeded on Earth through magma ocean phases. We have discovered that as Earth's core separated from its rocky mantle, it could have incorporated much more silicon and oxygen than thought, along with significant hydrogen. Crucially, the early precipitation of silicon oxides as the core cooled created a vigorous buoyant stirring force, increasing the likelihood of forming an early magnetic field. This in turn protected Earth's atmosphere from loss by solar wind. We have found that the cooling rate of early planetary surfaces is highly sensitive to solar irradiance. It differed by more than a factor of ten between near neighbours Venus and Earth, driving Venus into a stagnant lid greenhouse state and Earth into climate resiliency. As Earth settled into a layered structure of core, mantle, and crust, its earliest mineral differentiation may have locked in deep large-scale heterogeneities that continue to organise tectonic dynamics and magmatism even today. By modelling the partition and circulation of volatile elements, we explore the differences among rocky planets in their potential to sustain the complex chemistries needed for life to emerge and evolve.

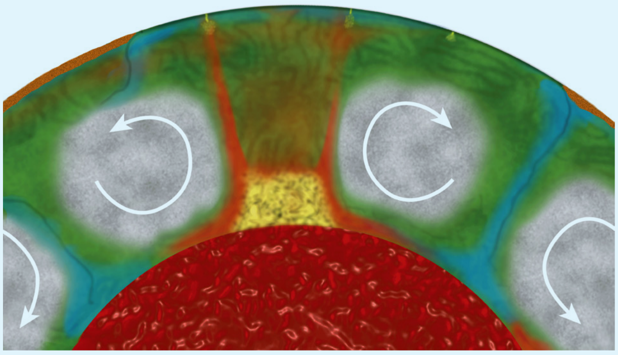
We explore Earth and other bodies in our solar system from the inside out to reveal the connections among planetary processes.

Questions

- Which planets form and retain atmospheres, oceans, and magnetic fields?
- How are heat, volatiles (i.e., water, nitrogen, etc.), and elemental abundance distributed among gaseous atmospheres, surface crusts, rocky mantles, and metallic cores?
- How has Earth's atmosphere changed over time?
- What processes are active on other bodies in our Solar System?
- What fraction of planets could harbour life?

Tools & Techniques

We weave together experimental, theoretical, and observational approaches to identify critical points in the planetary system that determine how a planet could potentially evolve. Seismic imaging is combined with high-temperature/pressure mineral physics and computational modelling to resolve and interpret deep-Earth structure and dynamics. ELSI scientists have written the world's most advanced computer codes to simulate giant impacts. We combine geological and biological signatures of ancient magnetism as context for models of Earth's core and geodynamo.



The Bridgmanite Enriched Ancient Mantle Structures (BEAMS) model proposes that the early Earth's highly viscous mantle sets the stage for sustaining plate tectonics.

KEYWORDS	*mineral physics - geochemistry - planet dynamics - seismology - core formation - geodynamo*

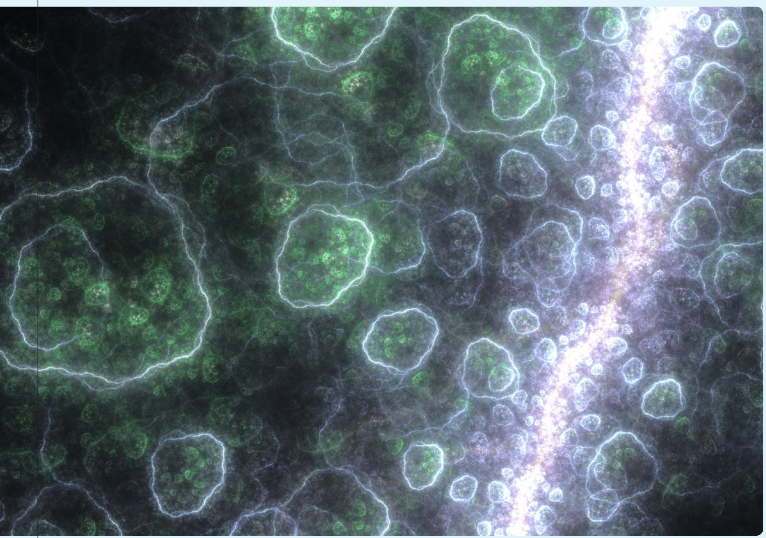
Formation of Chemical Environments

The Chemical Origins of Life

We seek to understand the origins of life as the emergence of a new Earth system, accounting for the interactions between the key ingredients for early chemical evolution: oceans, atmosphere and solid Earth. The most universal factor influencing complexity in carbon chemistry on a planet is the disequilibrium among reservoirs of electron donors and acceptors. In addressing this question, we have discovered that a single late giant impact could have produced a secondary hydrogen-rich atmosphere at the start of the Hadean aeon that lasted for up to 200 million years. Moreover, the complex stable isotope signatures of sulphur indicate that Earth maintained a higher ratio of CO to CO_2 than previously suspected well into the Archean. These two findings would significantly affect the synthesis of prebiotic organic compounds.

Diverse planetary surface conditions may have been essential for the emergence of life. We have studied the roles of the seafloor and land masses as nutrient sources; and the Sun, atmosphere, rock/water interface, and radioactive subsurface as sources of energy. We have also investigated the timing of water delivery, and composition of the earliest oceans and crust. These parameters clarify how special Earth may be in its capacity to spark life. Our research has shown how numerous energy sources can produce reactive C and N compounds, including electrochemical gradients at hydrothermal vents, secondary electrons from ionising γ-radiation, and atmospheric UV radiation. Our models indicate that species such as nitrate, ammonia, and CO were available in the early oceans, and we have found reaction pathways that produce precursors to biological compounds such as nucleobases, as well as activators that can drive polymerisation. Our understanding of how vital diverse environments are for life on Earth extends to our study of the Solar System and other stars, enriching the complex concept of habitability.

Computational combinatorial methods allow us to ask which aspects of terrestrial life reflect the inherent limits of chemistry, and which of these may be universal. We have shown that the biological set of amino acids cover a much wider range of properties essential to protein function than random sets of possible amino acids. Selection has made the biological set unique in that they are perched at the brink of chemical possibility.



Questions

- What is Life?
- What chemicals were available on the prebiotic Earth?
- How do chemicals in the environment assemble into living systems?
- What was the early Earth environment like and how did it contribute to chemical evolution?
- Are there many chemically different kinds of life or only one?

Tools & Techniques

Our approach to these questions combines theory, computation, chemical synthesis and analysis, and synthetic biology techniques. We have in-house facilities to mimic a variety of primitive planetary environments including high radiation environments, high temperature/pressure environments and evaporative environments, as well as state-of-the-art facilities for conducting sensitive chemical analysis.

We study how organic compounds can form and react in primitive planetary environments to understand how life originates.

KEYWORDS	*Origins of Life - radiation chemistry - hydrothermal environment - endogenous synthesis - RNA World*

Biosphere-Geosphere Interaction and Evolution

ELSI scientists study the major transitions that shaped the evolving biosphere: its architecture and modes of evolution and its dependence on planetary conditions over time. We also examine how biological evolution has in turn moulded Earth's geological history. We integrate synthetic and evolutionary biology to understand elements of structure and function in early organisms. We have demonstrated functional proteins translated using simpler genetic codes. ELSI has achieved increasingly complex functions in synthetic cell membranes, and coordination of molecular systems within and across them. Our researchers reconstruct genomes and bioenergetic systems of ancient bacteria, showing their coevolution with planetary chemistry and life's capacity to maintain ever larger and more reliable molecular systems. We have reconstructed isotopic and mineral signatures linking the rock record to major biological transitions, both for sulphur metabolism and for oxygenic photosynthesis: the biological innovation that has had the most impact on Earth's surface environments.

Terrestrial genomes are carried by two kinds of lifecycles: one in free-living cells and the other in viruses. A key question about the complexity of life is why these two major modes have likely persisted since their origin, and what role each has played in the evolution of systems of heredity. At ELSI, we have expanded global knowledge of the diversity of thermophilic Archaeal viruses by nearly 100%, and ELSI now hosts one of the largest collections of Archaeal viruses of any institution in the world.

We research the diversity and activity of microbes and viruses in environments which may be similar to those of early Earth.

Questions

- What were the earliest life forms like, and can we reconstruct them in the lab?
- How did planetary evolution affect biological evolution?
- What properties of ancient life can be deduced from chemical signatures in ancient rocks?
- How do life forms like viruses and cells work together to carry and shape life's genetic history?
- What is the history of biological evolution, and what types of life have yet to be discovered on Earth?

Tools & Techniques

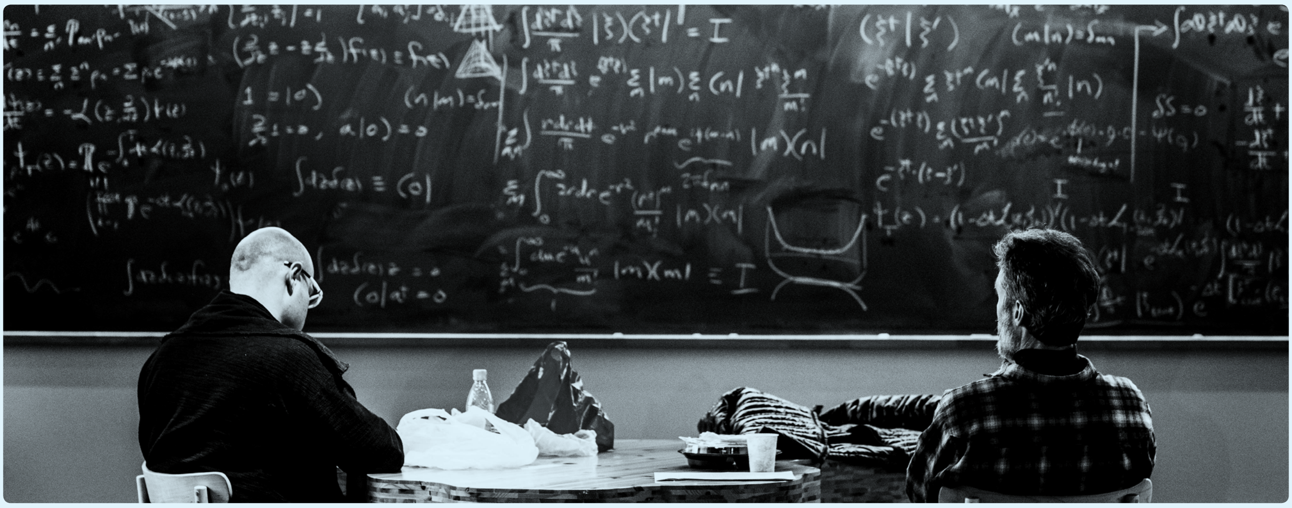
We combine bioinformatics, experimental evolution, isotope geochemistry, and synthetic biology to study the evolutionary history of genes and organisms, and to integrate them with models of planetary evolution. We use sequence comparison and synthetic methods to reconstruct ancestral proteins and pathways, which we relate to signatures of life in the rock record. We employ artificial cells to study key cellular functions. Laboratory evolution and microbial genetics are used to extract and characterise new genomes and lifecycles.

KEYWORDS	*isotope ratio mass spectrometry - metagenomics - enzymology - ancestral state reconstruction - artificial cells - virology*

Complex life

Our studies of the history of Earth and its life reveal a unifying paradigm of alternating stages of diversification and selection, which serves as a springboard to understand the habitability of planets around other stars and what principles may make life on them similar to or different from our own. At the core of understanding life's complexity is the question of whether hallmarks of life such as heredity and adaptability could have existed earlier in prebiotic chemical systems, and under what conditions these can emerge either within or growing out of planetary chemistry. We have formalised these questions in terms that can be applied to systems that do not yet have individual-based organisation or replication.

Our researchers have shown that some of these systems can support heredity and limited forms of adaptation. Heredity becomes most powerful when it can employ large libraries of possible chemicals created combinatorically. We have demonstrated how the diversity in such libraries can be produced from prebiotically plausible alphabets through simple reactions. We investigate methods to select among the resulting chemical polymers and control the folds that make them functional – in particular the crucial interactions of RNA with peptides – using high-throughput studies on libraries of linked RNA and peptides.



We tackle theories behind life's complexity through theoretical, computational and experimental approaches.

Questions

- How do chemical systems exhibit adaptation to environmental pressures?
- Which features in a given chemical system can undergo selection and which cannot?
- How can chemical specificity arise from non-specific complex chemical mixtures?
- Through what mechanisms can heritability and evolution arise from chemical systems?
- What determines whether evolution occurs through an open-ended succession of major transitions?

Tools & Techniques

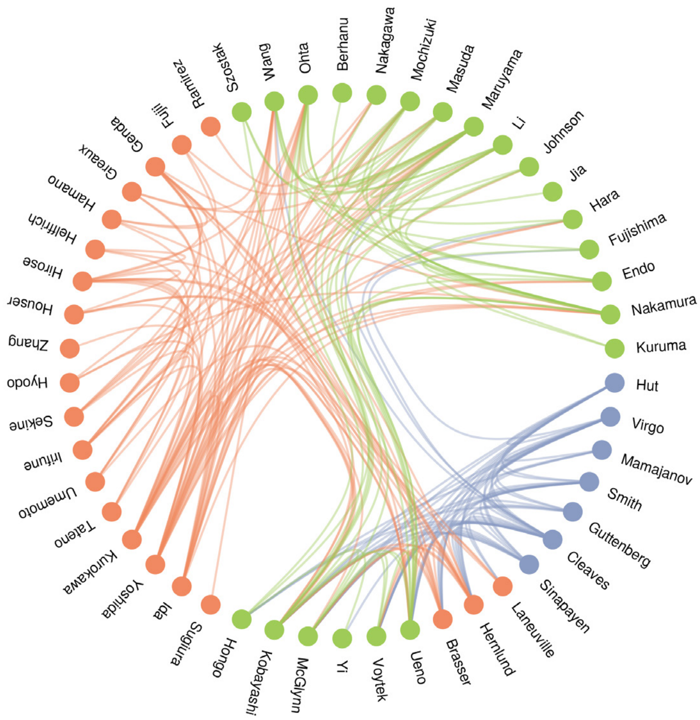
We integrate computational, theoretical, and experimental approaches to develop the overarching concepts of diversity generation and selection. Computational approaches include abstract 'minimal modelling' and machine learning. Theoretical concepts are drawn from information theory, coarse-graining, statistical physics, and phase transitions. Experimental approaches include generation of random oligomer libraries, mRNA-display, and cell-free protein synthesis.

KEYWORDS *open-ended evolution - machine learning - in vitro evolution - lineage selection - phase transition - minimal model*

FUSION

Interdisciplinary research at ELSI

Nature did not produce life more than 3.8 billion years ago by artificially dividing astrophysical, geological, and biological phenomena, and neither should we. The immense advances in the evolution of life, such as photosynthesis or multi-cellularity, required uniting unique combinations of life (proximity), facilitating cross-fertilisation (communication), and enabling the development of concerted and robust systems-level behaviours (culture) in response to the same kinds of external influences. At ELSI, we enable fusion between disciplines in much the same way as life achieved its major revolutions.



This figure shows active interdisciplinary researches at ELSI. Orange dots are researchers in geoscience/planetary science ('earth'), green dots are those in bioscience/chemistry ('life'), and purple dots are those in complex systems. The lines connecting them indicate publications co-authored by a team of interdisciplinary researchers. The data shown are for 2012-2019 FY.

Regular events to catalyse interactions

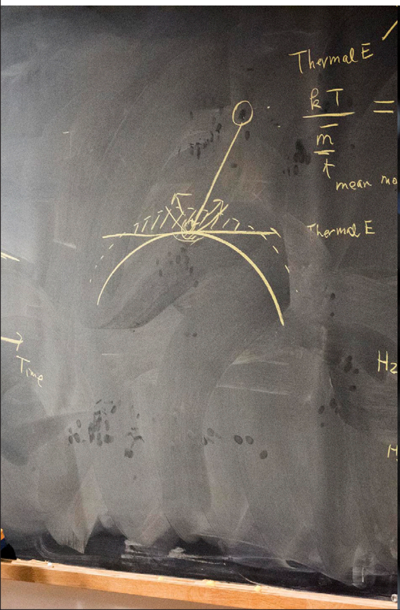
ELSI established regular events that increase interactions and encourage researchers from a broad range of fields to engage in dialogues on common questions. These events also seek to scientifically and socially dissolve language barriers, and increase cross-cultural understanding.


EARTH-LIFE SCIENCE INSTITUTE






Mercury
Lava
Surface of Venus
Mercury
Earth


Thermal E
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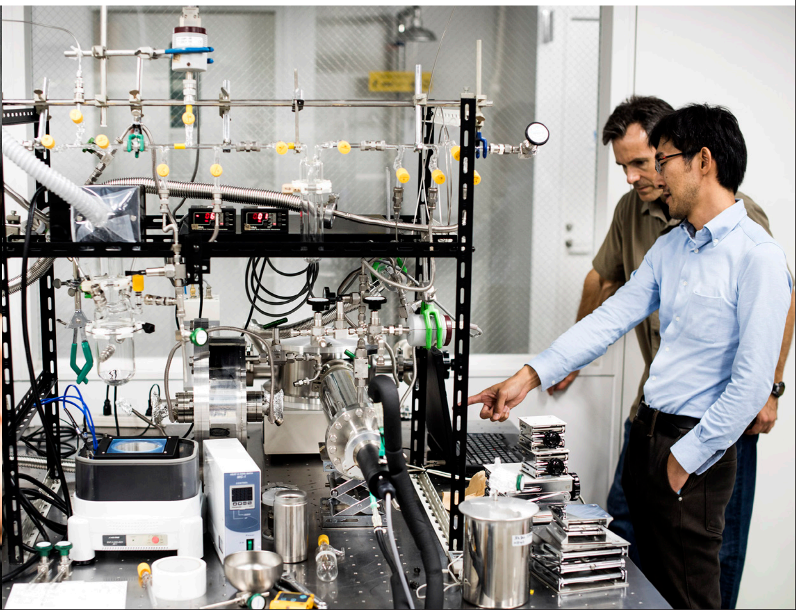
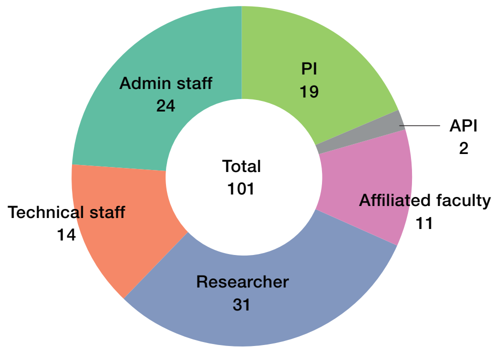


GLOBALISATION

Nothing distinguishes ELSI's achievements more than its strong international research environment and staff, which are catalysts for breakthrough science and administrative reform. ELSI has grown a vast international network and recruited top scientists from around the world at both junior and senior levels. Globally, ELSI is now considered the place to be for the very highest level of research in our fields. Applications from graduate students are on the rise, and our staff positions are highly coveted.

Geographical and gender diversity

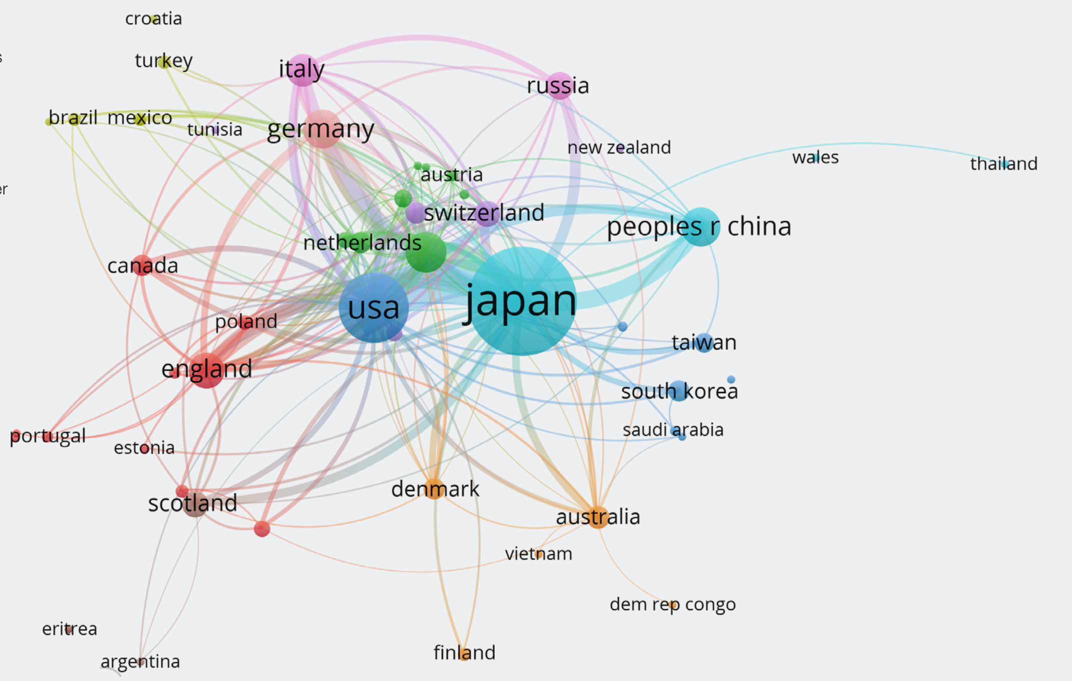
As of October 2019, the total number of ELSI researchers is 63: 19 PIs (Principal Investigators), 2 APIs (Associate Principal Investigators), and 42 other researchers. 29 are non-Japanese researchers (46%) and 14 are female researchers (22%).



Attracting foreign researchers

ELSI pursues a targeted strategy for the recruitment of internationally competitive young researchers that is unique among Japanese universities. ELSI's activities of inviting the students of our symposium speakers, hosting winter and summer schools, and actively sponsoring young researcher conferences have paid great dividends. In our past junior recruitment, ELSI received 363 applications from more than 30 countries around the world, most of which (75%) were from abroad.

Based on the number of publications, ELSI's research connects Japan to 44 other countries and regions on 6 continents, and to some of the premier institutes worldwide.



Satellites

ELSI maintains satellites at Ehime University, the Institute for Advanced Study, Harvard University, the University of Tokyo, and Columbia University in New York. ELSI has formalised collaborations with 23 research institutes and universities around the world, a number that continues to expand. ELSI has hosted 8 international symposia, dozens of workshops, several short schools, and has a vigorous visitor programme to invite top scientists to spend time and collaborate at our institute.

ELSI's symposia

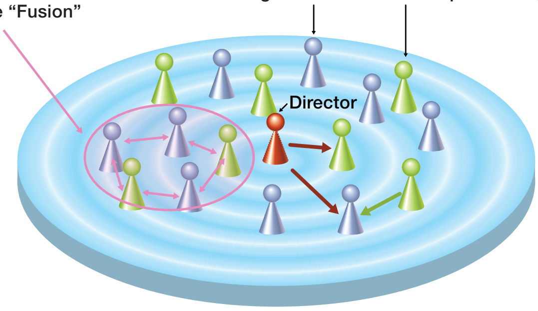
Annually, ELSI holds an international symposium on the origins of life research and its related fields. Every year, more than 100 researchers from more than 10 countries participate in presentations and debates. The symposia thrive on an active dialogue through breakout sessions, discussions and panels.

2013	March	The First ELSI International Symposium
2014	March	Origin & Evolution of the Earth-Life System
2015	January	Life in the Universe
2016	January	Early Earth, Venus & Mars
2017	January	Expanding Views on the Emergence of the Biosphere
2018	January	Building Bridges from Earth to Life
2019	January	Comparative Emergence
2020	February	Extending Views of Catalysis

REFORM

Open and flat research environment: no lab boundaries, no bosses

ELSI has adopted an open and flat research structure. To encourage interdisciplinary projects, young researchers are not assigned to any particular PIs; instead, they are spurred to collaborate with multiple researchers both within and outside ELSI.



Top-down management system

The directors make important management decisions at the weekly Director's Office meeting, which supporting coordinators and chiefs also attend. This centralised system allows for quick decision-making and effective management of the institute. Major decisions are reported at the monthly ELSI ALL Meeting – in which all staff (including administrators and technicians) and students participate – and feedback is collected from its researchers and staff. Important topics are often discussed at faculty meetings – attended by PIs and APIs – before the Directors make decisions. The Science Steering committee advises the Director's Office on research directions, strategy and the institute's research roadmap.

Efforts to foster young researchers

ELSI provides start-up funds to young researchers so that they can begin their research while acquiring external funds. The institute requires young researchers to apply to at least one external grant annually. This requirement is a form of professional training to cultivate the skills necessary to acquire competitive funds: managing grant application calendars, planning one's budgetary needs, and building proposal-writing skills. University Research Administrator (URA) staff assist non-Japanese researchers in preparing and submitting grant proposals to Japanese funding agencies.

Annual evaluation, incentive award, and performance-based pay system

Every year, individual researchers prepare annual evaluation sheets in November-December. Young researchers send theirs to senior PIs for review, and the results are scrutinised and summarised by the Research Promotion committee, who recommends candidates for the incentive award winners of the year. The Director's Office makes the final decisions on the incentive award winners and announces their names at the subsequent ELSI ALL Meeting. The winners will generally receive a 5% salary raise the next year, and research scientists with an initial three-year contract will gain a further two-year extension.

Younger researchers evaluated senior researchers once, but this was impractical. Therefore, in 2018 the institute asked its International Advisory Board to conduct an external review of senior PIs. The Board employed three reviewers for each PI and made quantitative evaluations of *** (superior), ** (median), and * (lowest). The 14 PIs reviewed obtained 38.5 stars in total: 2.75 stars per PI on average.

Support for research and daily life in Japan

The majority of ELSI staff are fluent in English, highly skilled and have abundant experience in meeting the unique challenges of a WPI institute. ELSI's Admin Office and Secretaries' Office have dedicated staff to support visa applications, housing, schools, and a smooth transition into life in Japan for foreign researchers. Recognising the importance of the Japanese language for daily life, ELSI has setup weekly Japanese language classes.

Tokyo Tech accommodating ELSI in the system

Tokyo Tech's International House gives ELSI visitor reservations high priority, allowing them a hassle-free arrival. Since April 2017, Tokyo Tech has set up an on-campus nursery school for staff and faculty members. This allows researchers with children to continue their work without worrying about the logistical challenges. Health and mental counselling, consultation for harassment and contract-related problems, are all offered in English. Starting from April 2019, the travel insurance for international business trips will be paid from the institution's budget, which is a new policy adopted by Tokyo Tech in response to ELSI's request.

Providing science communication skills

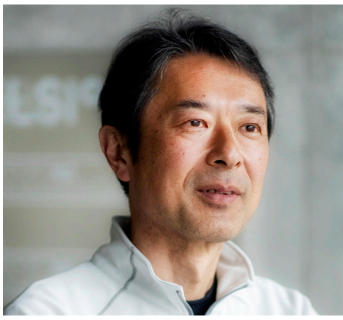
ELSI recognises that providing researchers and students with skills in science communication in English is crucial for their work and career. By providing regular training, workshops, and hosting conferences, ELSI acts as a venue for a science communication hub in Japan.

RESEARCHERS

PRINCIPAL INVESTIGATORS

"ELSI has created a good atmosphere to do high-impact research, explore from unique angles, and to publish in a timely manner."

Hidenori Genda
Planet formation



"ELSI has an environment that allows me to follow my own interest in exo-planets and exo-life, step by step, forwards."

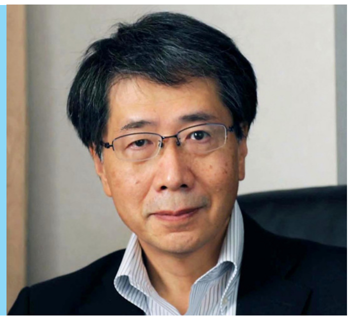
Shigeru Ida
Planet formation

"There is no Earth in a lab. To learn how it works, geologists interpret the experiments the Earth already did getting to now."

George Helffrich
Solid earth geophysics

"The give-and-take policy doesn't work in research collaborations. Just give, give, give and take; then you will have fruitful results and develop good human relationships."

Tetsuo Irifune
Solid earth material science



"Life results from an open planet-scale collaboration that we must emulate in the way that we do science in order to truly understand its origins and limits."

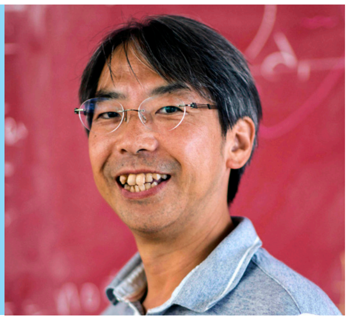
John Hernlund
Geophysical modelling

"At ELSI, science is not just picking up the grains of rice from the bottom corner of a bento box. We are lifting the covers of new boxes."

Joseph Kirschvink
Geobiology

"I've been working on deep Earth structure, dynamics, and evolution at ELSI. It is an amazing place for researchers from different fields to work together and expand their perspectives."

Kei Hirose
High-pressure geoscience

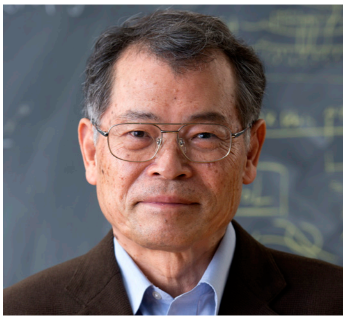


"Come rediscover the origins of life with us at ELSI!"

Irena Mamajanov
Astrobiology

"At ELSI you are free to talk to whom you want, learn and explore what you want – allowing you to discover much more than you thought you wanted to."

Piet Hut
Astrophysics



"I have unravelled one of the biggest mysteries: when, where, and how was life born? The next target is the establishment of Astro-Bioscience to explain the origin and evolution of Universal life."

Shigenori Maruyama
History of the Earth

"ELSI is probably the most intellectually exciting place I've been. It's a great place to get 'off the map' of current understandings and to become familiar with the unknown."

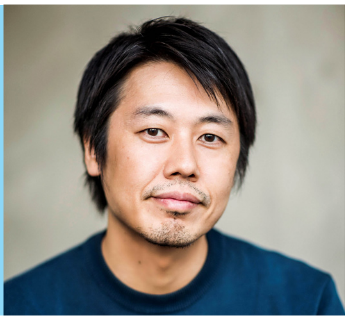
Shawn McGlynn
Microbial biogeochemistry

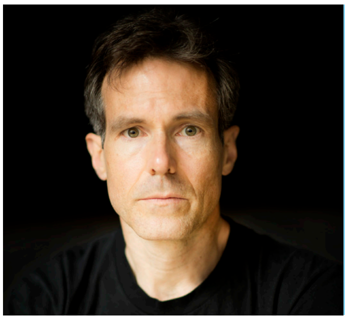
"I'm fascinated by the elegance and beauty in Nature's energy-conversion processes. At ELSI, I research how deep-sea electric currents may have provided the spark for the origins of life."

Ryuhei Nakamura
Electrochemistry

"My dream is to find life beyond Earth in the Solar System. ELSI is the best place where I can tackle this together with wonderful colleagues. What is your dream?"

Yasuhito Sekine
Astrobiology



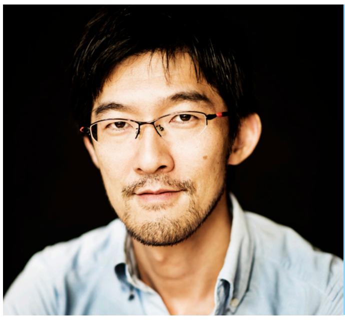


"We used to view Life and the geological Earth system in very different terms. Lately we are finding more and more areas where they cross into one another."

Eric Smith
Complex systems

"Encouraged by our small advances on the way, we are continuing to feel our way towards the tantalising goal of building replicating, evolving chemical systems."

Jack W. Szostak
Biochemistry



"We have developed a new geochemical technique and analysed ancient rock samples to study a biosphere of another planet 'Early Earth'."

Yuichiro Ueno
Biogeochemistry

"ELSI is a place to explore what's possible and what's impossible."

Mary A. Voytek
Astrobiology

"I investigate theoretically physical properties of rocks at the extreme pressures and temperatures of planetary interiors. By comparing predictions to observations, we see quantum physics expressed on a planetary scale."

Renata Wentzcovitch
Materials physics

"All molecules are composed of their isotopomers we still cannot see. Let's explore this frontier, the origin of molecules, to approach the origin of the Earth and Life."

Naohiro Yoshida
Environmental geochemistry

ASSOCIATE PRINCIPAL INVESTIGATORS

"What are we, in the context of the Universe? We are embarking on new astronomical explorations to learn more about it."

Yuka Fujii
Exoplanet Science

"Treating DNA as a fossil, a vehicle to travel back in time, we ask one of the basic questions of evolution: if 'life' replayed from early days, would it come out the same?"

Betül Kaçar
Organismic & evolutionary biology

EDUCATION & OUTREACH

Education

ELSI has a mandate from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan to provide a world-leading graduate studies programme. Within three years, ELSI's student base has grown substantially with 14 Ph.D. and 12 Master students (as of September 2019). These students come from Japan, Germany, Hong Kong, Italy, Malaysia, Mexico, Singapore and Taiwan. ELSI has succeeded in attracting many of these talented young individuals in part because of generous scholarships provided by the Japanese government. The institute also welcomes students without such funding, supporting them directly after they have arrived in Japan and assisting them with obtaining bursaries from JASSO, JSPS and private foundations.

ELSI's graduate students span all the scientific disciplines represented at the institute: geosciences, astronomy and planetary sciences, chemistry, and biology. Five tenured professors and a multitude of researchers are currently supervising students, advising them on their scientific projects and monitoring their progress. ELSI strongly encourages all its students to develop interdisciplinary awareness and collaborate with professors and scientists outside of their speciality.

ELSI is on course to become a thriving hub in Japan for international students from diverse backgrounds and scientific disciplines.

Outreach

ELSI's PR Office coordinates outreach efforts with students and the public in both English and Japanese, and works as an interface between researchers and the community. They focus on different strategies to introduce ELSI's interdisciplinary research to the public. The key outreach efforts highlighting ELSI's latest discoveries occur annually: ELSI's Public Lecture, Joint Public Lecture with Kavli IPMU and IRCN, and Tokyo Tech Festival (Kōdaisai).

Researchers frequently visit schools to share information about their scientific disciplines and careers, and school students are always welcome to visit ELSI for lab tours.

Together, the ELSI Editorial Board and the PR Office publish Press Releases and Research Highlights to bring the latest results to the community. Departing from tradition, the office thrives on discovering fresh, creative approaches that combine science and art, and highlight the human side of research. In conveying ELSI's most recent revelations to the public, the PR Office enjoys playing a part in sparking the interest, excitement and curiosity of the wider community.

INSIDE ELSI

Buildings and Facilities

By acquiring a supplementary budget from MEXT, the long-awaited research building called ELSI-1 (Ishikawadai Campus, Bldg. No.7; total floor area of 4,970m^2) was built in 2015 at the Ookayama campus. The building was designed under the concept of ‘harmony between Japanese and western styles’, paying attention to a good balance between research and communication spaces.

The entrance on the 1st floor features an open information-sharing space called the ‘Gallery’, and a lecture hall called ‘Mishima Hall’ that can hold over one hundred people. The 2nd and 3rd floors include compact and functional research rooms for ELSI researchers and extended-stay visiting researchers. Moreover, the ELSI-1 building hosts students’ rooms, the PR Office, Secretaries’ Office, and a Collaborative room for researchers from partner institutions to work at ELSI.

The open-ceiling communication room on the 2nd floor, called the ‘Agora’, can be used by many researchers for interdisciplinary communication.

ELSI started in 2012 in an existing building of 2,670m^2 that was renovated for the new institute at the time, and is now called ELSI-2 (Ishikawadai Campus, Bldg. No.8).

① High Resolution Isotope Ratio Mass Spectrometer (Thermo Scientific™ 253 Ultra™) enables the measurement of molecules that consist of multiple heavy isotopes. ② Comprised of natural diamonds, the Diamond Anvil Cell is a device that generates ultra-high pressure. ③ Cray XC30™ Supercomputer is used to investigate a variety of research. ④ Next Generation Sequencer (NGS) analyses genomes using a massive parallel sequencer.

The 1st floor houses a spacious yet cosy communication room called the ‘Lounge’, with tables shaped like the Earth’s continents, a large blackboard, and a refreshment area. This space is where the entire institute gathers for the monthly ELSI ALL Meeting, and it is often used for seminars as well as friendly chats with colleagues.

The basement of ELSI-1 contains an electron microscope, Cray XC30 supercomputer, high-pressure experiment lab, geochemistry lab, and chemistry lab. The ELSI-2 building accommodates biology-related labs. The Ehime satellite also has high-pressure experiment facilities.

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.

Exploring the Origins of the Earth and Life

Kei Hirose
Director, Earth-Life Science Institute, Tokyo Tech

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 recognised, 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, and to play a leading role in implementing and promoting administrative innovation and organisational 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 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.

JOIN ELSI

Study with ELSI, build you research career

ELSI has been highly successful in cultivating an attractive inter-disciplinary and international research environment that is able to advance unique scientific opportunities for its scientific research staff. ELSI launched its education initiative in 2016-2017 with the goal of extending the same opportunities to students performing research under the supervision of ELSI research staff.

ELSI Education Committee has developed and facilitates the educational activities of ELSI. If you are interested in doing your research studies at ELSI, please contact us via information@elsi.jp

Be a part of our research collaborations

ELSI's mission encompasses all aspects of the formation of planets and the emergence of life as a planetary process. Our researchers consider stages ranging from early stellar system formation to deep-time evolution and ecology, emphasising the crucial connection of the evolving planetary surface with the chemistry and energetics of life.

ELSI maintains a vigorous and widely interdisciplinary programme of domestic and international activities throughout the year. Collaborations are supported through visits to both ELSI and our many satellite and partner institutions worldwide.

Be a shareholder: donate to Science & Society

Your support is important! External funds help move research beyond traditional borders and limits, bringing efficiencies that unlock value to society. You help foster a highly skilled labour force, generate responsive public policies, attract global R&D investment, boost productivity and growth, and raise international competitiveness; all of which contributes to higher standards of living and the betterment of society. On an international scale, it has the power to address environmental issues, improve health and promote social welfare worldwide, and to work towards global resilience and sustainability.

We invite individuals, companies and foundations to be our partners in tackling one of life's most fundamental questions: the origin and evolution of life and the Earth, and what that tells us about life elsewhere in the universe. Your investment helps us hire and train the best researchers, keep our labs running, host visitors and meetings that bring minds together, and do public outreach that informs and gets generations excited about the wonders of our world.

Contact funding@elsi.jp to learn more about our various donation programs, including Tokyo Tech USA, Inc. an independent charity with 501(c)3 status.

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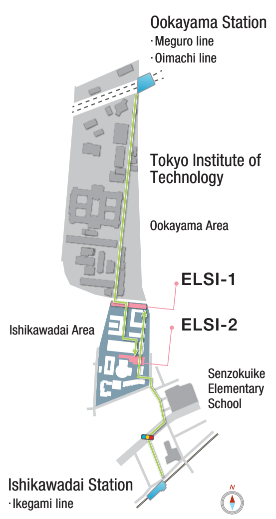
EARTH-LIFE SCIENCE INSTITUTE
TOKYO INSTITUTE OF TECHNOLOGY



ELSI Logo: Designed by art director Ms. Naoko Fukuoka, ELSI's logo is versatile in its symbolism: the globes to the right 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 symbolises 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.

Tokyo Tech

wpi

Acknowledgements: ELSI Prospectus, January 2020. Produced by Thilina Heenatigala and Minako Shirakura for Earth-Life Science Institute at the Tokyo Institute of Technology, with art direction by Masami Furuta (opportune design Inc.), illustration by Taku Bannai. Proofreading and figure designs by Lucy Kwok. Data figures by Arsev Aydinoglu and Nicholas Guttenberg. Content contributed by Takashi Sakurai, Reiko Hattori, Kaoru Nishimura, Eric Smith, Shawn McGlynn, James Cleaves, Ramon Brasser, Christine Houser, and Kosuke Fujishima. Photographs: R. Wentzcovitch by Tim Lee, J. Szostak by Aynsley Floyd on page 19. All other photographs on page 18-19, except for those of T. Irifune, S. Maruyama, N. Yoshida, as well as those on page 3 (bottom), 9-10, 11 (except for left bottom), 12-13 (except for the ELSI building), 15-16, 20 (upper), 23 are by Nerissa Escanlar. Page 6 image credit: NASA/JPL-Caltech.