FY 2021 Follow-up of WPI Program

By Program Committee

March 2022

(This document reports on progress made under the WPI Program in FY 2020.)

In 2007, the Japanese government launched an ambitious initiative to create globally visible and internationally open research centers. This program, World Premier International Research Center Initiative (abbreviated WPI), has, pursuant to the program's mission stated in 2007, successfully launched 13 centers over the 14-year period from 2007 to 2020. In 2020, a new mission was initiated that advances further the principles of the original WPI mission. The Launching of centers under the New Mission began in 2021. This 2021 follow-up report describes notable areas of progress in FY 2020 and new developments in FY 2021.

A. Highlights in FY 2021

Professor Benjamin List, PI of ICReDD, awarded the 2021 Nobel Prize in Chemistry

Figure. Prof. Benjamin List

The 2021 Nobel Prize in Chemistry was awarded to Prof. Benjamin List. He is a principal investigator (PI) in the WPI center ICReDD of Hokkaido University. Prof. List received the Prize jointly with Prof. David W.C. MacMillan of Princeton University for "*the development of asymmetric organocatalysis.*" The following description of their work is quoted from the announcement of the Nobel Foundation:

"Catalysts are thus fundamental tools for chemists, but researchers long believed that there were, in principle, just two types of catalysts available: metals and enzymes. **Benjamin List** and **David MacMillan** are awarded the Nobel Prize in Chemistry 2021 because in 2000 they, independent of each other, developed a third type of catalysis. It is called *asymmetric organocatalysis* and builds upon small organic molecules."

"Organocatalysis has developed at an astounding speed since 2000. Benjamin List and David MacMillan remain leaders in the field, and have shown that organic catalysts can be used to drive multitudes of chemical reactions. Using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells. In this way, organocatalysts are bringing the greatest benefit to humankind."

Prof. List has been a PI in ICReDD from its start in 2018. Since 2020, he has been a Specially Appointed Professor of ICReDD. Asked what prompted him to join ICReDD, he responded saying "a general innovative spirit of chemistry in Japan, which I always liked, and the idea of computational reaction design by Director Maeda, which I think has the chance of success now, so I wanted to be part of it!"

Final Evaluations of Kavli IPMU, IIIS, ELSI and ITbM

FY 2021 marked the 15th year since the launch of Kavli IPMU, and the 10th year for IIIS, ELSI and ITbM. The four centers, therefore, underwent their final evaluation of the WPI Program.

At its November and March meetings, the Program Committee carried out a vigorous examination of the four centers, which included presentations by the center directors and the heads of their host institutions, and reports from the Working groups conveyed by the Program officers. These hearings resulted in each of the four centers receiving an evaluation of "successfully achieving "world premier" status. For ITbM, there is an accompanying request to develop a more robust environment of scientific integrity to ensure its future growth.

This evaluation result allows Kavli IPMU to continue as a member of the WPI Academy, which it joined in 2017, and entitles IIIS, ELSI and ITbM to apply for Academy membership to start in FY 2022.

Interim Evaluations of NanoLSI and IRCN

FY 2021 marked the 5th year since the launch of NanoLSI and IRCN, which therefore underwent the Interim Evaluation of the WPI Program. Based on hearings with their directors and the heads of their host institutions, and reports from the Working groups conveyed by the Program officers, the Program Committee concluded that both of the centers deserve a score A+. The excellent progress that the two centers are making should enable them to achieve their research goals by their continuing current efforts.

Launching a new center, QUP, under the New WPI Mission

In 2021, MEXT announced the launch of one new center under the WPI's New Mission, which was formulated in 2020. After a vigorous selection process that ran from February to September, the Program Committee selected as the new center "International Center for quantum-field Measurement for Studies of the Universe and Particles (QUP)" at the High Energy Accelerator Research Organization (KEK) in its September meeting. QUP was officially launched on 16 December, 2021.

B. WPI Outline

In 2007, Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the WPI Program aimed at establishing internationally open and globally visible "World Premium Institutes" in Japan. The background was:

- Increasing worldwide competition in generating new research outcomes and in recruiting talented scientists.
- Strong need felt for more efficient forms of funding to advance fundamental and innovative sciences, which are essential to building knowledge-based societies.

- The advent of research excellence initiatives designed to encourage outstanding research by providing large-scale and long-term funding.

To sharply focus the aim of the Program, the following Mission was given to the WPI centers.

- Advancing to the highest pinnacle of globally leading-edge research
- Creating interdisciplinary domains
- Establishing international research environments
- Reforming research organizations

MEXT supports the WPI centers within the following context.

- Up to ¥700 million a year per center in principle
  (Up to about ¥1.3 billion a year for centers launched in and before 2010)
- Research money is not included.
- Support for 10 years (5-year extension is applicable for centers launched in or before 2012)

In 2020, the New Mission, advancing on the principles of the original mission above, was formulated, namely,

- World-Leading Scientific Excellence and Recognition
  - The Highest Level of Research Impact
  - Expanding Knowledge Frontiers through Interdisciplinarity and Diversity
- Global Research Environment and System Reform
  - Harnessing Talent and Potential through Global Brain Circulation
  - Interdisciplinary and Inter-Organizational Capacity Building
  - Effective, Proactive and Agile Management
- Values for the Future
  - Societal Value of Basic Research
  - Human Resource Building: Higher Education and Career Development
  - Self-Sufficient and Sustainable Center Development

The launching of centers under the New Mission started from 2021. MEXT supports these WPI centers within the following context.

- Up to ¥700 million a year per center in principle
- Research money is not included.
- Support for 10 years

C. WPI Centers

Nine WPI centers were launched during the first 10 years of the WPI Program.

The first five WPI centers launched in 2007 are now members of the WPI Academy.

- **AIMR** on materials science, Tohoku University.
- **Kavli IPMU** on the universe, The University of Tokyo.
- **iCeMS** on cell biology, Kyoto University
- **IFReC** on immunology, Osaka University
- **MANA** on nanotechnology, National Institute for Materials Science

The sixth WPI center was launched under the "green innovation program" in 2010, and it is now the 6th member of the WPI Academy.

- **I^{2}CNER** on energy, Kyushu University

Three WPI centers were launched under the new "WPI Focus" program in focused research areas in 2012.

- **IIIS** on sleep, University of Tsukuba
- **ELSI** on Earth-life, Tokyo Institute of Technology
- **ITbM** on bio-molecules, Nagoya University

In 2017, the 11th year of the WPI Program, two WPI centers were added:

- **IRCN** on neurointelligence, The University of Tokyo
- **NanoLSI** on nano-probe life science, Kanazawa University

In 2018, the 12th year of the WPI Program, two more centers were launched:

- **ICReDD** on chemical reaction design and discovery, Hokkaido University
- **ASHBi** on human biology, Kyoto University

In 2021, the 15th year of the WPI Program, one new center was launched under the New Mission:

- **QUP** on developing quantum-field measurement systems, High Energy Accelerator Research Organization (KEK)

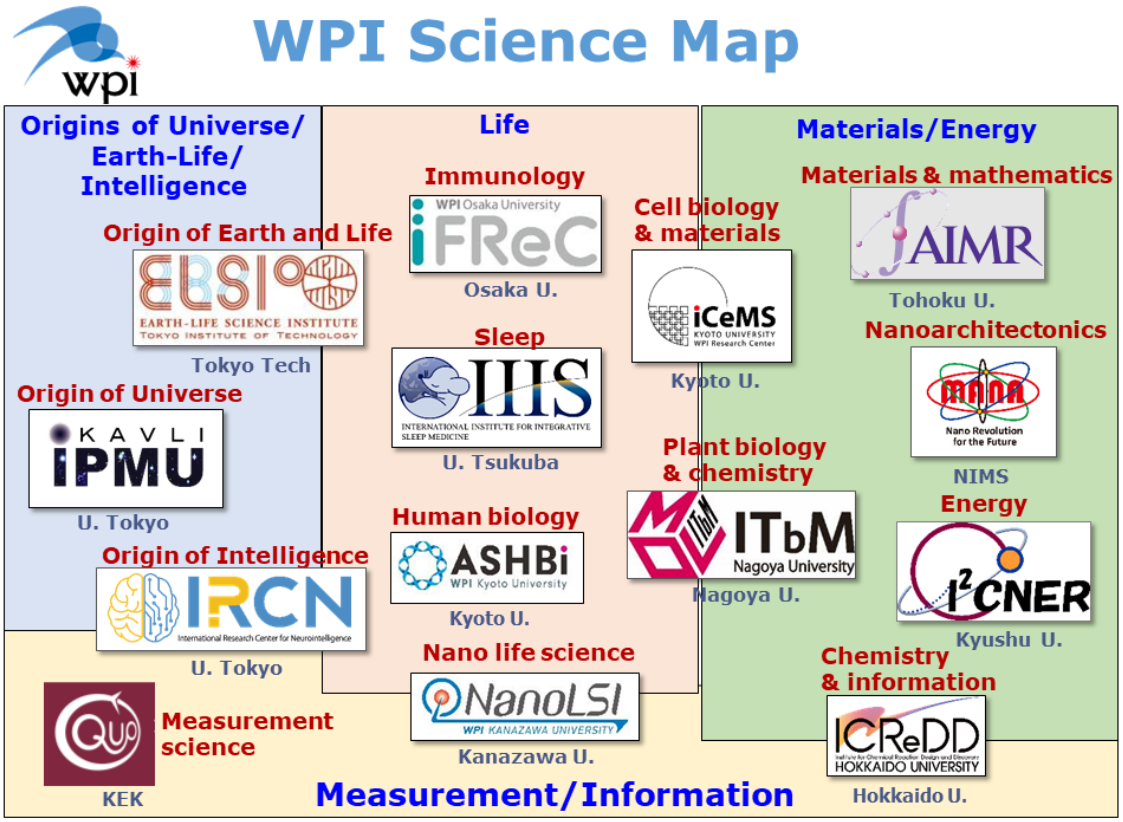


Figure. WPI centers in FY 2021

As shown above, the sciences explored by the 14 WPI centers extend from Origins of the Universe, Earth-Life, and Intelligence, Life, Materials/Energy, and Measurement/Information.

D. Follow-up framework

The WPI Program carries out a robust follow-up system comprising the international Program Committee, program director (PD), deputy program director (DPD), program officers (POs), and working groups (WGs). Since 2017, an academy director (AD), academy officers (AOs), and Academy working groups (AWGs) have been put in place to oversee the follow-up activities of the WPI centers that are members of the WPI Academy.

Program Committee

At the end of FY 2020, Dr. NAKAMURA Michiharu, Dr. NOYORI Ryoji, and Dr. SUZUKI Norihiko stepped down from the Committee. Three new members joined from FY 2021: Dr. AMANO Hiroshi, Professor of Nagoya University and Nobel Laureate in Physics, Dr. HASEGAWA Mariko, President of the Graduate University for Advanced Studies, and Mr. ISHIMURA Kazuhiko, President of Advanced Industrial Science and Technology.

Dr. HAMAGUCHI succeeded Dr. NOYORI as the Chairperson from FY 2021.
All the Committee members and their affiliations are listed in the following website:
https://www.jsps.go.jp/english/e-toplevel/07_committee.html

The FY 2021, the Program Committee held meetings on 9-10 September and on 17-18 November. Both meetings were conducted online, the COVID-19 pandemic having made an in-person gathering difficult. The main items of business on Committee's agenda in its September meeting were (1) selecting a new WPI center and (2) the status of the WPI Academy. In its November meeting, they were (3) final evaluations of four centers (Kavli IPMU, IIIS, ELSI, and ITbM), (4) Interim Evaluations of two centers (NanoLSI and IRCN), (5) follow-up reviews of two center (ICReDD and ASHBi), and (6) the future of the WPI Program.

PD, DPD, POs and WGs

PD: Dr. UKAWA Akira has been serving as Program Director since April 2017.

DPD: Dr. YOSHIDA Minoru has been serving as Deputy Program Director since December 2017.

POs: Experts in the research areas of each center. They chair site visits and prepare site-visit reports by compiling the comments of the site-visit team members.

WGs: Assembled for each WPI center, these groups principally consist of 3 domestic and 3 international experts in areas that cover the center's activities.

PD, DPD, POs and WG members and their affiliations are listed in the following website:
http://www.jsps.go.jp/english/e-toplevel/08_followup.html

AD, AOs and AWGs

AD: Dr. KUROKI Toshio left his position as the Academy Director in March 2021. Dr. UKAWA Akira, Program Director, has assumed that position from April 2021.

AOs: Experts in the research areas of the member centers. They chair site visits and prepare site-visit reports for the Program Committee.

AWGs: Assembled for each WPI center, these groups principally consist of 2 domestic and 1 international expert in areas that cover the center's activities.

AD and AOs and their affiliations are listed in the following website:
https://www.jsps.go.jp/english/e-toplevel/18_academy.html

Site Visits

Site visits to the WPI centers receiving ongoing funding were conducted during the period of June-September 2021. All the site visits were carried out online due to the continuing COVID-19 pandemic. However, learning from our experience in FY 2020 when the online site visits were shortened to 3 hours, this time full site visits spanning 2 days were held online. They

had full agendas including presentations by the center directors and the heads of the host institutions, presentations by the PIs, and poster sessions by researchers. These full site visits were impactful in conducting subsequent evaluations, including the final evaluations of Kavli IPMU in its 15th year and of IIIS, ELSI, and ITbM in their 10th year, and for the interim evaluations of NanoLSI and IRCN in their 5th year. The full site-visit agenda was also valuable in carrying out the follow-up reviews of ICReDD and ASHBi in their 4th year.

For these eight centers, reports on the site visits were submitted to the Program Committee and disclosed to the respective centers.

WPI Academy Site Visits

For the four Academy-member centers (AIMR, iCeMS, IFReC and MANA), site visits were held for recertifying them as members of the WPI Academy in their 4th year of membership. Postponed from the summer of 2020 due to the COVID-19 pandemic, they were conducted from December 2020 to January 2021. Attended by AD, AO and AWG with PD and DPD, these site visits were carried out online with a shortened duration of about 3 hours. Reports on the site visits were submitted to the Program Committee, whose domestic members conducted recertification evaluations in the Committee's February 2021 meeting.

For I^{2}CNER in its 1st year as a member of WPI Academy, an online visit by the AD and AO was carried out in December 2020.

E. Future plan of the WPI Program

In 2020, the Program Committee requested MEXT's strong and sustained support for the WPI program so as to allow it to continue making unique contributions toward further development and elevation of Japan's research environment.
(See the report "FY 2019 Follow-up of WPI Program" for the full text of this request. https://www.jsps.go.jp/english/e-toplevel/data/08_followup/FY2019/FY2019_Follow_up_Report_E.pdf).

In this year's November meeting of the Program Committee, Mr. IKEDA Takakuni, Director General of Research Promotion Bureau of MEXT, invited the Committee members to advance discussions on future directions of the WPI Program. He proposed a concept of systematically and continuously selecting new WPI centers on the same scale as the current WPI centers along with possible new ways of evaluating and supporting WPI academy centers, which will grow in number. This discussion will continue into next year.

F. Final evaluation of Kavli IPMU launched in 2007

Center director: OOGURI Hirosi

Program officer: SANDA Ichiro, Nagoya University

Conclusion of Final Evaluation:

Kavli IPMU has successfully achieved "world premier" status fulfilling all the missions of the WPI Program. Kavli IPMU has also continued to satisfy all the requirements to remain in the WPI Academy.

1. Identity of the center

Kavli IPMU has established a clear, widely known, prestigious global identity in pursuing the physics and mathematics of the Universe. It achieved this identity very early and has maintained and enhanced it during the extension period.

2. Advancing research of the highest global level

Kavli IPMU sets the "gold standard" for a successful WPI center with high international visibility. By bringing together top-level researchers in disciplines of

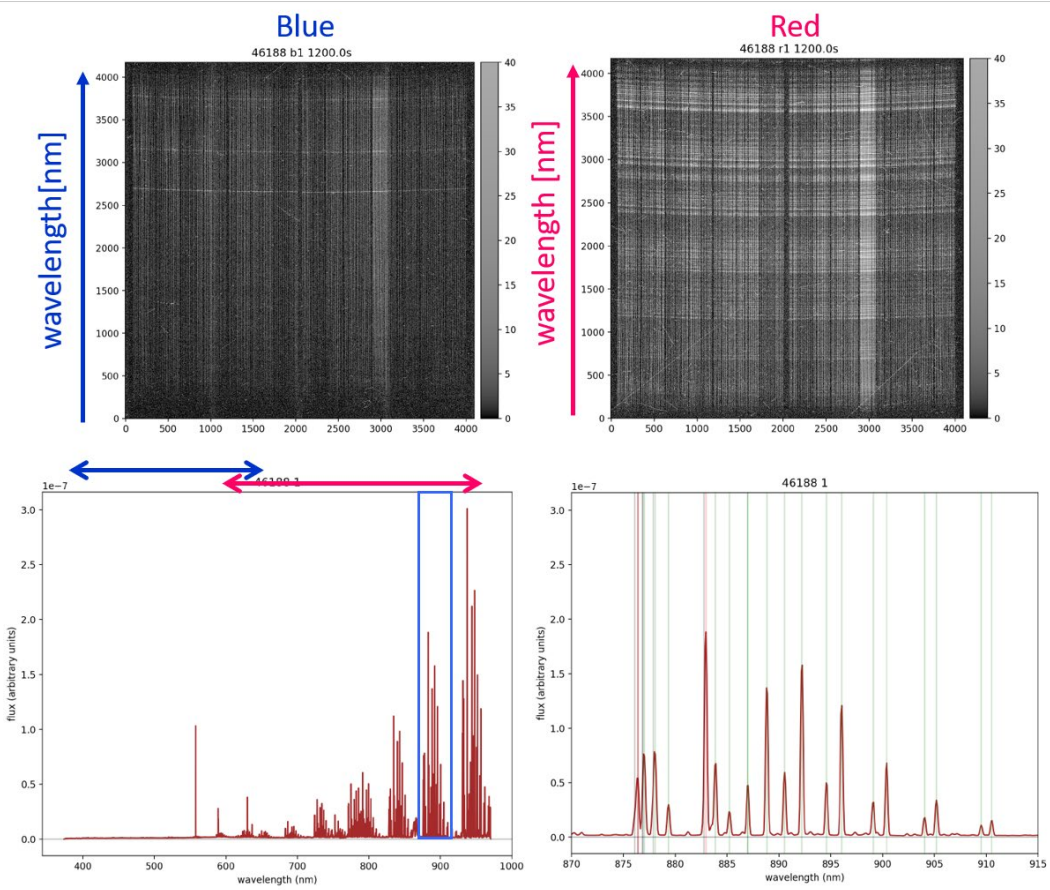


Figure. PFS can successfully observe night sky spectra (Credit: PFS Project)

observational/experimental research and theoretical/mathematical studies, and by creating an environment of interaction, exchange and collaboration, the center has continuously produced cutting-edge science which is reflected in its high level of publication citations. That postdocs from all over the world apply for positions at the center in such numbers that only 3% are successful attests to the attractiveness and high standard of research at Kavli IPMU.

3. Implementation as WPI center

Generating fused disciplines:

Kavli IPMU has successfully combined mathematics, theoretical and experimental physics, and astronomy. The WPI Program Committee hopes to see the center successful in integrating X-ray astronomy and medicine.

Realizing an international research environment:

The center has succeeded in creating a very vibrant and dynamic environment which attracts foreign researchers (who make up more than half of the full-time researchers at Kavli IPMU) and boosts international collaborations. Some 60% of postdocs have, after finishing their appointment at Kavli IPMU, gone on to tenured or tenure-track faculty appointments in major universities around the world. In addition, the center conducts collaborative programs aimed at bringing its research capabilities to bear in contributing to society. As the mission of these programs is shared by the international research community, Kavli IPMU's activities are highly visible worldwide.

Making organizational reforms:

Kavli IPMU has introduced a number of pioneering reforms that break down barriers within the traditional Japanese academic system, including split appointments and a merit-based salary system. Such reforms have now spread to other parts of the University of Tokyo and to other universities.

Emphasizing the major research contributions of female scientists is certainly a good way to motivate female students. Kavli IPMU contributes to diversity, equity and inclusion at the University of Tokyo, thereby helping Japan close gaps in this set of issues. The center is congratulated for establishing the C. S. Wu Prize.

Kavli IPMU has also been instrumental in creating the university bond, resulting in an endowment of 200 million US dollars.

4. Activities as a WPI Academy center

The center conducts very active outreach to enthuse the young in STEM in general, and their fields of scientific research in particular. Its outreach to students in areas of education

and career-counseling has been excellent. The WPI Program Committee recommends enthusiastically the recertification of Kavli IPMU as a member of the WPI Academy.

5. Progress plan after WPI grant ends

1) Proposed plan:

   Kavli IPMU has been successful in establishing an excellent WPI center. Now, the five open questions should be tackled. Continuous effort to stimulate people toward answering these questions will be necessary.

2) Support from the University:

   With the University of Tokyo support and the Kavli foundation endowment, funding for Kavli IPMU is at a level of $12M/year.

6. Advice/recommendations

1) Further effort in diversity associated with race and ethnic groups should be made. The University of Tokyo should take advantage of Kavli IPMU in recruiting more female students in science fields.
2) A clear plan should be established for promoting young and diverse scientists to PI status.
3) Capitalizing on its culture of creativity, Kavli IPMU should leverage this culture further by encouraging risk taking, independent of seniority. This kind of research freedom within a collaborative atmosphere creates a firestorm of innovation.
4) Kavli IPMU should also develop a program that creates research experiences for undergraduates.
5) There are overlaps associated with the LiteBIRD project between the two WPI centers, QUP at KEK, and Kavli IPMU at the University of Tokyo. (Overlaps are at the level of Directors, PIs, Oxford students, and Berkeley Satellite.) The Program Committee recommends QUP and Kavli IPMU to jointly present a concrete corporation plan that leads to a win-win situation with regard to the LiteBIRD project.

G. Final Evaluation of the 3 Centers launched in 2012

G-1. IIIS

Center director: YANAGISAWA Masashi

Program officer: KAIBUCHI Kozo, Fujita Health University

Conclusion of Final Evaluation:

IIIS has successfully achieved "world premier" status fulfilling the missions of the WPI Program. IIIS has positioned itself as a world leader in sleep with a unique structure focused on basic neuroscience of sleep states.

1. Identity of the center

The center has very strong scientific leadership with clear goals to understand the mysteries of sleep and hibernation. There is no equivalent in the world with this kind of success.

2. Advancing research of the highest global level

The impact and magnitude of the research coming out of the IIIS is truly remarkable. Most of the PIs have reported their findings in the top journals including publications in Nature, Science and Neuron. In particular, the discovery and identification of the sleepy mouse gene by Yanagisawa/Funato and outstanding follow-up experiments generating SIK3 loss of function mutations demonstrate causality of this signaling pathway on sleep homeostasis. The discovery by Sakurai that activation of Q neuron induces a hibernation-like state is unique and of immense potential. Generation of selective Orexin antagonists

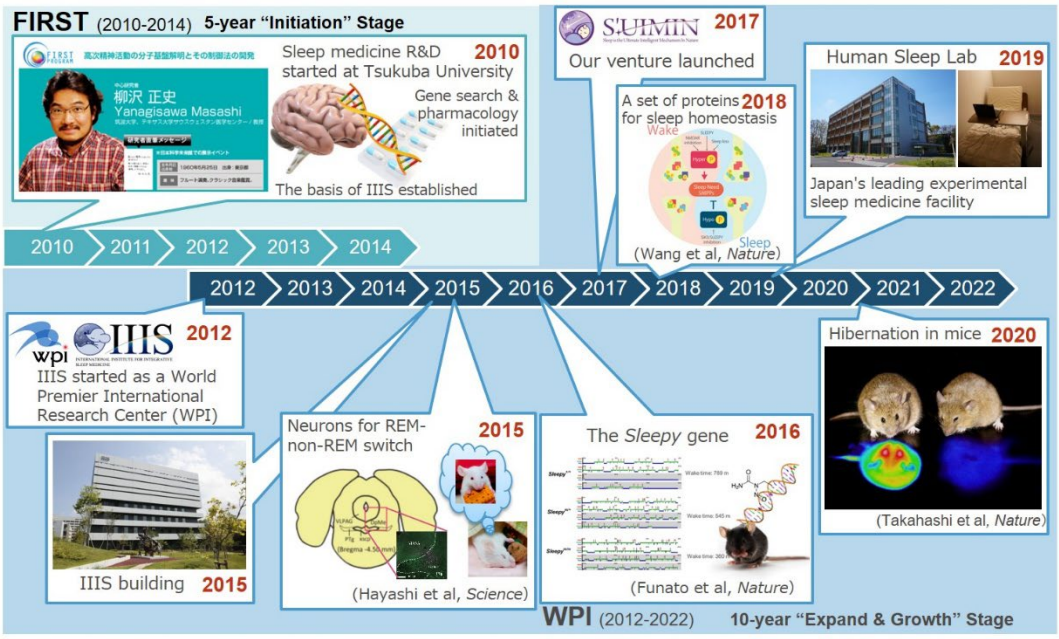


Figure. IIIS as a world-leading center of sleep research

and agonists by Nagase will lead to pharmacological treatments spanning arousal disorders, insomnia and narcolepsy.

3. Implementation as WPI center

Generating fused disciplines:

IIIS has conducted comprehensive sleep research activities, by integrating fundamental biology to pharmaceutical science, to experimental medicine, and further to cognitive science and psychology. This endeavor to fuse different research fields into a novel domain has definitely been successful, which is apparent from its wide-ranging academic achievements. Developing unique technologies such as the mobile sleep lab based on Toyota's fuel cell bus, as well as the wearable EEG device combined with AI-based sleep EEG staging for home sleep monitoring, has added a novel discipline to their fused sleep science.

Realizing an international research environment:

IIIS has successfully assembled excellent researchers from around the world; 29% of its PIs are from abroad (8/28) and 34% of its researchers altogether (24/70). IIIS's regularly held annual international symposia and seminars have brought a large number of researchers to the center from abroad, realizing an international circulation of talent in the science of sleep. Also, female researchers constitute 36% (25/70) though female PIs are somewhat smaller in number at 14% (4/28). The appointment of Dr. Kimura as Administrative Director is the first instance of a female scientist occupying this important position at a WPI center.

Making organizational reforms:

A flat personnel hierarchy constitutes a very important reform by IIIS. Director Yanagisawa's leadership, based on his experience in the USA, continues to work well. Extensive independent operations have been secured, including personnel affairs, environmental maintenance, and budget implementation. Strong administrative services provided under an able administrative director is another important reform realized at IIIS.

4. Progress plan after WPI grant ends

Building on the achievements of IIIS's first decade, its progress plan places basic biology research on hibernation-like behavior side by side with sleep itself, and couples them with clinical research into prediction/prevention of sleep-related diseases, with its main source of basic funding coming from the AMED Moonshot project.

5. Advice/recommendations

1) A total of 9 PIs will be tenured by FY 2022, and tenured positions are planned to be

increased year by year to reach 15 PIs in total by the end of FY 2026. This is a really great plan and must be realized by the leadership of the University President and Center Director.

2) IIIS has taken various measures to promote young researcher encouragement, institutional globalization, and system reform. Now it is time to disseminate these measures including its US-style flat organization, ability-based salary system, and top-down decision-making into other institutions and departments in the University of Tsukuba.

3) Unfortunately, the number of female PIs is low compared to institutes in other developed countries. The center should have a more systematic strategy on how to recruit and support women scientists.

4) IIIS has successfully integrated fundamental biology to pharmaceutical science, experimental medicine, and cognitive science. In addition, Kitagawa joined IIIS as PI in April 2021, and started fusion research with AI technology. However, IIIS should extend its work to fuse with other disciplines – for example, brain computer interface.

5) Monitoring the quality of sleep is now becoming one of the hottest topics in this field. Many competitors are developing smart wearable monitoring systems such as Apple Watch, Fitbit, Oura Ring, and SenseWatch. They possess big data. So, differences in the approaches and methods of IIIS should be clarified vis-a-vis GAFA and other industries.

G-2. ELSI

Center director: HIROSE Kei

Program officer: MIYAMA Shoken, Gifu Shotoku Gakuen University

Conclusion of Final Evaluation:

ELSI has successfully achieved "world premier" status fulfilling the missions of the WPI Program. ELSI is the only real research institution in the world dedicated to research on astrobiology evidenced by its large number of publications. ELSI has also made innovative progress within Tokyo Tech in areas of internationalization and organizational reform.

1. Identity of the center

Since its establishment in 2012, ELSI has made a great effort to become a world top-level institute studying the origins of the Earth and Life. Now, internationally recognized, ELSI attracts many researchers in its fields. ELSI has certainly succeeded in establishing itself as a world-recognized research hub on the origins of Earth and Life.

2. Advancing research of the highest global level

Working under the same roof, outstanding scientists from all over the world gather at ELSI to conduct a number of high-level interdisciplinary research activities. As a result, over 1100 papers were published during the period from ELSI's establishment through 2020,

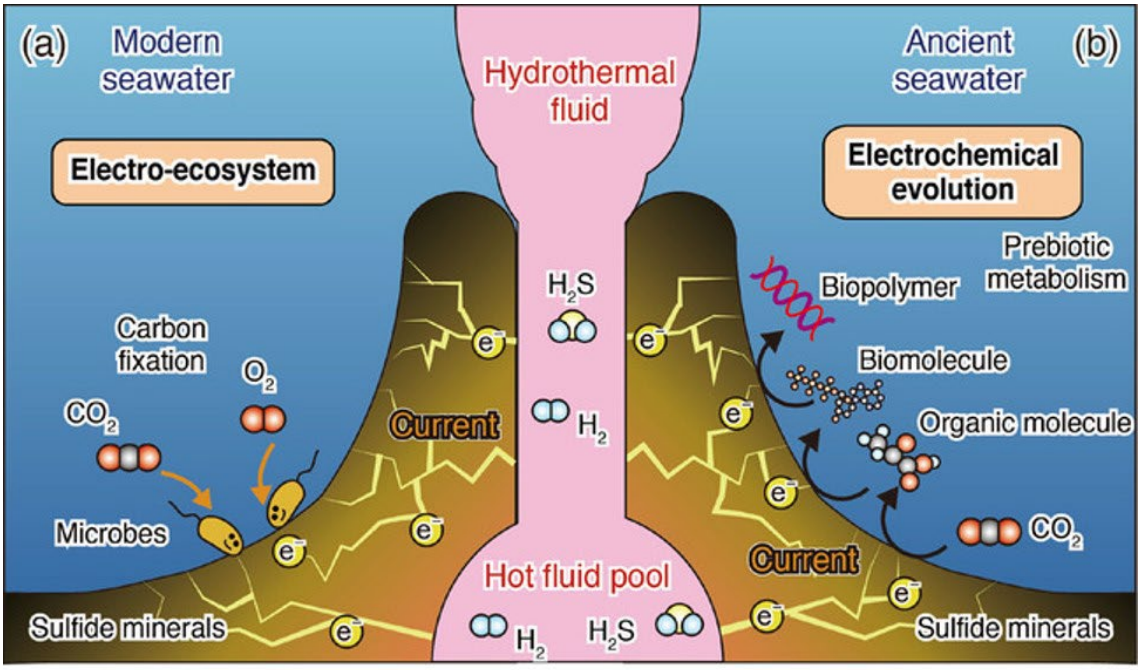


Figure. Electricity-driven ecosystem in the modern Earth and prebiotic metabolism evolution in the ancient Earth.
a) An electro-ecosystem sustained by electro-trophic microbial populations.
b) Prebiotic organic synthesis and metabolism evolution promoted by electric power on/in metal sulfide minerals

many of them in high-impact academic journals such as *Science* and *Nature*.

The center's achievements encompass the evolution of planetary Earth, its composition including water and early atmosphere, prebiotic synthesis of biomolecules, and the formation of cells and genomes. New findings have been made and hypotheses put forth on many of the key steps in the evolution of life within the context of the Earth's evolution.

3. Implementation as WPI center

Generating fused disciplines:

ELSI's vision of studying the origin of life in the context of the Earth is itself an interdisciplinary concept as the subject has both the faces of earth science and life science. Consequently, much of the research conducted at ELSI is inherently interdisciplinary. A good example is its finding of geoelectrical potential at hydrothermal vents for driving biologically relevant chemical processes, thus forming "geo-electro-chemistry."

Realizing an international research environment:

ELSI has successfully attracted top-level researchers from around the world. It has built an English-based environment which allows these researchers to carry out their research to their satisfaction. Indeed, 10 out of the center's 21 PIs are from abroad (47%) as are 24 out of its 62 researchers (39%). And, 60% of its young researchers have been successful in securing promotions at other world top-level institutions after working at ELSI, which promotes international brain circulation.

Making organizational reforms:

Tokyo Tech launched a new five-year graduate program for majors in Earth-Life Science (ELSI Course), to which ELSI PIs contribute. The program works to nurture the next generation of researchers in earth-life sciences. This removal of a major barrier between a graduate school and a research institute is a major achievement of the university's system reform.

ELSI's system of operation provides a role model for university reform at Tokyo Tech. Following ELSI's lead, Tokyo Tech will establish an Advanced Study Organization.

4. Progress plan after WPI grant ends

ELSI expresses an intention to expand its principal research theme from "Earth-Life" to "Planet-Life" and pursue research on how life may evolve in a wider context of exoplanets, which ELSI calls "Universal Biology." In this sense, the next target of ELSI is considered to be a challenging one.

ELSI's next approach will include working with space missions and telescope-observing institutions in looking for evidence of the "ELSI model" in future space exploration. To this

end, ELSI will assume the role of a "think tank." This is one of the natural and reasonable directions for ELSI to go in the future.

5. Advice/recommendations

The WPI Program Committee hopes that Tokyo Tech, the host university, will provide more support for ELSI so that its size will not have to be reduced. The university should not only help ELSI obtain competitive funds in Japan, but also obtain funding from overseas. Providing graduate education in ELSI is a milestone university reform. To maintain ELSI's new five-year graduate-student education program, Tokyo Tech must, as the host university, guarantee the program's financial support.

The current percentage of female researchers at ELSI is at a favorable level (19%), but ELSI should continue its effort to maintain a high level of diversity in the composition of its foreign researchers as well as its female researchers.

6. On the change of the director

The WPI Program Committee agrees that Dr. Sekine is an excellent choice to be ELSI's next director. His research achievements are excellent in the fields of astrochemistry and astrobiology, and the focus of his leadership being more on astrobiology will work well for ELSI in its next phase.

G-3. ITbM

Center director: ITAMI Kenichiro

Program officer: HAMACHI Itaru, Kyoto University

Conclusion of Final Evaluation:

ITbM has developed into an institute which is unique within the world in that it has successfully discovered and created a host of transformative bio-molecules through the fusion of chemistry and biology in a truly international environment. It has also contributed to the organizational reform of Nagoya University. ITbM has successfully achieved "world premier" status fulfilling the mission of the WPI program. At the same time, the scientific misconduct that occurred at ITbM is of serious concern. Implementing a more robust system for ensuring proper scientific conduct and developing a culture of openness and transparency at ITbM and Nagoya University is strongly required for ITbM to continue improving and growing.

1. Identity of the center

Since its establishment in 2012, ITbM has established a unique identity within the international research community based on its strong foundation of outstanding interdisciplinary research achievements between synthetic chemistry and plant and animal biology.

2. Advancing research of the highest global level

By mixing state-of-the art synthetic chemistry, biology and computational research, ITbM has conducted very unique and world-class research in its targeted research fields of plant chemical biology (combating the Striga parasite, plant hormone, plant reproduction), chemical chronobiology (circadian clock regulation, drug candidates for seasonal depression) and live imaging. As a result, over 1100 papers including 74 top 1% papers with high impact were published during the 10 -year period of ITbM's WPI grant.

3. Implementation as WPI center

Generating fused disciplines:

Driven by the strong vision of Director Itami toward mixing multiple science disciplines and scientific cultures, ITbM has successfully fused plant and animal biology with cutting-edge synthetic chemistry, which led to the discovery of a number of novel molecules capable of functioning in biological systems. A number of joint publications in top journals have been produced through collaborations among ITbM's members.

Figure. ITbM's collaborative research highlights in 2021

Realizing an international research environment:

ITbM has achieved an excellent international research environment as indicated by 38% of its PIs being from abroad (5/13) and 65% of its overall postdoc researchers being non-Japanese (69/106). The outstanding reputation of ITbM's interdisciplinary research programs has attracted the best young researchers from all over the world. As a result, 39 postdoctoral researchers from overseas have been successful in securing academic positions at other top-level institutions in Japan and oversea after working at ITbM, promoting international brain circulation.

Making organizational reforms:

A number of system reforms have been instituted in ITbM including top-down governance by the director, incentives based on evaluations, and English-based administration. Nagoya University has, as the host institution, fully embraced the Mix-Lab concept and is using

ITbM as a partner and role model in driving internal reform. The Graduate Program of Transformative Chem-Bio Research (GTR) was launched by positioning ITbM as the core institute within the WISE Graduate Program, a MEXT Doctoral Program for "World-leading Innovative & Smart Education." Also, a reform plan, based on the Mix concept, for Nagoya University's Graduate School of Science has now been approved by MEXT.

4. Progress plan after WPI grant ends

ITbM plans to tackle new challenges as ITbM 2.0. They will take the form of six flagship projects, all of which should exert major societal impacts and advance yet-uncultivated basic research. Focus on these projects is a logical but challenging extension of the Center's current achievements combined with new research strategies and visionary developments. Nagoya University's top administration has secured 19 tenure positions for ITbM and will increase the number to 29 in FY2022. This tight and strong support is very much welcome and will be significant in sustaining ITbM.

5. Advice/recommendations

WPI Program Committee is seriously concerned about the scientific misconduct that occurred at ITbM. While the Committee fully appreciates the fact that ITbM and Nagoya University have worked diligently and appropriately to address the incident, we strongly request the center and the university to not only implement more robust oversight and carry out education on scientific integrity and conduct but, more fundamentally, to further develop a culture of openness and transparency that forms the foundation for preventing misconduct. The Committee believes that such effort will be vital for ITbM to continue to improve and grow in the future.

Diversity in the composition of female researchers should be addressed more systematically and strongly such as strategically identifying female candidates.

ITbM should give attention to finding a good balance between curiosity-driven fundamental research and society-driven research. With regard to industry collaboration, ITbM needs to develop a more proactive approach to utilizing industry consortiums as a platform for knowledge transfer.

The new director needs to put forward a strong and active plan for ITbM2.0 not only on the direction of the Center's science but also including plans for addressing scientific integrity and conduct, diversity and gender equality questions, and a more proactive approach for industry collaboration.

6. On the change of the director

The Program Committees agrees that Dr. Yoshimura is the right person to lead ITbM as ITbM's next director. Given that he is a founding member of ITbM and that his research achievements are excellent in the field of animal chronobiology, his leadership from the biology side will work well for ITbM when exploring new research directions in its next phase.

To improve governance and oversight, however, Dr. Yoshimura should, as the new director, provide stringent leadership and commitment to addressing scientific integrity and to developing a culture of openness and transparency in the labs and center.

H. Interim Evaluation of the 2 Centers launched in 2017

H-1. IRCN

Center director: Takao HENSCH

Program officer: MISHINA Masayoshi, Ritsumeikan University

Interim Evaluation Score: A+

IRCN has made progress toward becoming a "world premier" international research hub that is fully in keeping with WPI Program standards. The center's subject and target goal are very challenging and exciting. There is a need, however, to sharpen its focus to ensure excellence and impact.

A. Advancing the establishment of the center

1. Science level

IRCN's work is pioneering and it is advancing toward being a world-top institute. The level of its basic neuroscience and brain development science is outstanding. Its interdisciplinary collaborations have produced very exciting advances in understanding and predicting psychiatric disorders.

IRCN's current AI research is exploratory. It should create a clear vision on how it will innovate next-generation AI based on principles of brain development.

The center's researchers have successfully obtained large amounts of external funding.

2. Implementation as a WPI center

Interdisciplinary research activities:

IRCN has brought neurodevelopmental research together with clinical research activities and computation science. It has initiated a significant number of interdisciplinary collaborations using a bottom-up team-science strategy. The number of interdisciplinary papers published by IRCN demonstrate its actual progress in fusion research.

The Director has created Sustainability, Synergy and Community Offices to intersect top-down leadership with bottom-up proposals. During the COVID-19 pandemic, the Director and researchers have interacted actively using virtual and remote formats.

Globalization of the institution:

Director Hensch has recruited talented young researchers including 4 junior PIs. IRCN has 4 overseas PIs and 33 overseas researchers.

IRCN has established an international network with 15 institutes. Representative scientists from these institutes frequently visit IRCN to attend symposia, do teaching,

and conduct research collaborations. The center regularly hosts foreign summer interns and conducts an international neuro-inspired computation course. During the COVID-19 pandemic, the center's international network remained active and successfully used virtual means for interacting with the other institutes.

Figure. An interactive exhibition about the research at IRCN was on long-term display at Miraikan, Tokyo. Visitors at the entrance of the exhibition (Left). Interactive displays within the exhibition area (Right)

Organizational reform:

IRCN has recruited scientists with diverse disciplines, nationalities and genders. It employs bilingual administrative staff and exchanges trainees from abroad. IRCN's team-science strategy has worked well and the four core facilities it set up provide a good framework for promoting collaborations. In these ways, IRCN has influenced university reforms.

The Director will need to exert greater leadership over IRCN through his physical presence.

Future prospects of the centers' project:

IRCN is on the right track to becoming a world-class international research center. It has been quite successful in competing for external grants including from the MoonShot program.

Many strong groups in the world are working to improve AI algorithms beyond the brute force approach of neural networks by employing bio-inspired methods. The center has not clearly explained its specific vision on this topic. The future vision and direction of IRCN needs further clarity especially as to how it will innovate next-generation AI based on principles of brain development.

IRCN needs to be sharper in defining its goals for the next 5 years. The prospects for IRCN's future after 2026 are currently uncertain.

B. Host institution's concrete action plan toward making its center an

autonomous research institute in the second half of the grant period (from the 6th year of the center's operation)

The University of Tokyo has been supporting IRCN by providing it space and funding for its renovation, basic instruments, and junior PI positions. The University of Tokyo has launched a working group to develop specific strategies for the permanent installation of IRCN within the university. However, the extent of support to be provided by the University of Tokyo is unclear, particularly with regard to its commitment for IRCN support and to securing tenured PI positions for the center's senior researchers. Plans should be implemented for constructing the new IRCN building and for providing long-term funding.

Advice/recommendations

(Including opinions on host institution's plan toward the sustainable Center)

1) IRCN should present concrete plans toward achieving its goals over the next 5 years. Especially, the center should articulate a clear vision as to how it will innovate next-generation AI based on principles of brain development. IRCN should strive to clarify how it will reveal the origin of HI. The Director will need to exert greater leadership over IRCN through his physical presence.

2) A system for training the next generation of researchers, especially through IRCN's own graduate program, should be established.

3) Continue to make efforts to improve gender balance.

4) The prospects for IRCN's future after 2026 are very uncertain. IRCN must continue its efforts to establish a long-term commitment of support for IRCN and to secure permanent faculty positions for its senior researchers.

5) The University of Tokyo should clarify the content of the support it plans to provide IRCN, particularly the number of tenured PI positions to be secured for the center. Plans for the new IRCN building and long-term funding should be implemented.

H-2. NanoLSI

Center director: FUKUMA Takeshi

Program officer: NAKANO Akihiko, RIKEN

Interim Evaluation Score: A+

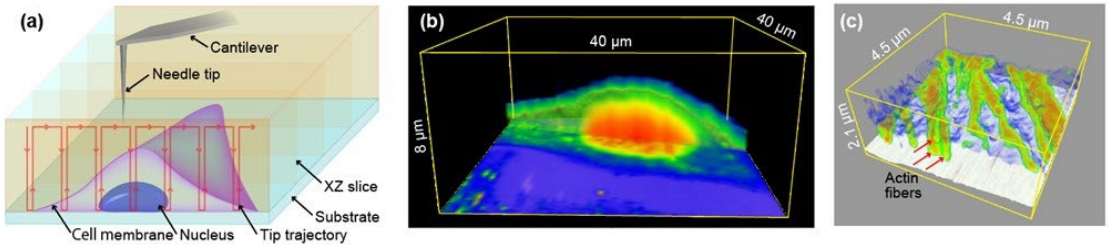
NanoLSI is close to becoming a "world premier" international research hub that is fully in keeping with WPI Program standards. The science level of NanoLSI and the implementation of its organization reforms are highly evaluated. The center is encouraged to achieve fruitful results by applying its world top-level Bio-SPM technologies to biological and medical problems, not limited to cancer research.

A. Advancing the establishment of the center

1. Science level

The center's level of science is excellent. Its Bio-SPM technology is at a top world level and its publications are glorious. Its high-speed AFM has become even faster, and its 3D AFM has now enabled imaging of cell surfaces and intracellular structures. NanoLSI is making use of these technologies to tackle problems of cell biology and cancer science. Applying chemistry to providing sensors for SICM is a challenge, but the center is making steady progress on this front. The equipment and facilities set up in the new building are world class, and NanoLSI is now recognized as an international hub for collaborative research.

Principle and example of intra-cellular 3D imaging by nanoendoscopy AFM.



(a) Principle. (b) 3D-AFM image of the live HeLa cell. (c) 3D-AFM image of the actin filaments in the live fibroblast cell. *(Penedo et. al., Sci Adv. 2021,* DOI: 10.1126/sciadv.abj4990*)*

2. Implementation as a WPI center

Interdisciplinary research activities:

Efforts to advance the fusion of research disciplines are being made at the initiative of Director Fukuma and have produced many visible results. A key is the fusion advanced by the center between nanometrology and supramolecular chemistry. Some of NanoLSI's approaches appear to be beginning to work, such as its development of molecular

sensors for important indicators of cancer progression. Application of cutting-edge Bio-SPM technology to crucial cell biological/medical questions will continue to be essential.

Globalization of the institution:

Despite the pandemic, the number of postdocs from abroad has steadily increased to 80% of all the center's postdocs now and the ratio of overseas researchers including PIs has exceeded 30%. The activities of the foreign PIs are good, and are enhanced by the employment of co-PIs on site.

Organizational reform:

NanoLSI has already implemented standard reforms under top-down management by the director. The new building has provided a very nice "under-one-roof" environment with many Bio-SPMs and high-end microscopes. Kanazawa University has set up NanoLSI to be an independent institute with full rights and has established the Graduate School of Frontier Science Initiative, Division of Nano Life Science. These are regarded as excellent drivers of system reforms.

Future prospects of the centers' project:

NanoLSI needs to continue to produce impressive research outputs and maintain its world-level position into the future. A key will be the application of Bio-SPM technology to unsolved problems of life science. Its research roadmap should be continually reviewed and updated. Targets for cancer research should be carefully selected and focused. NanoLSI's funding track record is so far quite strong and its continuation will be very important for the center's future.

B. Host institution's concrete action plan toward making its center an autonomous research institute in the second half of the grant period (from the 6th year of the center's operation)

The WPI Program Committee members are very impressed by the vigorous statements of President Yamazaki on Kanazawa University's commitments to provide sustainable support for NanoLSI into the future. These plans are very good and feasible and will be vital to maintaining NanoLSI as a top world-level institute for the second half of the grant period. Given that the university's present top management will change at the end of FY 2021, confirmation of the incoming management's commitment will be needed.

Advice/recommendations

(Including opinions on host institution's plan toward the sustainable Center)

1) Indicate clear challenges in the center's roadmap and continually update the map.
2) Make a continuing effort to solicit more robust activities by the foreign PIs at NanoLSI.

3) Establish a more comprehensive strategic approach for benefitting from diversity, rather than individual effort, and for increasing the number of female scientists, especially at the PI level.

4) Allocating the promised number of personnel in Kanazawa University's support plan should be done shortly.

5) Concrete plans should be made for advancing Bio-SPM technology in the future to prevent the center from becoming obsolete or from losing its cutting edges.

6) The biosensors that the supramolecular chemistry group has developed are not high enough in selectivity and sensitivity to be of practical use with Bio-SPM. This situation needs to be substantially improved.

7) Human resources will be very important for the center’s progress. Recruiting young researchers and getting students involved even at undergraduate levels is recommended.

8) Consider introducing robotics and AI in Bio-SPM technology. Inviting broader fields of researchers will greatly contribute to understanding cell functions.

I. Follow up on the 2 Centers launched in 2018

I-1. ICReDD

Center director: MAEDA Satoshi

Program officer: TATSUMI Kazuyuki, Nagoya University

1. Advancing research of the highest global level

The research at ICReDD continues to be of high quality, and impressive progress has been made in advancing various projects with high-rated research outputs. Collaborative efforts between theoretical chemists and synthetic chemists have created new opportunities in designing reactions and in creating new strategies for chemical synthesis. While the outcomes in biological applications are limited, recent collaborative studies suggest there is great potential for hydrogels to revolutionize stem cell biology and cell therapy. The large amount of external funding (about 900 MY) secured by individual PIs also attests to the recognition by funders of the high level of research competitiveness at ICReDD.

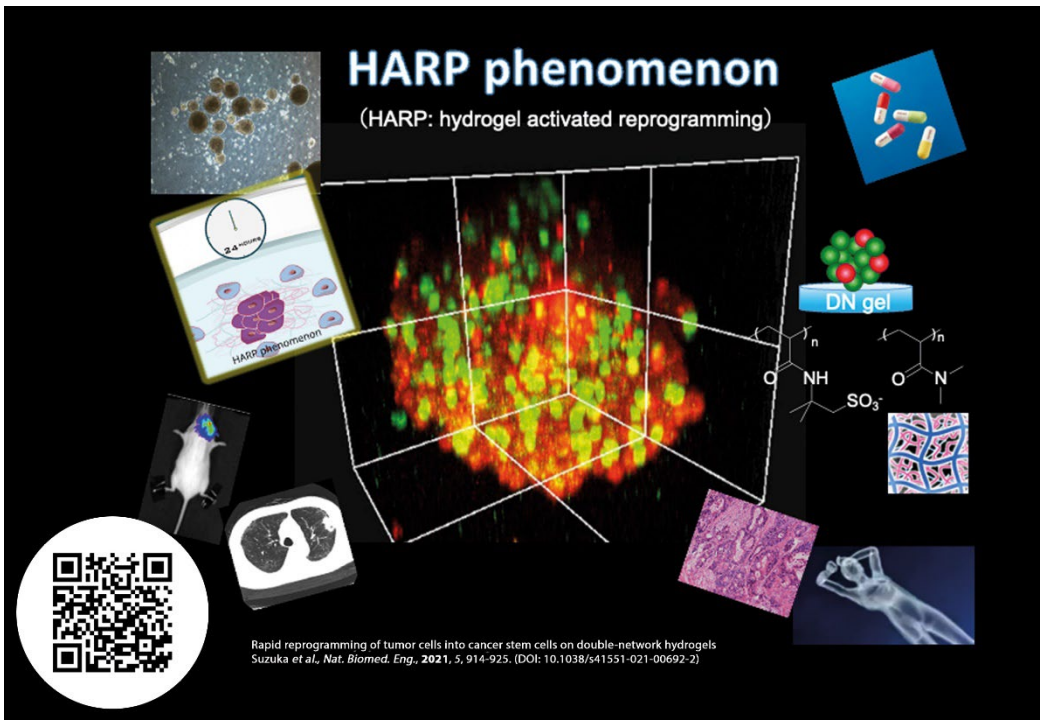


Figure. Double-network (DN) hydrogels were found to revert differentiated cancer cells into cancer stem cells within 24 hours. This research was promoted as ICReDD's monthly research postcard in March 2021.

2. Implementation as a WPI center

Generating fused disciplines:

ICReDD has put a particular emphasis on promoting their fusion research by setting up mix-lab and mix-office and various seminars and by providing a start-up grant for

interdisciplinary research. Noteworthy is its establishment of a "fusion research start-up grant," with which young researchers have launched challenging bottom-up fusion projects. ICReDD has also made significant efforts to improve the contribution of information science to their research activity. Information science has been strengthened owing in part to the appointment of new PIs.

Realizing an international research environment:

The activities of the 3 foreign PIs are becoming more visible, aided by the appointment of co-PIs and researchers in Sapporo. In addition, ICReDD plans to hire new junior PIs from abroad at the associate professor level in three different core disciplines, and to provide start-up packages to each of them. Particularly encouraging is the offer from Hokkaido University to provide ICReDD with tenure-track positions for hiring junior PIs. Although it is a difficult time for recruiting candidates due to the current pandemic, the Center has decided to take one experimental junior PI, and is now close to a decision on taking a theoretical junior PI.

Making organizational reforms:

ICReDD's organizational reforms have been effective, facilitated by the appointment of an Executive Director and by the support of the new University President. Three working groups have been established: Future Planning WG, New Building Preparation WG, and Equipment Installation Management WG. They all look to be in a much better situation than last year. The Director can now think and plan more strategically while delegating tasks and authority to collaborators and managers within the center.

Effort to secure the center's future development over the mid- to long-term:

Hokkaido University has given the Center strong support with physical space in the form of the new building (5500 m^2). The initiation of a Future Planning WG to ensure the sustainability of ICReDD beyond the WPI funding period is a welcome move. The MANABIYA system could become a valuable asset for the center. It has been used to initiate collaborations and to make new contacts and strengthen existing contacts with industry. However, success is limited at this stage due to the COVID-19 pandemic.

Center's response to the follow-up results in the last year

The Center has positively responded to most of the points raised last year. In particular, securing more lab space and the strong support provided by Hokkaido University can be seen as very positive outcomes.

3. Actions required and recommendations

1) Continue efforts to achieve top-level science based on the fusion of

computational/informational/experimental sciences. The 7 flagship projects have been a very active vehicle for achieving this purpose.

2) ICReDD needs to address the issue of gender balance. In FY 2020, 13 researchers were newly hired (9 foreigners, one female). 24 of 66 researchers are foreign nationals and 7 are female, which is still very low. A plan for how to support younger female scientists must be put in place as well as a plan for promoting and recruiting female PIs. There has to be more successful role models for young female researchers. ICReDD has the opportunity to gain international recognition by elevating Japanese female researchers.

3) Continue efforts toward increasing international visibility through the recruitment of talented young researchers. The Center is advised to bring in more researchers and students from established top-institutes abroad.

4) There seems to be some difficulties among clinicians and chemists in sharing the deeper meaning of scientific knowledge when collaborating to advance cancer diagnosis. ICReDD should encourage them to establish a mechanism for promoting better communication.

5) In tune with ICReDD's important mission, it will be important for the Center to develop more active programs for outreach beyond the academic community, which will help demonstrate the societal value of basic research.

6) To establish ICReDD as a permanent research institution beyond the WPI funding period, a clear and concrete plan will be required. An important item will be to increase the number of research and administrative positions that belong to ICReDD.

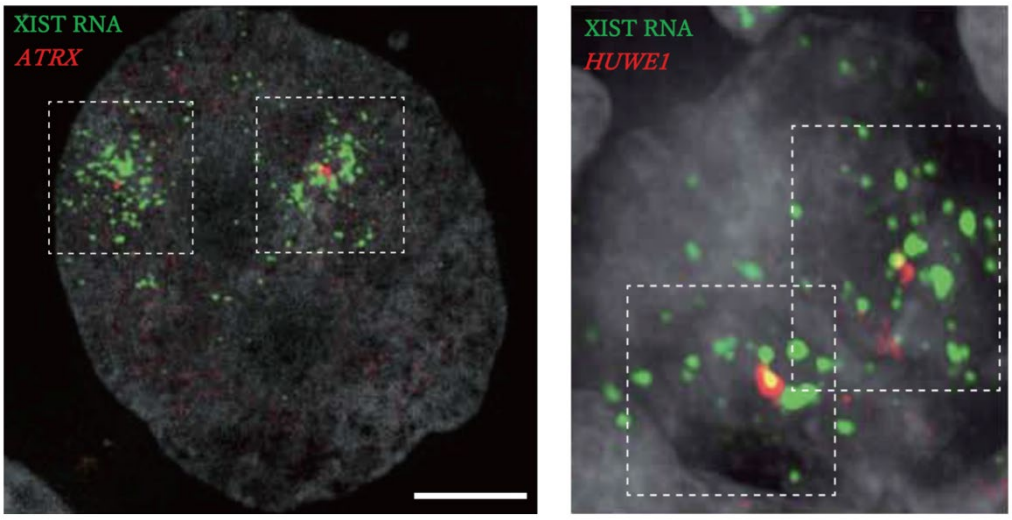
I-2. ASHBi

Center director: SAITOU Mitinori

Program officer: OKANO Hideyuki, Keio University

1. Advancing research of the highest global level

Scientific research is making good progress at ASHBi, including very impressive achievements. Their 3 cores, SignAC, PRiME and NPAF, are functioning well in providing powerful genome analyses and animal experiment materials for much of ASHBi's research. Responding to advice from the Working Group, ASHBi has seriously discussed setting up "Flagship Projects" for advancing each of its 5 goals. The degree of maturity in planning and/or stage of execution appears to differ from project to project. Particularly, the project on aging is still vague in scope and in its relation to the 5th goal. So, this project will need to speed up its planning process.



M. Saitou

I. Okamoto

Figure. [Left] Three-dimensional structured illumination microscopy (3D-SIM) images of XIST RNA (green) and X-linked genes (ATRX) (red) in a trophectoderm of female E8 embryos. [Right] 3D-SIM image of XIST RNA (green), X-linked genes (HUWE1) (red) in E57 female germ cells.

2. Implementation as a WPI center

Generating fused disciplines:

Fusion of biology and mathematics is making steady progress at ASHBi. A wonderful method called xRECODE for noise reduction in single-cell RNA sequence data analysis has been developed and appears to be working very well even in comparison to other existing methods such as MAGIC. On the other hand, it will be important to make this method universally available to see how it competes with many other methods. Regarding the

fusion of bioethics and life science, it is notable that ASHBi helped to shape the highly influential ISSCR guidelines for ethical conduct in fields of stem cell research and regenerative medicine. The new recommendations address recent scientific advances involving embryos, stem cell-based embryo models, chimeras, organoids, and genome editing, some of which were proposed by ASHBi and all of which are highly relevant to ASHBi's activities.

Realizing an international research environment:

ASHBi has made conscious efforts to improve its diversity in terms of both nationality and gender over the previous year. It is welcome news that a female foreign PI will join ASHBi. The international makeup of its PIs will improve to 22% (4/18) and of all researchers to 27% (15/54). The ratio of females will also improve to 17% (3/18) for PIs and 24% for all researchers. However, it should be noted that the ratios of non-Japanese researchers and PIs are still below the average levels of other WPI centers.

Making organizational reforms:

Strong administrative support is one of the very good aspects of ASHBi's system reform. In addition, ASHBi's research activities are highly interdisciplinary, and its collaborations with Kyoto University Hospital and CiRA of Kyoto University have been strengthened. It is hoped that the streamlining of ASHBi's operations will lead to organizational reform across Kyoto University. On the other hand, Kyoto University will need to change its rules for employing researchers residing outside Japan if ASHBi is to be able to hire talented foreign researchers who cannot come to Japan until the restrictions on entering Japan due to the COVID-19 pandemic are lifted.

Effort to secure the center's future development over the mid- to long-term:

We recognize that tremendous efforts have been made by ASHBi and Kyoto University in this fiscal year (FY2021) with an aim to advancing the center's future development. Kyoto University has provided very strong support for kicking off ASHBi in the forms of a building and space (2,010 m^2), funding for purchasing advanced instruments for its 3 core facilities, a 50% portion of its indirect funding with multiple-year budgeting, and 2 tenured positions. However, given the number of newly hired PIs, two tenure positions are not sufficient to ensure the sustainability of the center. It is preferred that more proactive support from the host institution be provided in this area.

Center's response to the follow up results in the last year:

ASHBi appears to have generally responded well to the advice it was given last year, except for the issue of diversity [(6) internationalization and (7) gender balance]. Gene selection (5) may need attention. Since non-human primate research resources are extremely

valuable, a clear rationale for which genes should be selected for genetic modification experiments, such as the use of information on human disease genetics that has not been elucidated in past rodent studies, should be provided. This is particularly important in creating a primate model of anxiety-related diseases.

3. Actions required and recommendations

Administration

1) Next year (2022) when the center will undergo its interim evaluation, ASHBi should summarize the achievements it has made so far and devise a plan for its goals and strategies in the second half of the 10-year WPI funding period.

2) Looking beyond the 10-year funding period, further support from Kyoto University will be necessary to sustain the center's operation in and beyond its 11th year, although the university has already helped to build up ASHBi over the previous few years.

3) ASHBi's still relatively small number of young female investigators appears to be at odds with the trend in other world top-level research institutes, such as Stanford, Broad Institute, UCSF, etc. Continuous efforts to address the under-representation of female scientists at ASHBi is especially important at this stage.

Science

1) Toward establishing ASHBi's scientific brand, it will be important to polish up its Flagship Projects and vigorously execute them in ways that will serve as a beacon or light house to be seen by the international science community in recognizing ASHBi's unique scientific identity.

2) It is important for ASHBi to quickly make its xRECODE method universally available to see how it competes with many other methods.

3) ASHBi is encouraged to take a leadership position in bioethics discussions.

4) From the standpoint of ASHBi's translational research into human medical science, it would be useful to try to connect human diseases to non-human primate models and vice versa.

5) Whatever human-specific traits are observed, they are ultimately generated from the human-specific genomic sequence. The kinds of epigenetic modifications introduced, how much certain genes are activated, and the activity of gene products would be in fact determined by genomic sequences. It could, therefore, be said that one of ASHBi's goals is to identify the genomic sequences (or regions) that make us human.

J. New WPI center launched in 2021

In February 2021, MEXT invited proposals for one new WPI center to be launched in 2021. Carrying out a vigorous three steps selection procedure, the WPI Program Committee selected the project "International Center for quantum-field Measurement for Studies of the Universe and Particles (QUP)" at the High Energy Accelerator Research Organization (KEK) in its September meeting.

Headed by HAZUMI Masashi, QUP focuses on quantum field measurement systems in pursuing its aim to bring about innovative development through interdisciplinary research in particle physics, astrophysics, condensed matter physics, measurement science, and systems science. Its achievements will not only give humanity new "eyes" in various scientific fields beyond physics but will also pave the way for implementing in future society.

QUP was officially launched on 16 December, 2021.

K. WPI Academy

K-1. Aims and members

Concurrent with the end of the 10-year support period for the initially established five WPI centers, a WPI Academy was launched by MEXT in 2017. Its aim is to enhance and amplify the WPI brand and to play a vanguard role in internationalizing and reforming Japan's research environment by leveraging the WPI achievements attained so far.

Academy membership requires certification by the WPI Program Committee that a center has achieved "world premier" status. Centers, then, need to be recertified every 3 to 4 years by the WPI Program Committee, which determines whether they have maintained their "world premier" status.

Currently, the WPI Academy centers are AIMR, iCeMS, IFReC, MANA, and Kavli IPMU from FY 2016, and I^2CNER from FY 2020.

K-2. Recertification of the 4 centers that joined the Academy in 2017

For AIMR, iCeMS, IFReC and MANA, the Academy site visits, postponed from the summer of 2020 due to the COVID-19 pandemic, were conducted in December 2020 to January 2021, using an online format and a shorter duration of about 3 hours. Site visit reports by the Academy Working Groups were forwarded to the Program Committee, whose domestic members carried out the recertification evaluations in the Committee's February 2021 meeting. The Committee fully confirmed that each of the four centers had maintained a standard of research and operation at a "world premier" level, as called for in the "Academy of the World Premier International Research Center Initiative." The Committee noted that,

despite difficulties associated with the end of WPI funding, efforts by the centers and support from their host institutions were instrumental in maintaining the centers' strengths and activities.

AIMR:

After AIMR's transition to the Academy, the Center director changed from Dr. KOTANI Motoko, a mathematician, to Dr. ORIMO Shin-ichi, a materials scientist, in 2019. Under the new directorship and with the same mission of mathematics-materials science collaboration, three Advanced Target Projects (ATPs) were formulated. AIMR's research productivity remains very strong and it maintains a world-leading research status in materials science, continuously publishing many papers in high-impact journals. AIMR actively promotes interdisciplinary studies with mathematicians. The Center has been sustained financially by a total budget of ¥1.7-1.8 billion/year, including about ¥0.8 billion provided by the host institution.

iCeMS:

iCeMS's high level of scientific activity has been maintained as a member of the WPI Academy since the Center's WPI funding ended in FY2016. Since its establishment in 2007, iCeMS has ambitiously challenged the integration of materials science and cell biology as its mission under the WPI program. Although the scale of the center was reduced, it has continuously published many excellent papers in high-impact journals. As for its internationalization, iCeMS has established collaborative laboratories in Thailand, Taiwan, China, France, and the USA. The Center is sustained by strong support from the host institution, including 21 researcher positions, research spaces and equipment. Kyoto University established KUIAS (Kyoto University Institute for Advanced Studies), a new organization for implementing advanced studies. As core members of KUIAS, iCeMS and ASHBi, another WPI center, take a lead in advancing challenging research within the host institution.

IFReC:

The program committee greatly appreciates IFReC's outstanding accomplishments in immunology and its interdisciplinary studies between imaging technology and bio-informatics. IFReC's recent introduction of human immunology as one of its main research thrusts marks another step in the Center's progress. Globalization of the Center is also remarkable as seen in its organizing of international symposia and its "Winter school" on immunology held in cooperation with overseas institutions. The committee is particularly impressed by IFReC's comprehensive collaboration agreements with two pharmaceutical companies, which make it possible for the Center to fully sustain its activities while securing

the freedom of its researchers.

MANA:

MANA was incorporated into NIMS as one of its seven research centers after the WPI funding ended, and is now responsible for basic research on materials science at NIMS. Upon this reorganization, MANA's five research fields were rearranged into three fields, i.e. Nano-materials, Nano-systems, and Nano-theory. During the period from 2017-2019, 206 researchers published more than 1,400 papers. The remarkable outcomes of the Center's research include 2D-nanosheets, atomic switches, nano-porous metallic materials, thermoelectric materials, and topologic photonic crystals. MANA has established two more overseas satellites since 2017 bringing the total number to seven, which enhances the Center's research exchanges and global brain circulation.

K-3. Follow-up of I^{2}CNER that joined the Academy in 2020

FY 2020 was the 1st year for I^{2}CNER as a member of WPI Academy. Dr. Sofronis continued as Director, Prof. Chapman became Administrative Director, and University of Illinois (UI) confirmed to continue the UI Satellite. While the total number of researchers became about 2/3 compared to 2019, all 24 PIs were maintained. Strong external funding is expected over the next 5 years, and strong support from Kyushu University is continuing. Overall, the transition to WPI Academy center is so far moving smoothly.

K-4. Change of the Director of MANA

In March 2021, NIMS, the host institution of MANA, proposed a change of the center director from Dr. SASAKI Takayoshi to Dr. TANIGUCHI Takashi. Following the procedure for changing WPI Academy center directors, a pre-evaluation by the AD, AO, PD and DPD was conducted on 8 March 2021, and a hearing by the domestic members of the Program Committee was held on 27 July 2021. As the result, the change was approved and Dr. TANIGUCHI started his directorship on 1 August 2021.

Dr. TANIGUCHI is a renowned material scientist, well-known for his fabrication of quantum materials. He will lead MANA while maintaining Nanoarchitectonics as the center's core concept, and emphasizing research originality, international perspectives, and innovation led by mutual understanding and collaboration.

L. WPI Reputation Survey

In 2021, the WPI Center in JSPS conducted a reputation survey. Its purpose was to ascertain the views held by academic experts, funders and policymakers around the world regarding the WPI centers and the WPI Program.

As its methodology, interviews based on a questionnaire regarding the missions and goals of

the WPI Program were conducted with 66 interviewees around the world, comprising 55 academics, three editors, and eight policymakers. The interview responses were analyzed via thematic coding to pick out the major opinions expressed by the interviewees. The survey was commissioned to Research-Consulting, an UK-based research company, through SpringerNature. Its major findings are as follows:

By the academics:

- WPI centers deliver excellent science, but the broader WPI Program is not widely known.
- WPI centers are having an impact on the scientific community.
- Curiosity-driven research and funding underpin its uniqueness and reputation.
- The scale of fusion efforts in the WPI Program is unique.
- WPI centers are developing as globally connected centers, and have a strong proposition to attract foreign academics.
- Academics are interested in different interactions with WPI centers depending on their level of seniority.
- There is potential for WPI centers to develop long-term societal impact.

By funders, policymakers and editors:

- Views on the WPI program are positive, but awareness is very limited.
- WPI centers have the potential to drive long-term change in Japanese academia.
- Opportunities for collaboration could be better leveraged.
- The focus on long-term funding is key, and extensions past the 10-year timeframe may be appropriate.

Regarding areas for improvement:

- The WPI Program and centers could benefit from enhanced communications.
- The funding horizon for WPI centers might benefit from further extension.
- The focus on humanities and social science disciplines is limited.
- Cultural barriers may hinder the long-term success of the WPI Program.

Final remarks:

The WPI Program is broadly delivering on its strategic objectives. Areas for improvement include: i) Clarifying pathways for foreign organizations to engage with WPI centers and the WPI Program, ii) Extending the funding horizon beyond the current 10-year timeframe, upon periodic review of individual WPI centers, iii) Providing clarity on venture opportunities available to further develop and potentially commercialize discoveries made at WPI centers, and iv) Continuing to improve the levels of gender and national diversity, building on the successes achieved to date.

M. Branding and outreach

Due to the continuing COVID-19 pandemic, online gatherings continue to be the main mechanism for much of the WPI's branding and outreach activities this year.

In January 2021, a new gathering entitled WPI Embassy Seminar was organized under the auspice of Science and Technology Diplomatic Circle (S&TDC), an association of members from over 80 diplomatic missions and affiliated organizations in the Tokyo area. The seminar aimed to provide an arena to connect people from the WPI centers, research institutions and funding agencies around the world. Presentations at the seminar provided an overview of the WPI program, followed by more detailed introductions to several WPI centers and their researches. The seminar was held for a second time in December 2021, in which German DFG and EU Commission provided information on funding opportunities for WPI researchers.

Figure. High school students in 10th WPI Science Symposium

In December 2021, the 10th WPI Science Symposium was held in Kanazawa on the theme "Nano World orienting toward the Future" jointly with the Research Presentation Meeting of Super-Science High Schools in Ishikawa Prefecture. NanoLSI of Kanazawa University led in organizing the symposium. Thanks to a lull in the COVID-19 situation in Japan in the fall, the symposium could be held in a hybrid fashion: over 360 high school students gathered in person at the Prefectural Music Hall in Kanazawa to hear talks by researchers from WPI centers. They also interacted with the researchers via an online poster session.

WPI Forum https://wpi-forum.jsps.go.jp is a venue on the WPI website for disseminating WPI experience and know-how to such stakeholders of universities and research institutes. This year, a new content "Research creation unique to WPI" has been added to the "WPI Research Stories" page. Picking illustrative examples, the stories on this page describe how the WPI strategy, especially on research environment and operation, has led to successful creation of fusion research unique to WPI.