



FY 2020 Follow-up of WPI Program

By Program Committee

February 2021

(This document reports on progress made under the WPI Program in FY 2019.)

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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), successfully concluded its first 10 years of implementation in 2016. The second decade of the program started in 2017 with the launching of 2 centers, IRCN and NanoLSI, and 2 more centers, ICRoDD and ASHBI in 2018. This year is the 4th year of the Program's second decade of operation, or its 14th year when counted from its establishment. The 2020 follow-up report describes important areas of progress achieved in FY 2019 and new developments made in FY 2020, in particular a future plan for the WPI Program including deliberations on new missions toward further advancing the WPI Program. Also reported is how the Program has coped with the COVID-19 pandemic, which suddenly appeared in early 2020 and has rapidly spread around the world.

A. 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.

Four missions are given to WPI centers.

- Advancing to the highest pinnacle 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)

Many countries are now carrying out Research Excellence Initiatives (REI) against the following background. The WPI Program is regarded as an REI role model.

- 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 REIs designed to encourage outstanding research by providing large-scale and long-term funding.

B. 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.

- **I²CNER** on energy, Kyushu University

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

- **IIS** 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

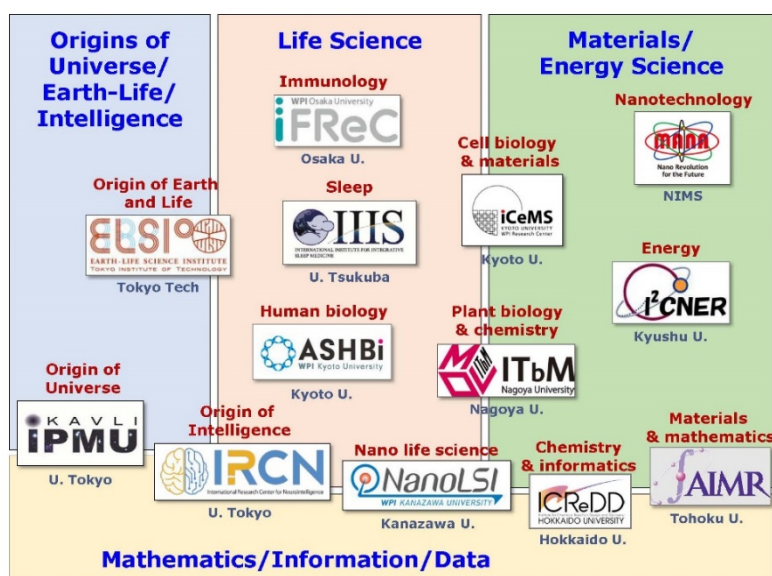


Figure. WPI centers in FY 2020

As shown above, the 13 WPI centers cover four science areas: Origins of the Universe, Earth, Life, and Intelligence; Life Science; Materials/Energy Science; and Mathematics/ Information/ Data Science.

C. 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

The Committee membership changed at the end of FY 2019: Dr. KOBAYASHI Makoto resigned.

All the Committee members and their affiliations are listed in the following website:

https://www.jsps.go.jp/english/e-toplevel/data/07_committee/PC_member_list_2020.html

The FY 2020 Program Committee meeting was held on 13-14 October. The COVID-19 pandemic having made an in-person gathering difficult, the meeting was held on-line. The main items of business on its agenda were (1) progress evaluations of the eight WPI centers that are receiving ongoing funding, which were carried out based on presentations by the presidents of their host institutions and center directors and on site-visit reports and the centers' own progress reports, and (2) the future of the WPI and deliberations on new

missions for further advancing the WPI.

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 has been serving as Academy Director since April 2017.

AOs: Experts in the research area 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 2020. Due to the COVID-19 pandemic, all the site visits were conducted on-line.

A full site visit, albeit shortened to about 3 hours, was carried on the four centers, IRCN and NanoLSI in their 4th year and ICR/DD and ASHBI in their 3rd year. The members of the site-visit teams were the PD, DPD, PO, WG, MEXT officials, and members of the JSPS secretariat. The AD participated as an observer. Interested Program Committee members also participated. The visit schedule started with briefings by the center director and the president of the host institution followed by discussions between them and site-visit team members.

For Kavli IPMU in its 14th year and IIS, ELSI and ITbM in their 9th year, a site visit was conducted without WG participation. The schedule started with briefings by the center

director and the president of the host institution followed by discussions between them and site-visit team members.

For all 8 centers, reports of the site visits were submitted to the Program Committee and disclosed to the respective centers.

WPI Academy Site Visit

For I²CNER in its 1st year as a member of WPI Academy, an on-line site visit by the AD and AO was carried out in December.

For the four Academy-member centers (AIMR, iCeMS, IFRcC and MANA), site visits by the AD, AO and AWG with PD and DPD were scheduled for the summer of 2020 in the centers' 4th year as members of the WPI Academy. Due to the COVID-19 pandemic, these site visits had to be postponed until the winter of 2020-2021.

D. WPI Program under the COVID-19 pandemic

The sudden appearance of the SARS-CoV-2 virus and the ensuing rapid spread of COVID-19 worldwide since January 2020 has been a major development. In Japan, the first wave of the infection started in March and intensified in April, pushing the Japanese Government to declare a state of emergency from April to May. Though legally not binding, the declaration requested people to stay at home and reduce social movement and activities. Conscious



Figure. NanoLSI on-linesite visit on 14 July 2020

effort by people and society led to the subsiding of new infections in May, which stayed low in June. After the reopening of movement and activities in early summer, however, the infections spiked three-fold in August and again in November.

The activities of the WPI centers have been seriously hampered by the pandemic. With university campuses closed from spring to summer, experimental research requiring on-site accesses had to be slowed down, albeit theoretical research which could be conducted on-line was less affected, and efforts toward publication accelerated. The circulation of researchers between the centers and overseas institutions became difficult as travel across national borders became restricted. Conferences and symposia, vital for interaction between researchers worldwide, had to be cancelled or postponed. Nonetheless, the WPI centers coped with the situation in a spirit of innovation. To cite just a few examples, hiring of postdocs prior to their arrival or "en passant," providing short-term positions for postdocs who cannot start their new appointments elsewhere in the world, was initiated, and symposia moved on-line attracted surprisingly large attendances.

The period from summer to fall is usually the busiest time for the WPI Program. Due to international travel restrictions and health safety concerns, all site visits in the summer and

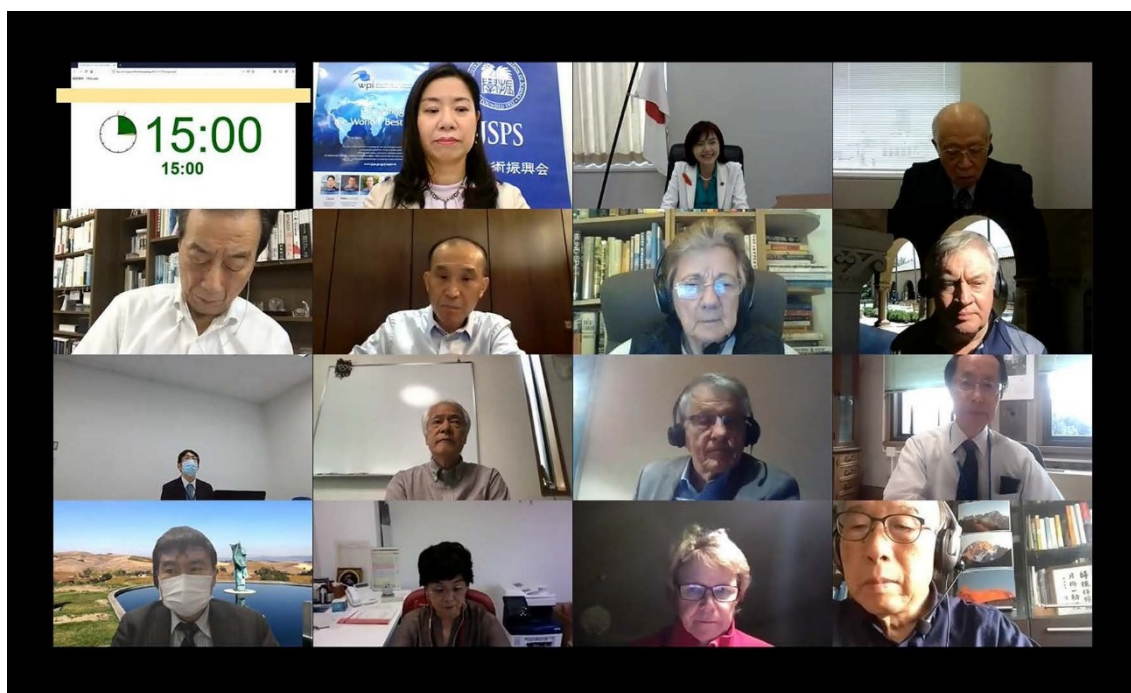


Figure. On-line Program Committee on 13-14 October 2020

the Program Committee meeting in the fall were held on-line. As Japan, America and Europe are 8 to 10 hours apart in time zones, and since the overseas participants in meetings and site visits are distributed across the three regions, 2 to 3 hours was the maximum time practical for each day's meetings. Even then, arranging the timing of the meetings was a challenge. In spite of the difficulties, all site visits and the Program Committee meeting were fully attended by the overseas members, and fruitful discussions were carried out.

E. Future plan of the WPI Program

At last year's Program Committee's November meeting, MEXT presented a mid- to long-term plan for the WPI. The Committee offered comments and advice regarding it, and requested MEXT's strong and sustained support for the WPI so as to allow it to continue making unique contributions toward the further development and elevation of Japan's research environment. (See last year's 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 Program Committee's October meeting, Mr. SUGINO, Director General of Research Promotion Bureau of MEXT, presented a future plan consisting of 3 parts:

- (1) Formulate "New Missions" of the WPI with a view to the next decade,
- (2) Select new WPI centers in a periodic and planned fashion,
- (3) Take initiatives to maintain and strengthen the WPI Academy centers.

Building upon the numerous remarkable achievements guided by the WPI's four missions, *i.e.*, science, fused research, globalization, and system reform, MEXT held discussions with WPI stakeholders in formulating new missions for guiding the WPI into its next decade of development. These new missions include upgrading of the existing four missions and adding a new one, adding a "Values for the Future" concept, which includes advancing human-resource development by linking the WPI centers to higher education, and ensuring the sustainability from the 11th year onward. While incorporating in its plan the importance of diversity, a viewpoint emphasized by the Program Committee, MEXT finalized the new missions, along with perspectives on their implementation and evaluation criteria, as follows:

New Missions, Perspectives, and Evaluation Criteria

Mission	Perspectives	Evaluation Criteria (Examples)
● World-Leading Scientific Excellence and Recognition	<ul style="list-style-type: none"> • The Highest Level of Research Impact • Expanding Knowledge Frontiers through Interdisciplinarity and Diversity 	<ul style="list-style-type: none"> • Research Impact; Comparison with benchmark institutes; Impact Factors, Citations (Top 1%/10%) • Metrics derived from research fronts (highly-cited papers clusters) • Diversity of center personnel (in terms of internationality and gender) • [Narratives regarding scientific achievements]
● Global Research Environment and System Reform	<ul style="list-style-type: none"> • Harnessing Talent and Potential through Global Brain Circulation • Interdisciplinary and Inter-organizational Capacity Building • Effective, Proactive and Agile Management 	<ul style="list-style-type: none"> • International collaborations; Top researchers/Postdocs exchanges; World-class research meetings; Presence of foreign researchers • Disciplinary diversity of research environments and outputs (teams, articles, journals) • Host institutions' efforts for making system reforms • [Narratives regarding practices]
● Values for the Future	<ul style="list-style-type: none"> • Societal Value of Basic Research • Human Resource Building: Higher Education and Career Development • Self-sufficient and Sustainable Center Development 	<ul style="list-style-type: none"> • Societal impact of social sciences and natural sciences • Rolling out the best practices; Contributions to higher education reform • Branding strategy for the WPI program and host institutions; Outcomes of outreach activities • [Narratives regarding practices]

In conjunction with the adoption of the new missions, MEXT plans to adopt and launch new WPI centers in the coming years. In FY 2021, one new center is to be launched through an open call. The center aims to be a top world-level center for advancing basic research in ways that fuse research domains, in order to deepen international brain circulation considering the impact of COVID-19. In FY 2022 and onward, MEXT aims to adopt a number of new centers at set intervals solicited through open calls so as to give potential applicants a framework for planning their proposals in advance.

The WPI Academy centers will continue to be regarded as valuable assets within Japan's science and technology policy, and their knowledge, know-how and achievements on system reform are to be shared throughout Japan's science community. MEXT is currently considering a mechanism for building a world-class research infrastructure in Japan by establishing a world-class research fund for universities.

F. Follow up on Kavli IPMU, launched in 2007

Center director: OOGURI Hiroshi

Program officer: SANDA Ichiro, Nagoya University

1. Scientific achievements

Through its effort to understand the universe, Kavli IPMU has revealed the greatness of the value created by science. In doing so, Kavli IPMU has renewed the research culture of Japan. Such achievements make Kavli IPMU an outstanding WPI institute.

2. Implementation as WPI center

Interdisciplinary research:

- Interdisciplinary activities are well embedded in the institute. It is great to see that their world-class science conducted by fusing disciplines has led to new approaches in solving big problems.
- Kavli IPMU is continually searching for new opportunities. Just to mention one example, they have used X-ray expertise from astronomy to develop a new technology for in vivo imaging of cancer cells.

Internationalization:

Kavli IPMU maintains a high global reputation with its excellent scientific output. Internationalization of Kavli IPMU is obvious. Nearly 50% of full-time scientists, fully paid by Kavli IPMU, are foreign citizens. As for students, three Oxford students, for example, have worked at Kavli IPMU and received their Ph.D. in 2019. Two will receive their Ph.D. degrees in 2020. One is expected to receive his Ph.D. in 2021. Another student arriving from Oxford is expected to receive hers in 2022.

System reform:

- The Director should be commended for being proactive in making changes to improve the center's culture and working environment. The Program Committee (PC) is happy to see that The University of Tokyo (UT) is following the Code of Conduct and Diversity set up by Kavli IPMU.
- The success of Kavli IPMU has convinced the Government to allow universities to issue bonds secured by their knowledge creation efforts. Both the President of UT and Kavli IPMU should be congratulated for this breakthrough success.
- The PC hopes that other Japanese universities will follow suit. This would indeed revolutionize the way research is being done in Japan.

3. Efforts toward sustainability

- UT will keep its financial support for Kavli IPMU at the present level. This implies 26 permanent positions for scientists, about 34 administrative staffs, and yearly funding of approximately US\$10 million.
- Encouraged by this UT support, Kavli Foundation decided to increase its endowment by another \$10 million.



Figure. The Kavli Foundation of the United States, which supports for sustainable Kavli IPMU, receives the University of Tokyo's Shokumon Award.

(From left, first row): University of Tokyo Executive Vice President and Vice President Teruo Fujii, President and CEO of the Kavli Foundation Dr. Robert Conn, University of Tokyo President Makoto Gonokami, Kavli IPMU Director Ooguri Hiroshi; (From left, back row): Kavli IPMU Deputy Director Tomiyoshi Haruyama, General Manager Isao Uehara. (Credit: The University of Tokyo)

4. Actions required and recommendations

- (1) Kavli IPMU maintains a very good relationship between the university president and other university management teams. It has contributed to UT by offering ideas for system reforms, as well as improving UT's international position. The PC would like Kavli IPMU to maintain a close relationship with the new president, who will take office in the spring of 2021.
- (2) Japan's copyright law prevent Japanese academia from quickly releasing lecture materials to the public on line. This is a university issue, and its management must solve this problem quickly.

- (3) Diversity initiatives are an important step for improving any organization. Kavli IPMU's initiatives should be a role model for UT as well for other institutes and companies.
- (4) Some organized effort should be taken by Kavli IPMU, UT, and MEXT to imbed the successes achieved by Kavli IPMU in the way research is done in Japan.
- (5) Kavli IPMU still needs to address the issue of the gender balance as few of its PIs are female.

G. Follow up on the 3 Centers launched in 2012

G-1. IIIS

Center director: YANAGISAWA Masashi

Program officer: KAIBUCHI Kozo, Nagoya University

1. Scientific achievements

The quality of science is excellent. IIIS is one of the leading sleep research institutes in the world. Investigations range from basic biology to pharmaceutical science and experimental medicine. They discovered the potent OX2R selective agonists, and confirmed its anti-narcoleptic effects in a murine narcoleptic model. They found a group of neurons in the hypothalamus whose forced-activation induces a hibernation-like state in mice (Takahashi et al., Nature, 2020). This finding opens up an avenue for developing the induction of a hibernation-like state including in humans.

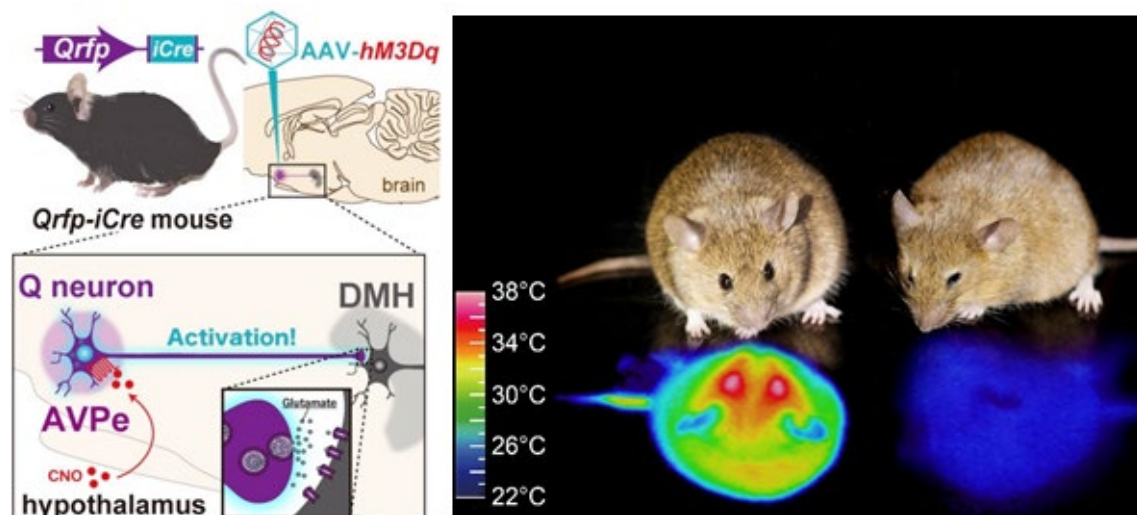


Figure. Of the two mice, Q neuron-induced hypometabolic/hypomobile (QIH) state is induced in the mouse on the right side showing low body temperature.

2. Implementation as a WPI center

Interdisciplinary research:

IIIS has done a good job at catalyzing the fusion of fields, including basic biology, experimental medicine, and pharmaceutical science, to produce sleep science. IIIS is fully meeting WPI standards for delivering world-class research results that reflect new “fusion” between disciplines. The expansion of its core mission to include hibernation-like state as well as regular sleep is an excellent indication that the center will continue to evolve in a sustainable fashion.

Internationalization:

IIIS has a world-class international reputation. IIIS has successfully developed a very international research environment with scientists and trainees from outside Japan. This is credited to the director and his relationship with the University of Texas Southwestern Medical Center. However, the concentration of satellite PIs in UT is too restricted. Recently, a new collaboration agreement with Q. Liu of the National Institute of Biological Sciences, Beijing is making good progress.

System reform:

The basic concept of IIIS's organization and operation involves creating a new style of research center by learning from the merits and virtues found in the organization of "departments" in major US universities. So far, these efforts have been successful.

The ripple effect on other departments of the host institution is not great so cannot be highly appraised, especially with regard to the US style. It remains to be seen whether IIIS will broadly reform University of Tsukuba.

3. Actions required and recommendations

The plan for post-WPI funding is still a bit weak. The overall mix of post-WPI funding sources seems like a realistic projection, although it is rather highly leveraged on large competitive projects (e.g. the Moonshots). They need to be working more at the present time to increase funding from collaborative projects. Relationships that produce funding through collaboration take a long time to build up.

It will be important for quality and branding purposes to find ways to involve industry more, although the percentage of industry-funded (collaborative) projects may remain modest. Even before the end of the WPI term, they will need to show more active involvement with industry, e.g. as partners (and funders) in collaborative research or in "affiliate program" membership frameworks.

Toward giving qualified PIs tenured appointments, University of Tsukuba has proposed resource redistribution and made draft budget requests to MEXT for the appointment in IIIS of a few qualified PIs. However, only three tenure positions including director and vice director are currently secured by the university. IIIS has proposed acquiring governmental grants and using them to cover PI labor costs for the time being, but this is not deemed to be appropriate.

University of Tsukuba should consider resource redistribution to provide IIIS with more than

ten tenured positions. Otherwise, some PIs, especially young and talented PIs, will leave IIS before the WPI program term ends.

G-2. ELSI

Center director: HIROSE Kei

Program officer: MIYAMA Shoken, Hiroshima University

1. Scientific achievements

ELSI has globally established itself as one of the foremost institutions in the origin of Earth and life research. ELSI is the only real research institution working on astrobiology in the world. The high quality of ELSI's science is evident from the large number of publication (184; 2019 Jan – Dec) and the high rate of papers published in high-ranking top journals (60 in Nature Index Journals).

One of the highlights of its recent research is the formation of the Uranus rotation axis and the satellite orbital plane, which are offset by 98 degrees from the Uranus orbital plane.

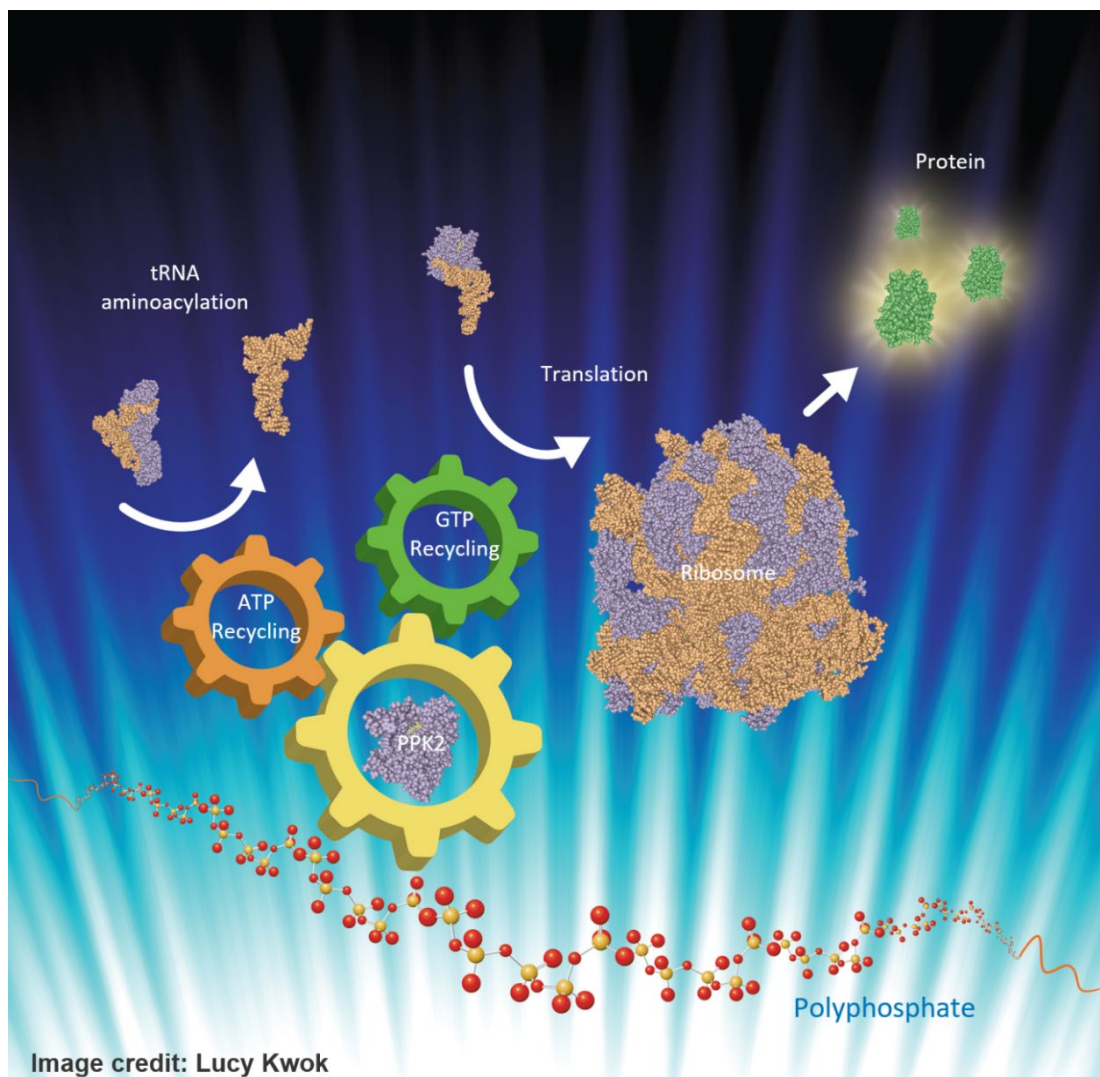


Figure. ATP and GTP are regenerated using polyphosphate

(Nature Astronomy, 2020). In the field of life science, Drs. Wang, Fujishima and MacGlynn et al. have shown that ATP and GTP are regenerated using polyphosphate by a single enzyme, which is able to drive translation in a cell-free system (ACS Synbio, 2019). Polyphosphate can be produced in abiotic settings including volcanic production, and so can be one of the plausible energy molecules on early Earth.

2. Implementation as a WPI center

Interdisciplinary research:

In ELSI, the fusion of different research areas is basic and essential in advancing their research work. The fusion of planetary science and physical chemistry has shown that inner seas are universal for planets and satellites in the outer solar system. PI Sekine et al. investigated Pluto and identified an insulation mechanism that may prevent a subsurface ocean from freezing. This would bring about a dramatic increase in the number of habitable worlds in space (Nature Geosci., 2019).

Internationalization:

The recent boost in ELSI's international public relations has increased its international recognition. ELSI has increased the quantity and quality of its press releases, not only Japanese but also English (from 17 in 2018 to 32 in 2019), allowing overseas media to pick up ELSI's research stories (in all 430 in 2019).

System reform:

Using ELSI as a model, the President of Tokyo Tech is constructing, establishing, and developing a flexible research system that is not bound by conventional rules or operating systems. Tokyo Tech has also established an English-based consultation desk and a counseling office within the university to strengthen the supportive environment for foreign researchers. President Masu emphasized Tokyo Tech's commitment to supporting ELSI with 10 PI positions.

3. Actions required and recommendations.

ELSI should clarify to what extent the questions and assumptions in its original roadmap have been answered and confirmed by the center's research. This will be crucial in bridging the Earth and Life research in ELSI's first decade across to the research plan for its second decade and beyond.

ELSI should also provide more concrete and detail strategies regarding its universal biology

project, which is one of the center's future plans. Center director Hirose states that universal biology includes studies on artificial cells, machine learning and artificial intelligence; however, the Program Committee wonders whether such universal biology will be a proper target in ELSI's future plan.

The Program Committee would also like to hear a clear and concrete plan regarding the management of ELSI after the end of WPI funding. Important issues are: the directorship of ELSI, the outlook for funding, the composition and number of researchers, and the position of ELSI within Tokyo Tech.

G-3. ITbM

Center director: ITAMI Kenichiro

Program officer: HAMACHI Itaru, Kyoto University

1. Scientific achievements

ITbM continues to produce research outputs at an excellent level in its flagship areas: plant chemical biology, chemical chronobiology, and chemistry-enabled live imaging. Based on its large number (227 papers, January 2019 - June 2020) of publications in high-ranking journals (Science and Nature sister journals etc), it is evident that ITbM's science is of exceptional quality. The record of competitive research funds granted to ITbM's research members is remarkably high. In one of ITbM's main project that attempts to combat the parasitic plant *Striga*, their most promising molecule (super-strigolactone: SPL7) was transported to Kenya where a field test was initiated in tight cooperation with a Kenyan institute (KALRO). ITbM has also discovered a new molecule, Celastrol that can rescue winter-depression like behavior. In addition, ITbM has

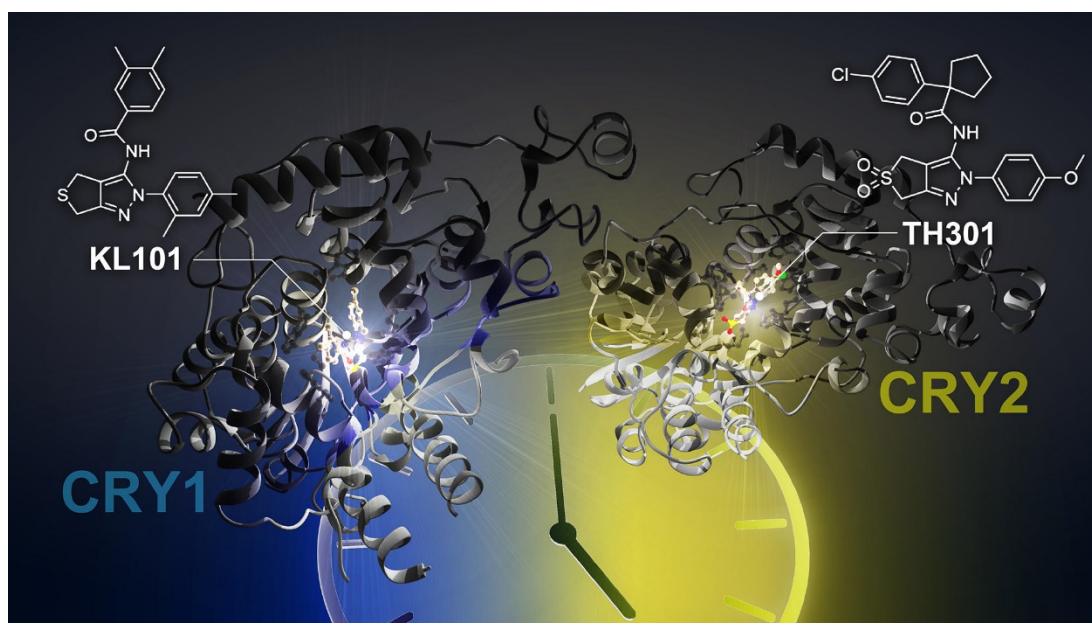


Figure. ITbM developed new small molecules KL101 and

developed many other unique synthetic molecules such as stomata controlling molecules, chemicals mimicking plant hormone signaling, compounds to modulate circadian clock-related disorders/diseases, super photo-stable imaging probes for

subcellular organelle imaging, and a variety of unique nanocarbon molecules such as carbon catenane/knot and carbon nanobelts.

2. Implementation as a WPI center

Interdisciplinary research:

The Mix-lab system, which is ITbM's unique concept, has been exceptionally successful in fusing cutting-edge chemistry and biology with structural biology and computational science. Each PI has continued to carry out tight collaboration with one or more other PIs, which has produced a number of joint papers.

Internationalization:

ITbM successfully organized its EMBO workshop at Nagoya University (NU) in FY 2019 with Vice-Director Professor Higashiyama as its chairperson. It is the first EMBO workshop with experimental courses in Japan to focus on molecule visualization. Of the 13 PIs, five are from abroad (38%) and 35% of all its researchers are from abroad. Half of the administrative staff is bilingual, and its administrative office operates well as a support system for overseas researchers.

System Reform:

A number of "standard" system reforms, such as top-down governance by the director, incentives based on evaluations, and English-based administration, have already been instituted in ITbM. Its exceptional success in the top-level research and its many efforts in advancing organizational reform have led to ITbM providing a great role model for Nagoya University, one that facilitates reform of the university system. Pursuant to President Matsuo's Initiatives for Reform, Autonomy and Innovation 2020, NU launched the "Nagoya University Institute for Advanced Study (NAIAS)" in FY 2019, in which ITbM is positioned as a core research center. It is impressive that ITbM has received strong and constant support in many aspects from NU's top administration.

3. Actions required and recommendations

While overseas PIs have undoubtedly made significant contributions to ITbM's research activities, it is recommended to make further efforts to maintain and strengthen their activities at ITbM including after the WPI subsidy ends. It is also recommended to further improve the researcher gender balance at ITbM. Excellent collaboration with the four supporting centers is seen to be instrumental in achieving the remarkably high

activity and interdisciplinary research at ITbM. For ITbM's long-term sustainability, careful consideration should be given to securing tenured positions for core staffs in these research centers.

H. Follow up on the 2 Centers launched in 2017

H-1. IRCN

Center director: Takao HENSCH

Program officer: MISHINA Masayoshi, Ritsumeikan University

1. Scientific achievements

IRCN tackles the challenging question of how human intelligence arises by establishing bottom-up principles of neural circuit development, by innovating artificial intelligence based on these principles, and by unraveling mechanisms of human neurodevelopmental and psychiatric disorders.

Principal investigators (PIs) of the center have published excellent papers in high-impact journals and shown significant progress in various fields of neuroscience, computation, and psychiatric disorders.

However, there remains a gap between the neurodevelopment and computation groups.

It is critical for the center to select the most promising avenue of research, one that can demonstrate a long-term impact on “neurointelligence.”

2. Implementation as a WPI center

Interdisciplinary research:

IRCN has started a bottom-up “team science” approach to promote collaborative and interdisciplinary research and has chosen 12 themes. This is a very positive development and should be encouraged.

However, IRCN needs to establish some criteria for evaluating research in these groups and should use the criteria to focus the center’s scope.

IRCN should show a clear strategy for leveraging its findings from neurodevelopmental research in building neuro-inspired artificial intelligence.

Internationalization:

The director’s continuous initiative has advanced the formation of an outstanding international network and research environment within IRCN.

He recruited four talented PIs and also young foreign researchers. Thus, the lineup of PIs and researchers across four units is now well balanced.

IRCN has developed strong international collaborative programs, and it frequently invites world-leading scientists from abroad to its seminars and workshops.

System reforms:

IRCN has carried out an innovative reorganization of its management.

Joining the MEXT WISE graduate program will stimulate the involvement of young students in IRCN and the interaction with Kavli IPMU.

Cooperation with UTokyo's Beyond AI Institute and Neuro-Creativity Program will contribute to the next UTokyo-wide AI projects.



Figure. Whole Brain Clearing and 3D Visualization Training Course in collaboration with WISE-FoPM program

Effort to secure the center's future development:

The center has provided young researchers with independent positions.

Support from UTokyo has stimulated the center's under-one-roof organization. UTokyo has increased its support to IRCN through its new frameworks for industry-academia AI collaborations.

3. Actions required and recommendations

- (1) Because of the COVID-19 pandemic, it has become difficult for the Center Director to be physically present in Tokyo. It is, therefore, urgent to establish a system for him to be able to exert his leadership in IRCN in a remote manner while the current situation

continues.

- (2) It will be important to hire an appropriate person as the Administrative Director after Ms. Kubo stepped down at the end of May 2020.
- (3) The establishment of 12 collaborative teams is a very positive development and should be encouraged. However, it will be critical to select the most promising avenue of research, one that can demonstrate a long-term impact on “neurointelligence.”
- (4) The center’s effort to bridge the neuroscience and computation units should be strengthened. More computational work needs to be done based on the center’s biological findings.
- (5) IRCN’s roadmap is very vague. It needs to have concrete targets and timelines for key decisions. Criteria also needs to be established for how these decisions will be made.

H-2. NanoLSI

Center director: FUKUMA Takeshi

Program officer: NAKANO Akihiko, RIKEN

1. Scientific achievements

NanoLSI continues to make good and steady progress. The level of its science is of very high quality. With their cutting-edge technology of BioSPM, they have succeeded in imaging fine structures within and around living cells. New methods for functionalizing probes are also being developed. A concern still remains though as to the estimation of the perturbation of cellular activities by high-speed scanning of a probe in a living cell.

2. Implementation as a WPI center

Interdisciplinary research:

NanoLSI is working hard to achieve a fusion of disciplines, for example, consideration is being given to target molecules to be measured by nanoprobe sensors, which should be useful for tackling problems in life science. Results are not clear yet, and the center is encouraged to seek key impactful applications toward the next phase. Combining BioSPM with optical microscopy will also be very important, and the center is making progress along this line. NanoLSI should also accept bottom-up research ideas from its young researchers.

Internationalization:

The activities of the foreign PIs were not presented satisfactorily. They need to spend more physical time at NanoLSI. International joint research collaborations should also be further pursued. Even during the COVID-19 pandemic, frequent online seminars and research discussions can be held with overseas partners.

System reform:

A new graduate school "Division of Nano Life Science" has been successfully started, and the construction of the new building is almost completed as planned.

Effort to secure the center's future development:

NanoLSI will undergo its interim evaluation next year. Therefore, it should hold extensive discussions on what it aims to have achieved by then and also on its goals for the latter half of the ten-year period. Having obtained a large amount of external funds in FY 2019 is a good sign reflecting the high quality of the center's science. But longer-range perspectives and clearer and more focused strategies will be necessary for the center's

future development.



Figure. NanoLSI new building (completed in Sep, 2020)

It has already been ensured that NanoLSI will be an independent institute in Kanazawa University. Securing junior PI positions will be very important for the center's sustainability in the future. It is good that President Yamazaki has promised to give these researchers tenure after their tenure-track period.

From the viewpoint of diversity, the low enrollment of female researchers in the center, especially at the PI level, is a serious problem. Considering the directions in which NanoLSI is going, more female scientists need to be involved.

3. Actions required and recommendations.

While the achievements and efforts made by NanoLSI are appreciated, the center will soon need to summarize its achievements of the first five years and propose strategies for moving forward towards its final goals. Creating a strategic plan and roadmaps for the latter half of the funding period and beyond will be most critical. At the same time, the center is encouraged to sharpen even further its fundamental technologies of BioSPM, which are already world-class.

As mentioned above, there is room for improvement regarding the fusion of disciplines, internationalization, and diversity. In particular, many members of the Program Committee pointed out the inappropriate gender balance at NanoLSI. The center should seriously

consider ways to improve this situation, and is requested to present a concrete plan for doing so.

I. Follow up on the 2 Centers launched in 2018

I-1. ICReDD

Center director: MAEDA Satoshi

Program officer: TATSUMI Kazuyuki, Nagoya University

1. Scientific achievements

Seven flagship projects have been established to provide concrete targets for research based on the conceptual focus formulated in Center's four flagship research areas. Substantial developments have been made through fruitful collaborations, and the quality of ICReDD's science has been elevated to a level required for the Center to thrive. The center is becoming internationally visible through research publications of high quality. Focus on the highest quality of Center's research needs to continue as there are signs that a number of its programs have now significant potential to make important additional discoveries.

Achievements that deserve mention are: 1) development of "remote" C-H functionalization catalysts with carboxylic amides as receptor ligands with the aid of AFIR-derived "QCaRA" search, 2) development of solvent-free mechanochemical reactions, 3) progress in the research into rapid induction of cancer stem cells by certain hydrogels, and 4) synthesis of the Eu (III) complex as an effective photosensitizer with bright-luminescence.

2. Implementation as a WPI center

Interdisciplinary research:

ICReDD has set up a mix-office, mixed labs, and the ICReDD salon, where researchers from different fields can gather to incubate ideas for new fusion research. Start-up support has been established to promote interdisciplinary bottom-up projects. Fusion Seminars, Stirring Seminars, Tutorial Seminars, and Seeds/Needs Seminars have been held frequently on a regular base. The center's mission and research objectives are now shared well among the center members, leading to the seven flagship projects, all interdisciplinary and unique to ICReDD.

Strong synergies developing between computational science and experimental science have led to research publications of high quality. However, cheminformatics and data -driven approaches to chemistry are not being exploited to their full extent. Fusion of chemistry and information science needs to be further integrated into the Center's research projects.

Internationalization:

ICReDD now has 22 foreign nationals (37%) among its 57 researchers. This and the establishment of the mix-office and mix-labs has helped to upgrade the center's international research environment. Some improvement has also been made in its global outreach activities.



Figure. Automated chemical synthesizer designed for organic synthesis, which can quickly validate new chemical reactions, at ICReDD Mix-Lab

However, the majority of its postdoctoral researchers are not yet coming from top institutions. This situation has not changed very much from last year. The Center must become a first class location for attracting highly talented young researchers from top institutions throughout the world. Further strengthening of the Center's international networking will be needed to ensure its long-term impact within the international community. Inviting established scientists with high international reputations would increase the Center's worldwide visibility.

MANABIYA is moving ahead, but has not as yet been satisfactorily established. It still appears to be a school for teaching AFIR, and has not yet been elevated to a platform for creating international/domestic research collaborations.

System reforms:

The Center needs to improve its diversity, especially its gender balance at all levels including its Advisory Board. ICRéDD also needs to establish a clear internationalization plan that can work to enhance its research activities.

Many layers of committees have been set up, e.g., Steering Committee, Executive Committee, PI meeting. The Center Director should maintain his strong top-down management approach using these committees for advice. The establishment of the Future Planning Working Group should allow more strategic thinking under the leadership of the Center Director. These committees need to have at hand terms of reference.

The appointment of the Executive Director is a very positive step toward strengthening both the administration and execution of research at ICRéDD.

Effort to secure the center's future development:

It is desired that strong communications be established with the new University President, for example by holding regular and frequent meetings between the President and the Center director so as to make prompt and effective decisions on the future development of the Center.

The acquisition of a sizable amount of external funds by the PI's is indicative of the high quality of research at ICRéDD. The PI's and all members of the Center need to continue these efforts during and after the period of the WPI project.

In addition to securing the 2,600 m² research space in the CRIS building, Hokkaido University is making a budget request to the Ministry of Education and Science for a new building adjacent to the CRIS building.

3. Actions required and recommendations

- 1) The Center needs to improve its diversity at all levels of its researchers and committees by recruiting more foreign and female researchers.
- 2) It is recommended that the Center recruit new PI(s) at an appropriate opportunity, preferably young researcher(s) from abroad who can carry out research in Sapporo.
- 3) The three academic PI's from outside of Japan need to be encouraged and aided by all the PI's in Sapporo to further integrate their projects across the Center.
- 4) The Center needs to make every effort to establish itself on the international scene as a

place that international postdocs from international top institutions want to be.

- 5) Information science should make a stronger contribution to ICRéDD's research. In order to take advantage of the rapid progress being made in quantum computation technologies, ICRéDD may wish to increase its external exchanges with major new projects such as the Japanese National Project on Quantum Information Sciences and the European Commission's "Quantum Flagship" project.
- 6) To establish and strengthen the leadership of the Center Director, continuous efforts should be made to assemble a strong administrative/scientific team.
- 7) The advisory board should be activated, and a system established through which the Center Director and ICRéDD obtain useful advice at regular intervals from the board.
- 8) Regarding the MANABIYA system, it is urgently required to clarify how it is to be managed and how to link it to the graduate school systems of Hokkaido University.
- 9) Securing more lab space is an urgent matter; the construction of a new building is highly desirable.
- 10) Strong support from Hokkaido University is essential for securing the sustainable development of ICRéDD. Close communication with the new University President should be established as soon as possible and be regularly maintained.

I-2. ASHBi

Center director: SAITOU Mitinori

Program officer: OKANO Hideyuki, Keio University

1. Scientific achievements

Both the quality of ASHBi's science and of its publication are excellent. In particular, its basic science on developmental biology and cancer etiology are of global top-level significance. However, their approach does not challenge the boundaries of traditional disciplines. Furthermore, the alignment between research conducted and ASHBi's five stated goals is less clear, and has not been capitalized on to encourage fusion research. Thus, ASHBi can do better by starting flagship projects aligned with each of its five goals, thereby creating opportunities to further advance its fusion research.

2. Implementation as a WPI center

Interdisciplinary research:

ASHBi's fusion science has greatly advanced and their approaches have become much clearer than before. It should also be pointed out that Mathematics is merely being used as a tool in the fusion of Biology and Mathematics. True fusion should have an impact on the field of Mathematics as well.

Given the unique strength of the non-human primate (NHP) genetically engineered model developed at ASHBi, it is disappointing that the center has not linked itself closer to clinical research. The center's collaboration with the medical/clinical community is limited and not strategic; it is not taking advantage of their unique NHP genetically engineered models and its proximity to medical school/hospitals to study human diseases.

Internationalization:

ASHBi is severely behind in its effort to bring in foreign researchers and promote diversity within its research force. It is barely meeting the criteria for WPI centers and may fall below the criteria in the next year if there is no improvement in the situation. ASHBi should take a more aggressive approach to increase its international visibility as well as its direct collaboration via online seminars, workshops, etc., even during the COVID-19 pandemic.

System reform:

ASHBi is receiving good support from Kyoto University. In addition to the new physical facilities, it was great to know that the University is allowing ASHBi to “keep” the indirect cost reimbursement funds included in its grants. Despite these efforts, however, its ripple effect on other departments of the host institution is limited.



Figure. Online press release under the COVID-19 pandemic

Effort to secure the center’s future development:

Kyoto University’s commitment is improving by providing more independence to the two WPI centers, including ASHBi. The university has contributed to the sustainability of ASHBi starting with 2 tenure positions for young PIs in 2019 and 2020 and plans to provide additional tenure positions. However, more detailed plans will be needed to provide ASHBi greater future independence.

3. Actions required and recommendations.

- (1) We don't want ASHBi to be an organization where excellent scientists merely use common equipment and facilities. We strongly hope that scientists from different fields will always share their problems toward opening up new academic fields and obtain synergistic effects. Young PIs will become more aware of the value of ASHBi’s organization and contribute to its enhancement by being actively involved in its operation.

- (2) ASHBi should set up flagship projects in each of its 5 lines of key research goals with an aim to promote human biology, clarify principles defining species differences, generate NHP models for human diseases, reconstitute human cell lineages or tissues, and contribute to formalizing an international ethics standard. It should explain how each of its key published papers has addressed ASHBi's 5 goals.
- (3) Also, more thought needs to be put into how ASHBi is going to answer or more completely address key questions: What key biological traits make us human? How can knowing these traits lead to better cures for diseases? In such ways, a basic understanding of Human Biology should be able to be applied to clinical research in the future, such as disease-oriented research.
- (4) The center's goal of contributing to formalizing an international ethics standard seems to be only connected to stem cell research. This seems to be too narrow since there are so many more important questions in the area of ethics.
- (5) Given the great amount of work that is involved in the genetic engineering of non-human primates, it is important for the center to have a systematic process for selecting the genes to be investigated.
- (6) Internationalization of ASHBi is below the WPI standard. Foreign PIs are fewer than 20%. This situation must definitely be improved.
- (7) ASHBi is severely behind in promoting diversity within its research force. It must develop a plan going forward to increase diversity at all levels.

J. WPI Academy

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. The first five "WPI Academy centers" are AIMR, Kavli IPMU, iCeMS, IFRc, and MANA. They are certified as having reached "world premier" status by the WPI Program Committee. Among them, Kavli IPMU has received extended WPI support for another five years in recognition of its exceptionally outstanding achievements.

In FY 2020, I²CNER became the 6th member of the WPI Academy having been certified by the Program Committee to have achieved "world premier" status.

Follow up of WPI Academy Centers

A site visit to I²CNER by AD, AO with PD and DPD was carried out in December. The findings were as follows.

I²CNER

I²CNER is a permanent institution that forms the core of Q-PIT, Kyushu University Inter/Transdisciplinary Energy Research. The new President Ishibashi and Executive Vice President in charge of research Hisaeda confirmed that the university is providing the center strong support in terms of personnel, research facilities, and funding.

The University of Illinois's Board of Trustees endorsed the continuation of I²CNER Satellite Office at Illinois in the Grainger College of Engineering (GCOE) and the Dean of the GCOE endorsed the continuation of Prof. Sofronis as the director of I²CNER. I²CNER's research organization has been restructured from 8 divisions into 3 Thematic Clusters (Energy materials, Energy systems, Energy future and environment) and 2 Platforms (International collaboration, Social implementation).

The number of PIs has remained roughly the same, including the number of PIs from abroad, while the number of postdocs has somewhat decreased. The center's securing of external funding has been quite robust including a "Moonshot" project on global CO₂ recycling technology awarded in 2020.

Global brain circulation is being boosted by hiring junior researchers in the Center's Platform for International Collaboration. The center's research output remains high both in terms of quality and quantity. Overall, I²CNER has successfully executed its transition from a WPI-funded to a self-sustained WPI Academy center despite difficulties caused by the COVID-19 pandemic.

K. Branding and outreach

Due to the rapid spread of COVID-19 since January, much of the branding and outreach activities of the WPI has had to go on-line this year.

The 4th Symposium of Research University Consortium, co-sponsored by the WPI, was held on-line in November on the theme "Toward accelerating research power through novel research style under the COVID-19 pandemic." Panel discussions were conducted on 3 themes: International brain circulation in the age of the new coronavirus, Successful research support under the COVID-19 pandemic, and Issues and perspectives of novel dissemination of research information. Several WPI researchers and URAs participated as moderators and panelists providing perspectives from a WPI vantage point.

In December, "WPI Symposium 2020 for high school students" was held on-line. Not unlike in-person gatherings, physical distance between participants and venues is not an obstacle

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Figure. Main visual of WPI Symposium 2020 for high school students

in such on-line meetings. To the delight of the WPI organizers, over 300 students and teachers from 37 prefectures across Japan and overseas participated in the event, enjoying lectures by 13 young researchers from WPI centers and Q&A sessions. The annual WPI Science Symposium for the general public is also planned to be held on-line in February.

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. The “On-site experience” page of the site conveys stories of how innovative research support works to push forward top science at WPI centers, while the “WPI stories” page provides a popular account of remarkable scientific achievements at WPI centers as well as the scientists who advance them. Making full use of this website to announce events such as those introduced above, WPI Forum aims to attract the interest of an ever-wider audience to the WPI.