Japanese Universities Gain a Competitive Edge

Twenty-two academic institutions have been chosen to enhance Japan's ability for cutting-edge science and technology and keep Japan competitive among the world's top universities. The recruitment of high-quality researchers from overseas, revising university management, and improvements in global visibility are the major challenges ahead for the group of 22 institutes. ***By Adarsh Sandhu***

Initiating a nation-wide effort to boost Japan's scientific landscape, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has launched the Program for Promoting the Enhancement of Research Universities, which exemplifies new trends in research funding in Japan. Twenty-two academic institutions have been singled out from the hundreds of Japanese universities and institutes to lead Japan's efforts to stay at the forefront of science.

These now-elite institutions were chosen via a nontraditional, top-down selection process—a rarity for these types of initiatives in Japan. The funding process is simple: set strategic research targets and priorities, conduct preliminary surveys for potential researchers and institutes most likely to achieve the goals, and provide generous funding to small numbers of top scientists for long periods of time. Representatives from the smaller and newer institutes assert that this unusual metrics-based assessment has enabled them to take on projects that would be unheard of with the traditional bottom-up, proposal-based funding procedures, which can favor larger universities.

After being awarded the prestigious status and funds, these 22 universities are now responsible for developing Japan's scientific infrastructure and making the necessary infrastructure-related reforms to strengthen their research portfolios. This includes hiring research administration managers, recruiting top researchers from overseas, and analyzing global scientific trends in order to formulate new research strategies. The financial support to accomplish these goals ranges from US$2 million to US$4 million annually for 10 years, with a midterm assessment after five years that promises funding cuts in cases of poor performance.

The institutes selected (Table 1) include well-established former Imperial Universities (Hokkaido, Tohoku, Tokyo, Nagoya, Osaka, Kyoto, and Kyushu) as well as three smaller, newer institutes (the University of Electro-Communications, Toyohashi University of Technology, and Nara Institute of Science and Technology) and two large, research-based private universities (Keio and Waseda).

Intriguingly, despite having produced the largest number of Nobel Prize Laureates in Asia, Japan is not well represented in world university ranking tables. For example the *2013–2014 Times Higher Education World University Rankings* lists only two Japanese universities in the top 100, on par with Singapore, but behind South Korea and China with three each.

This lack of visibility and representation in world rankings is a source of considerable discussion in academic circles in Japan. Many of the 22 universities have declared that part of the funding from the MEXT program will be used to pull their institutes into the top 10 of the rankings tables by the end of the 10-year program, with others aiming for a more modest goal of being within the top 100.

Some of the major challenges these universities will be faced with overcoming are: the low birth rate that has led to major decreases in the number of high school children qualified to enter university; severe constraints on research funding for universities, and the need for greater internationalization and visibility.

THE DEMOGRAPHIC LANDSCAPE

Japan's coffers are feeling the pinch. As of May 2013 there were approximately 770 universities in Japan: 86 national institutes, 83 prefecture or city-run, and 601 private. They all rely on government subsidies to run education and research programs. Financing university education and research is putting a huge burden on government resources that are also being strained by increases in medical costs due to the rapidly aging population (24.1% are over 65 years old), the costs for reconstructing the Tohoku region following the devastating earthquake and tsunami in 2011, and demands for investment in trillion-yen international "big-science" projects.

Government subsidies are crucial for the majority of universities to exist. The falling birthrate in Japan has led to excess capacity within the education system, causing an increase in bankruptcies of private universities and forcing national universities to introduce early retirement plans to reduce personnel costs.

The MEXT program sends a clear message to university administrators that MEXT cannot continue to subsidize all the universities in Japan. Future funding for research will be limited and based on objective statistics, such as citations, revenue from technology transfer, and international rankings. This funding must be used to improve university infrastructure, hire top researchers and managers, and engender innovation to improve Japan's global competitiveness in science.

UNIVERSITY MANAGEMENT

In 2004, the Japanese government overhauled the management of national universities by introducing a more corporate-like structure and giving presidents (elected by faculty) more autonomy to hire staff, determine salaries, and set long-term goals for education and research. Furthermore, MEXT started reducing government financial support to national universities by 1% per year. This has led to financial dilemmas for universities that are unable to fill the resulting funding gap with other sources of income.

Another common theme is revamping the role of university research administrators (URAs) to undertake a multitude of tasks including supporting researchers in procuring funding, interacting with industries to license university intellectual property, and analyzing trends in research themes to devise strategies for future, unexplored areas of research. Some universities plan to hire as many as 40 URAs as part of the program in order to take some of the administrative pressure off research faculty. More senior URAs will likely be recruited from the private sector, but many universities will tap into the postdoctoral pool, training them as part of new URA career paths. It's notable that Japan has a huge number of postdocs looking for permanent posts, particularly in the life sciences.

Table 1. Universities and research institutes selected for the MEXT Program for Promoting the Enhancement of Research Universities. (Numbers indicate annual funding in millions of Yen.)

Hiroshima University (300)
Hokkaido University (200)
Kobe University (200)
Kumamoto University (200)*
Kyoto University (400)*
Kyushu University (300)
Nagoya University (400)*
Nara Institute of Science and Technology (300)*
Okayama University (200)*
Osaka University (300)
Tohoku University (400)
Tokyo Institute of Technology (300)*
Tokyo Medical and Dental University (300)
Toyohashi University of Technology (200)*
University of Electro-Communications (300)*
University of Tokyo (400)
University of Tsukuba (300)*

Private Universities
Keio University (200)*
Waseda University (300)*

Other Institutes
High Energy Accelerator Research Organization (300)
National Institute of Informatics (300)
National Institutes of Natural Sciences (300)

*universities featured in this advertorial

INTERNATIONALIZATION

The projects in the MEXT program contain some common themes and goals. The universities have all made internationalization or *kokusaika* one of their highest priorities. *Kokusaika* has different meanings to different people. Here the interpretation is to increase the number of overseas researchers and students, and improve international collaboration by implementing various plans: increasing accommodation facilities for overseas researchers, introducing English language courses for students, training administration staff to produce bilingual documents, and introducing new salary scales commensurate with institutes in the United States and Europe.

So what are the challenges in hiring foreign staff? Short-term stays in Japan for young researchers can be highly rewarding and valuable for boosting their later employability, but establishing a long-term career may be more challenging due to potential family-related issues such as securing a job for a spouse and a good education for accompanying children.

The Japanese language can also be a stumbling block. Foreign researchers may feel isolated and conducting independent research can be extremely taxing; simple exercises such as ordering equipment and taking part in departmental meetings are difficult without reasonable proficiency in Japanese. Even with excellent language skills, foreign academics are unlikely to be awarded top positions such as dean and president in Japanese academia.

The emphasis on *kokusaika* reflects concerns about Japanese researchers becoming too inward looking. Several years ago journalists coined the term "Galapagos Syndrome" to describe the situation, exemplified by highly advanced Japanese mobile telephones that were incompatible with systems in other countries and thus globally irrelevant.

Improving global rankings and attracting top-class foreign researchers are two of the main challenges ahead as the MEXT program moves forward. Needless to say, project managers are well aware of them and have no doubt devised solutions to resolve these issues to achieve their goals. Only time will tell if the 22 institutes will each achieve their goal of becoming globally competitive. The main issue will be the degree to which Japan's academic community is recognized for its contribution to the global creation of knowledge. Perhaps this is the true meaning of *kokusaika*.

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Toyohashi University of Technology

"Value Creation Engineering" for New Industries

President Yoshiyuki Sakaki

Vice President Makoto Ishida

Toyohashi Tech Campus Buildings

"Our research and education has been recognized through the receipt of three major project awards this year," explains **Yoshiyuki Sakaki**, president of Toyohashi University of Technology (Toyohashi Tech). Sakaki is a molecular biologist who was chosen as a Person of Cultural Merit in 2013 by the Japanese government. The three projects are: the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities; the Program for Leading Graduate Schools on Brain Information Architects; and a joint project to establish an overseas campus in Penang, Malaysia.

Toyohashi Tech was established approximately 38 years ago. With about 2,000 students and 200 faculty members, it is one of the smallest national universities in Japan. "A little giant, comparable in size to Caltech in the USA," says Sakaki. "Being selected for the MEXT program is a like a shot of adrenaline for our researchers; we're very excited about it!"

Sakaki notes that the selection procedure for the program was top-down and based on independent objective metrics, such as citations, royalties from patents, and research funding grants received. "Toyohashi Tech was selected as one of 22 outstanding research universities and research institutes," continues Sakaki. "This acknowledges our research to date, and the contributions of the Electronics-Inspired Interdisciplinary Research Institute [EIIRIS], the engine driving research at Toyohashi Tech" (see sidebar below).

OBJECTIVES OF THE PROGRAM

"In our projects we will devise methods for creating positive value from nominally negative assets," explains **Makoto Ishida**, vice president of Toyohashi Tech and the person in charge of research. "For example, using waste to create valuable assets, such as biofuels, and extending the functions of our imaging devices to universal self-diagnosis health care biosensors. We refer to this as Value Creation Engineering."

The Value Creation Engineering project will be managed by the Research Administration Center—set up in December 2013—which includes the University Research Administration Office.

The creation of new industries is one of the major objectives of the Toyohashi Value Creation Engineering project. "Our university has an excellent record in technology transfer," explains Ishida. "We want to build on this by linking up with global partners to generate ideas for new innovative industries." Toyohashi Tech will use its expertise in interdisciplinary research, together with research talent at EIIRIS, to achieve these goals. The project will entail collaboration with research institutes and companies worldwide, hiring research staff and students from overseas, and reforms in the personnel system.

Toyohashi University of Technology:
www.tut.ac.jp/english

The Electronics-Inspired Interdisciplinary Research Institute

EIIRIS is the flagship research hub of Toyohashi University of Technology. It was established in October 2010 to build on Toyohashi Tech's expertise in microelectronics and act as a platform for the creation of new research paradigms combining electronics with the life sciences. The institute aims to solve problems in diverse areas including environment, energy, food production, and population. For outreach, EIIRIS organizes international conferences, such as The Irago Conference Series, and advertises its activities through regular press releases and a quarterly Toyohashi Tech e-newsletter.

Research covered at EIIRIS includes advanced medical technology, brain-related technology, and green technology. EIIRIS has 11 researchers, two technical assistants, two research support staff employed directly with EIIRIS funding, and 10 tenure-track researchers.

EIIRIS has a range of high-quality research facilities. On the first floor of EIIRIS-1 there is a 1,500 m^2 clean facility, completed in 2010. It houses lithography process rooms, Raman spectroscopy and scanning electron microscopes, and optics areas with advanced fluorescent microscopes and systems for measuring minute electrical signals used in neuroscience research. EIIRIS-2 is a huge 2,300 m^2 clean facility connected to EIIRIS-1 via a bridge on the third floor. It contains design and fabrication equipment for large-scale integrated circuits and micro-electro-mechanical systems (MEMS). Finally, EIIRIS-3 is a life sciences experimental facility for full-scale experiments using animals—an unusual research facility for an engineering university.

One highlight of research at EIIRIS is

Electronics-Inspired Interdisciplinary Research Institute

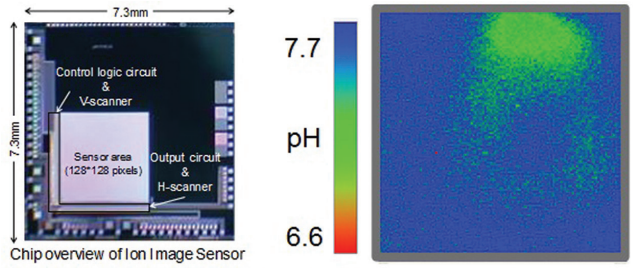
the so-called Toyohashi Probe, invented by **Makoto Ishida** and his colleagues. The probe consists of vertical silicon nanowire electrodes—produced by a vapor-liquid-solid synthesis process—that are inserted into living tissue to detect electrical signals in cells. EIIRIS researchers **Tetsuhiro Harimoto** and Hideo Oi are developing arrays of multichannel electrodes that they plan to use to measure neural signals in the retina, as well as in a brain-machine interface device.

Other exciting research, in this case in the field of functional materials, is being done by EIIRIS scientist **Tran Viet Thu** and colleagues who have synthesized graphene and composites by bacteria-mediated reduction, and silver-reduced graphene oxide nanohybrids for the development of highly efficient catalysts.

Electronics-Inspired Interdisciplinary Research Institute: www.eiiris.tut.ac.jp

Researcher Spotlight

Kazuaki Sawada has integrated conventional biosensing technology, such as functionalized membranes, with charge-coupled device (CCD) image sensors to produce an innovative camera for monitoring the two-dimensional (2-D) movement of compounds on a microscopic scale. The device consists of an array of CCDs covered with a functionalized membrane. The 2-D variation in the ion concentration leads to charge accumulation in the CCD devices, which is presented visually as color-coded images. "The initial device was used for 2-D imaging of the pH outside cells," says Sawada. "We have recently extended the applications of the sensor for monitoring neurotransmitters in cells. This signal can be connected to external circuits for applications such as a chemical-human machine interface to monitor and control chemical reactions in the body in real time via an implanted device."



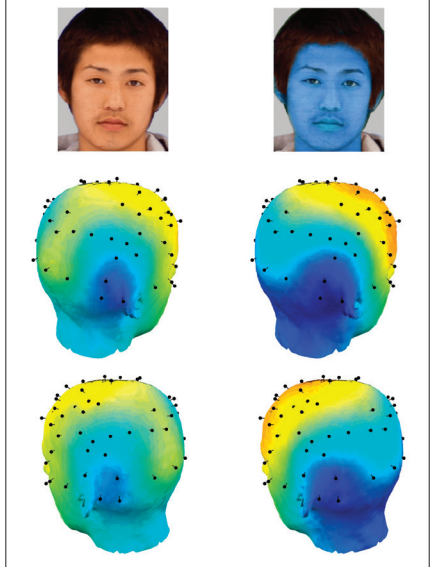
Detection of Acetylcholine (ACh) Distribution From Hippocampus Using Real-Time Bio-Image Sensor

Sawada has used the ion imaging sensor for the first ever, real-time imaging of acetylcholine (ACh). Knowledge of the variations of the concentration of ACh may yield clues for the treatment of diseases such as Alzheimer's.

Sawada Laboratory: int.ee.tut.ac.jp/icg

Shigeki Nakauchi studies visual perception and cognition to answer questions such as: Why are humans able to recognize objects the instant they see them but machines cannot? His research covers three main areas: understanding visual systems, measuring brain activity by electroencephalography, and visualizing otherwise invisible information using infrared-spectrum imaging. A particularly intriguing set of experiments involves studying the differences in the perceptual processing abilities of experts and novices. As an example, Nakauchi has been investigating the relationship between the subjective quality and pictorial features of a pearl, as seen by a pearl appraiser and a novice. "I am developing an optical system to capture how an expert sees features," says Nakauchi. "This research is ultimately aimed at elucidating neuromechanisms of congenital ability and memory."

Nakauchi Laboratory: www.vpac.cs.tut.ac.jp



Activity of Face-Sensitive ERP Component with Natural and Unnatural (bluish) Face Color Stimuli

Hiroyuki Daimon is studying the efficient utilization of biomass, carbon dioxide (CO_2), and heat as part of a major project on creating sustainable, recyclable energy to counter the adverse effects of climate change. "We have constructed a prototype within the Toyogawa sewage treatment plant," says Daimon. "We collect biomass, ferment it to produce methane, and use the methane gas to generate electricity. The residue is used to produce fertilizer."

Notably, Daimon and his research group leave nothing to waste. Any CO_2 produced during the fermentation is introduced into a marine plant farm for seaweed production, and the CO_2 and heat generated during the generation of electricity is delivered into a greenhouse for growing tomatoes. "These are early demonstration experiments with which we have begun the Toyogawa Biomass Park," says Daimon. "We invite visitors to join us and even taste our delicious tomatoes and vegetables!"

Daimon Laboratory: water.ens.tut.ac.jp/index.html

Toyogawa Biomass Park Demonstration Facilities at Toyogawa Sewage Treatment Plant