Developing new models for global partnerships

Nagoya University is implementing various reforms under the strong leadership of President Michinari Hamaguchi, who knows how to make the university more globally visible while maintaining its integral role in the dynamic local economy. Here, Hamaguchi, himself a distinguished cancer researcher, describes his university, its history and strong local ties, and his vision for the future since assuming the presidency in April 2009.

Located in the capital city of Aichi Prefecture in central Japan, Nagoya University is one of the country's leading research universities. It is rooted back to a temporary hospital established in 1871 to serve people in the region; a region that 400 years ago produced many of Japan's heroic leaders including Oda Nobunaga and Toyotomi Hideyoshi.

The Greater Nagoya region, which also includes the prefectures of Gifu and Mie, is renowned for long-standing artisan skills, such as festival floats, pottery and the regular renovation of the main sanctuary of the *Ise shinto* shrine over the past 1,300 years. We have lived with the concept of a sustainable society for centuries, but our region has also another, modern character of strong manufacturing in the automotive and aerospace industries. It is especially well known as the home of the Toyota Motor group.

This rich cultural background is behind the strengths of Nagoya University, which was founded as Japan's seventh — and last — imperial university in 1939. Coupled with a beautiful natural environment, the university's free and vibrant academic culture has nurtured scientists' creativity, producing four Nobel laureates to 2008. There are no gates on our campus, and no barriers among disciplines.

Not only is the university at the forefront of basic science, it also actively integrates with local businesses and promotes collaborations.

Global Center of Excellence programs

The university is composed of nine schools and 16,500 students. Its modest scale allows researchers to communicate naturally and collaborate with each other beyond the boundaries of their individual disciplines. A good example is the Global Center of Excellence (G-COE) initiative of the Japanese government. The five-year G-COE programs provide substantive funding to selected projects to develop world centres of research excellence. Nagoya University has been awarded G-COE funding for seven research projects, many of which are formed from inter-disciplinary teams.

Beyond conventional global partnerships

Nagoya University began its global expansion earlier than many other institutions in Japan, and our efforts already go beyond conventional researcher exchanges. For example, our university sends legal experts to Vietnam and other developing countries to help construct legal systems or assist in collaborative research projects. We also hold a popular intensive summer program for automotive engineering studies, inviting lecturers from top companies and Nagoya University. The majority of participants are visiting students.

Under the Japanese government's 'Global 30' program, which promotes internationalization of Japan's research environment, we plan to double the number of overseas students from the current 1,500 by 2021. Nagoya University and its schools have also formed partnership agreements with 265 universities and research institutes worldwide.

Michinari Hamaguchi, president of Nagoya University.

It is important to break language barriers — at least by enabling foreign students to handle administrative documents in English. As one of the major reforms I am initiating, we are in the process of creating all common curricula in English, an unusual endeavour for a Japanese university. I am also simplifying administrative tasks for faculty staff by abolishing unnecessary committees.

Back to the basics of education

Our population is rapidly aging, and many young people feel uncertain about their future. University researchers, under pressure to obtain competitive grants, are increasingly focusing on their narrow research field rather than education. Despite these problems, the faculty staff should make every effort to help the potential of every student to bloom. Because a tiny opportunity could change the rest of a student's life, we are keen to recruit excellent researchers who are good at mentoring.

Willing or not, globalization is inevitable and it is forcing people to not only acquire English-language ability but also to accept an integrated culture. We'd like to avoid imitating Western models, instead establishing our own style of education and research to contribute to the betterment of society.

International Planning Division,
Nagoya University

Research Strategy and Promotion Office,
Nagoya University

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Nagoya University's Nobel foursome

Nagoya University's place as one of Japan's leading research universities is highlighted by its achievement in producing four recent Nobel laureates: Ryoji Noyori and Osamu Shimomura in chemistry, and Toshihide Maskawa and Makoto Kobayashi in physics.

A tireless champion of chemistry

Noyori shared the 2001 Nobel Prize in Chemistry with William S. Knowles and K. Barry Sharpless for their work on chirally catalysed reactions. Noyori's impassioned calls for a "practical elegance in synthesis" epitomize Nagoya University's scientific aesthetic. In chemical reactions, Noyori's practical elegance refers to converting all of the inputs into the desired output, leaving no waste. This means using resources efficiently and minimizing environmental impact. Catalysis, of course, is especially important in maximizing resource efficiency, and Noyori is a tireless spokesmen for the value of hydrogenation and other catalytic reactions in 'greening' the chemical industry.

Noyori occupies a high-visibility pulpit in his proselytizing for practical elegance in synthesis and for environmental sensitivity in science and industry. He is the president of RIKEN, a scientific research organization funded by the Japanese government that operates several large research institutes. He has headed RIKEN since 2003 while serving as university professor of Nagoya University.

The legendary Nagoya University professor Yoshimasa Hirata (1915–2000) recruited Noyori in 1968. Noyori was then working as an instructor at Kyoto University, where he earned his doctorate in 1967 under Hitosi Nozaki. The job offer from Hirata, who was famous for his work in natural organic chemistry, came as a total surprise to then 29-year-old Noyori. He began at Nagoya University as chair of a research group studying organic synthesis and organometallic chemistry, and in 1969 interrupted his work in Nagoya to spend a year at Harvard University in the US. There, he worked under E. J. Corey, who received the 1990 Nobel Prize in Chemistry for advances in organic synthesis. The experience at Harvard steered Noyori toward a career in research on catalytic asymmetric synthesis for producing single-handed organic compounds — a vital field of research given the dependence of life on molecular chirality, or 'handedness'.

Another Hirata protégé

Shimomura shared the 2008 Nobel Prize in Chemistry with Martin Chalfie and Roger Tsien for the discovery and development of green fluorescent protein. Hirata, too, had an influential hand in Shimomura's Nobel-winning career. Shimomura came to Hirata on an introduction from his former professor at what is now the Nagasaki University School of Pharmaceutical Sciences. Shimomura had earned his undergraduate degree there and was working at the school as a teaching assistant. Hirata accepted the young chemist in 1955 and put him to work on bioluminescence.

Nagoya University's Nobel laureates and their mentors. Clockwise from top left: Ryoji Noyori, Osamu Shimomura, Yoshimasa Hirata, Shoichi Sakata, Makoto Kobayashi and Toshihide Maskawa.

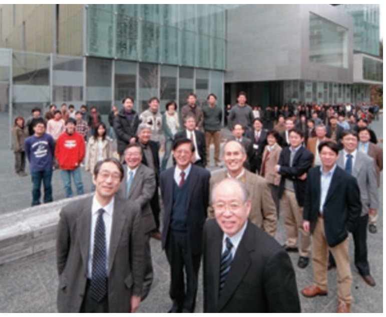
"Hirata nurtured two Nobel laureates and many other internationally famous professors, including Toshio Goto, Koji Nakanishi, Yoshito Kishi, Kiyoyuki Yamada and Daisuke Uemura," declares Masato Kitamura, a professor of chemistry at Nagoya University's Research Center for Materials Science. "That's in addition to doing Nobel-quality research on his own account."

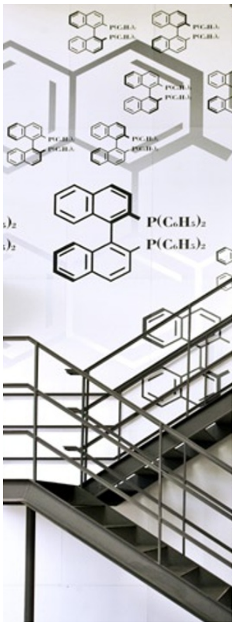
Shimomura studied the bioluminescent crustacean *Cypridina*, displaying prodigious technique and doggedness in isolating the extremely unstable luciferin responsible for the luminescence. He succeeded in obtaining pure crystals of this long-sought-for substance, making its structural identification possible. He published his findings in Japan, and the paper came to the attention of Frank Johnson, a professor at Princeton University. Johnson lured Shimomura to Princeton in 1960, the year that the Japanese researcher received his doctorate from Nagoya University.

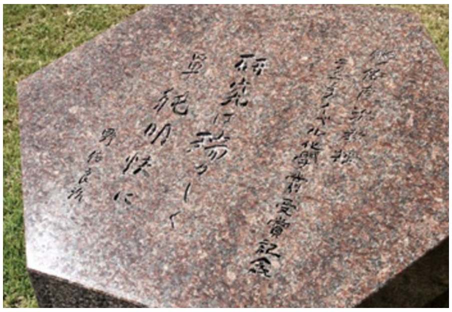
With Johnson, Shimomura spent his summers harvesting bioluminescent jellyfish in Washington state, taking the samples back to the laboratory at Princeton for analysis. That work led to the discovery of green fluorescent protein in the palm-sized jellyfish *Aequorea victoria*. That protein has become an indispensable tool for cell biologists, who use it to tag proteins and to track processes inside cells.

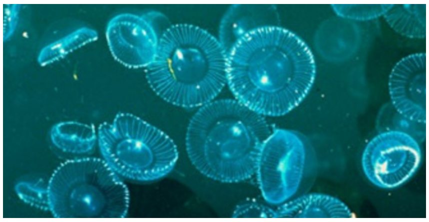
Broken symmetries

Maskawa and Kobayashi shared the 2008 Nobel Prize in Physics for elucidating the origin of broken symmetry in subatomic physics and the related discovery of a third family of quarks, making a crucial contribution to our understanding of the universe. They described how the symmetries of matter and antimatter









(charge conjugation symmetry) and of left and right (parity symmetry) get broken. That breakdown, known as 'CP violation', is why the universe has more matter than antimatter and why, therefore, we can exist.

Experiments had verified a small CP violation in 1964, but subatomic theory in the early 1970s could only account for the weak electromagnetic forces of leptons. Maskawa and Kobayashi developed a theory that accounts for the role of what we now know as quarks through CP violation. Their theory predicted the existence of at least six kinds of quarks — three more than were known at the time. The theory was met with incredulity, but all three additional quarks were experimentally confirmed by 1995.

Both Maskawa and Kobayashi earned their doctoral degrees at Nagoya University. Maskawa served briefly as a research assistant at Nagoya University after completing his doctoral work there in 1967 and subsequently worked mainly at Kyoto University. He will return in 2010 to Nagoya University to head a full-time laboratory.

Kobayashi worked as a research assistant at Kyoto University after receiving his doctorate from Nagoya University in 1972. He moved to Japan's High Energy Accelerator Research Organization in 1979, where he holds the title of emeritus professor.

The Sakata influence

Maskawa and Kobayashi are disciples of the Nagoya University physicist Shoichi Sakata (1911–1970), who had studied under Hideki Yukawa (1907–1981), Japan's first Nobel laureate. In 1943, Sakata presented his 'two-meson theory', the correct final form of Yukawa's original theory and an achievement of equivalent importance to Yukawa's earlier work. Sakata conducted further revolutionary work that resulted in the Sakata model of 1956, which paved the way for the quark model and remains a useful framework for interpreting various subatomic phenomena.

The Sakata model was later developed into the 1962 Maki–Nakagawa–Sakata theory, another Nobel Prize-level work that became famous after the prediction of the neutrino oscillation, which also suggested the existence of the four fundamental particles that crucially motivated the Kobayashi–Maskawa paper.

Koichi Yamawaki, a professor of physics at Nagoya University who has worked with Maskawa, describes the Sakata connection. "Maskawa," says Yamawaki, "believes in milking well-conceived theories rather than flitting on to one new theory after another. He had set out to use field theory, then disbelieved by the world's leading physicists, to verify the composite-model approach advocated by Sakata. With Kobayashi, he did everything possible to explain CP violation with the four fundamental particles inspired by Sakata's approach. Only after that proved impossible did they resort to six quarks."

Nagoya's crucible of discovery

Although Nagoya University was just one of several formative settings for the Nobel laureates Noyori, Shimomura, Maskawa and Kobayashi, a distinctive 'Nagoya' originality resonates clearly in the legacy of each. Also evident in their legacies are the definitive influences of their Nobel-class mentors: Hirata and Sakata. Asked about the origins of the university's uniquely fertile culture, Yamawaki offers some historical background.

"Nagoya University's academic forebear," explains Yamawaki, "was the last of the imperial universities established by the Japanese government. That was in 1939. The imperial universities had become notorious for feudalistic practices that stifled discourse and impeded advances in research and education. The authorities were determined to promote faster progress in science and technology, and the new university in Nagoya was a bold experiment in encouraging vigorous discourse. Its administrators lured Sakata from Kyoto University in 1942, and Sakata became instrumental in establishing a new model for research and education. Top-down lines of hierarchical authority gave way to vibrant teacher–student groups where a free-swinging give-and-take prevailed."

Hirata continues to invigorate research at Nagoya University through the Yoshimasa Hirata Memorial Lecture series. The university inaugurated the annual lectures in 2004 to host presentations by prominent young chemists from outside Japan. Shigehiro Yamaguchi, a professor of chemistry at Nagoya University, says, "We would like to keep the Hirata spirit to encourage and give opportunities to young chemists."

Yamawaki also notes the contributions of the chemist Noyori to the culture of originality at Nagoya University. "Noyori cautions us against confusing science with sport. 'In sport, you have clear-cut rules,' he says, 'and the goal is to finish in first place. In science, you have no rules, and the goal is to attain a unique place.'"

Department of Physics, Graduate School of Science, Nagoya University

Department of Chemistry, Graduate School of Science, Nagoya University

Research Center for Materials Science, Nagoya University

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Classic and novel approaches to systems biosciences

Researchers participating in the Global Center of Excellence (G-COE) for Advanced Systems Biology cross the border of agricultural and biological sciences to understand complex interactions in living organisms.

Systems biology is a new field of research that has emerged in the post-genome era. Unlike conventional molecular biology, which focuses on simple functions of specific molecules and genes, systems biology takes a more holistic approach and looks at how various elements in a living organism interact with each other and constitute a complex network. Nagoya University's G-COE for Advanced Systems Biology is headed by Takao Kondo, a professor of biological science. The program takes advantage of Nagoya University's innovative and creative young brains, who are closely involved in some of the program's flagship projects. The participants, all experimental biologists, are from nine laboratories of the Division of Biological Science in the Graduate School of Sciences and eight labs of the Graduate School of Bioagricultural Sciences.

The objective of the G-COE program is not only to pursue cutting-edge research but also to provide advanced education for graduate students, giving them extra abilities aside from molecular biology. The 'pre-fellow' system, for example, allows postdoctoral researchers to join other laboratories in different disciplines for six months or one year to broaden their scientific perspective.

The G-COE program will move to a new building for interdisciplinary research in two years' time. The Advanced Live Imaging Center in the same building will be invaluable for understanding biological systems.

Circadian clocks in cyanobacteria

Kondo is a pioneer of the biological circadian clock. In 2005, he demonstrated an *in vitro* reconstruction of a 24-hour periodic oscillation in a state of the cyanobacterial clock protein simply by mixing three clock proteins with adenosine tri-phosphate (ATP), an energy source for living organisms. It was a surprising result given that many researchers had believed gene expressions would be necessary to generate the circadian rhythm.

The clock works by the harmonization of two proteins KaiA and KaiB with the key protein KaiC to produce the master oscillation — a self-sustained cycle of KaiC phosphorylation and dephosphorylation. Kondo also found that the period of the rhythm *in vitro* was stable with respect to ambient temperature changes and matched the rhythms of gene expression in cyanobacterial cells.

Kondo and his team continue to elucidate the detailed mechanisms of KaiC that generate the circadian oscillation. One of the most important findings is that KaiC possesses extremely weak but stable ATP hydrolysis activity, and that the enzyme responsible, ATPase, is the key to keeping the clock ticking. Kondo subsequently suggested that KaiC's ATPase and kinase/phosphatase activities influence each other to construct the circadian clock at the protein level.

To his surprise, the speed of the circadian clock was determined by the ATPase activity. Comparing wild-type and mutant KaiCs, Kondo's team found that increased ATPase activity raised the 'ticking' speed of the clock. "The result meant that the biochemical reaction to hydrolyse ATP determines the circadian cycle. This is what I had long dreamed to see because it explains how the cycle length of the Earth's rotation is implemented in living cells — by just one enzyme," says Kondo.

The team also reported that the ATPase activity is independent of temperature, even though the activity of most enzymes increases when the temperature rises. This may answer the question of why living organisms can maintain their internal circadian clock, which corresponds to the Earth's 24-hour rotation, in any season.

"We appear almost to have reached our goal to understand the circadian clock, but we have also realized that there are many fantastic mysteries inside the protein structure of KaiC," Kondo says.

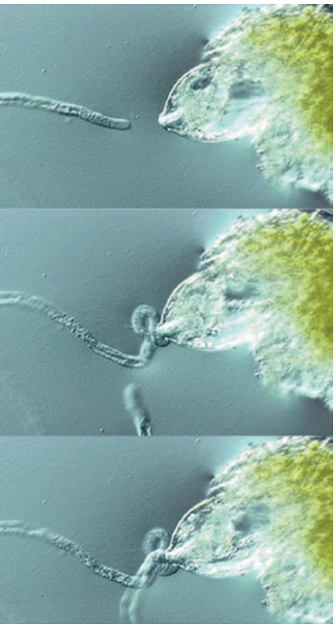
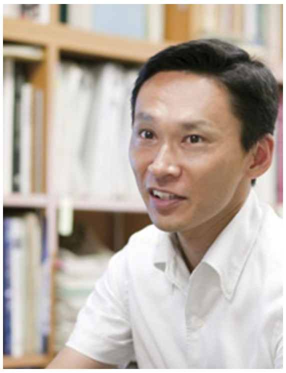
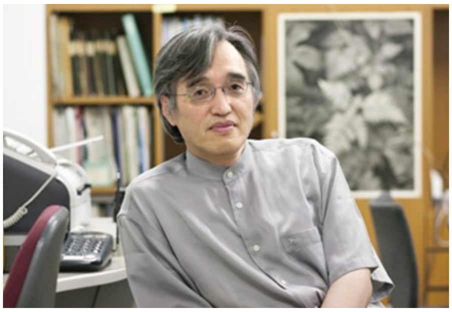
A hormone that heralds the advent of spring

Takashi Yoshimura is investigating how Japanese quails adapt their behaviour to the environment and seasonal changes, such as the period of daylight.

Past studies have suggested that the mediobasal hypothalamus (MBH) in the brain is an important centre that controls photoperiodic time measurement. And exposure to light doesn't need to be continuous: even in a short day, additional exposure to light pulses at night can induce the development of gonads in these quails. In 2003, Yoshimura, a professor and director of the Avian Bioscience Research Center, sequenced the genes expressed upon such additional light exposure, and identified a key gene called *DIO2* in the MBH. He reported that the DIO2 enzyme activates thyroid hormones as the day gets longer, leading to secretion of a hormone that triggers reproductive activities.

Following the completion of chicken genome sequencing in 2004, Yoshimura's team implemented a comprehensive screening of the quail genes that undergo a change in expression when the birds experience a transition from short to long days. They discovered the important role of the pars tuberalis — a part of the brain to which few people had paid attention.

In the pars tuberalis, a hormone called thyrotrophin (TSH) is induced by the lengthening period of daylight. TSH stimulates the expression of *DIO2* in the hypothalamic area, thereby controlling seasonal reproduction. The finding was worth rewriting textbooks because TSH was previously known only to be a metabolism regulator, secreted from the anterior pituitary into the blood in peripheral tissue, not into the brain. "Nature gave more than one role for this



Advanced systems biology: designing the biological function

single hormone to enable animals to adapt to a changing environment," says Yoshimura.

Now he is investigating how animals understand the length of the day. "The study could contribute to our understanding of seasonal depression in humans," he says.

Developing tailor-made rice crops

As expansion of the global population begins to cause increasing food shortages, demand is strengthening for greater yields of tastier, safer and more resilient crops.

Makoto Matsuoka, a professor of the Bioscience and Biotechnology Center, has been unveiling important genetic and molecular mechanisms in rice, and has suggested new breeding methods that could lead to the development of tailor-made cultivars.

In agriculture, the 'semi-dwarf' trait is important for increasing productivity by enhancing crops' resistance to wind and rain. Progress in molecular genetics has now enabled researchers to discover that such dwarfism is due to mutation of the *SD1* gene. In 2002, Matsuoka's team reported that *SD1*'s role is to encode an oxidase enzyme involved in the biosynthesis of gibberellin (GA), a plant growth hormone.

Matsuoka and his colleagues have also isolated and characterized two key genes, *GID1*, which encodes a GA receptor, and *GID2*, which encodes a positive regulator of GA signalling. Loss-of-function in either results in GA-insensitive mutants.

Binding of the GID1 receptor produces a protein complex and triggers various GA actions. The researchers have built a molecular model of GA signalling, which has led to the discovery that the GID1 receptor could adapt to chemical compounds other than GA by replacing amid acids associated with the GA binding. Matsuoka says this finding could pave the way for developing new growth hormones.

By picking out chromosome segments containing advantageous genetic information from a number of varieties, Matsuoka's team has identified five genes responsible for grain counts. The researchers back-crossed two varieties of rice: the Japanese premium variety Koshihikari, and the much shorter Indian variety Habataki. They thus created a variety of Koshihikari that carried a Habataki gene and had a yield 30% higher than that for regular Koshihikari, and the taste remained unchanged.

"We can apply this method to find more valuable traits from wild rice, and develop innovative varieties," Matsuoka says. In their latest achievement, his team has reported the mechanisms of two genes that enable high-rise rice in South Asia to survive floods and keep standing in deep water.

Unveiling the navigator that directs pollen tubes to ovules in flowers

When pollen comes into contact with a pistil of a flower, the pollen extends a pollen tube down to the ovule to deliver its two sperm cells. The details of this fertilization process have remained elusive for more than 140 years, although plant biologists always assumed that the tube was guided by some means. Tetsuya Higashiyama, a professor of the Division of Biological Science, has uncovered the mystery, not only by identifying the attractants, but also by controlling and visualizing the process itself.

All of the numerous previous attempts to observe fertilization processes in living plants had failed because the embryo sac, which contains the egg cell, is firmly enclosed in ovule tissue at the base of the pistil. But Higashiyama had his eye on a unique plant, called *Torenia fournieri*, which has a protruding embryo sac that is easier to observe. He successfully videotaped the process of fertilization *in vitro* when he was a graduate student.

Higashiyama then started to search for pollen tube attractants. He assumed that the two synergid cells that sit next to the egg cell would be the likely origin of the attractants. He proved this and identified the attractants as two types of secretory polypeptides containing abundant amino acids called cysteine. He named these proteins LUREs, and demonstrated with live imaging how the tube is guided to the attractants.

The series of findings wouldn't have been achieved without technologies originally developed by Higashiyama. It had been extremely difficult to inject chemical agents into plant cells, but his laser-assisted, thermal-expansion micro-injector made it possible. Visualizing the fertilization process also required special imaging techniques because the process is often inhibited by exposure to light.

Higashiyama and his colleagues are now investigating the mechanisms of 'double fertilization', whereby one sperm cell reaches an egg cell and the other reaches a cell called a 'central cell'. "Even though we have yet to unveil this well-known phenomenon, we are getting closer to confirming the process with live imaging," says Higashiyama.

Nagoya University Global Center of Excellence (G-COE) Programs

Office of Advanced Systems Biology, Division of Biological Science, Graduate School of Science, Nagoya University

Office of Advanced Systems Biology, Graduate School of Bioagricultural Sciences, Nagoya University

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A centre of chemistry excellence

Nagoya University's Global Center of Excellence (G-COE) in Chemistry brings together researchers from all branches of the chemical sciences.

The Chemistry G-COE is one of seven such programs in the physical sciences, life sciences, medicine, engineering and humanities currently running at Nagoya University. The mission of each of the G-COE centres is to carry out research at the apex of international excellence and to strengthen the education and research functions of their respective graduate schools. Founded in 2007, the Chemistry G-COE program brings together outstanding scientists in a diverse array of chemical-related fields including synthetic chemistry, polymer science, nanochemistry and the chemical aspects of life sciences. The result is a broad, interdisciplinary mélange with intellectual freedom leading to scientific excellence at its core.

Organometalloprotein science

Yoshihito Watanabe, project leader of the Chemistry G-COE, started out as an organic chemist and so he might have stayed but for an encounter with haemoproteins whilst a postdoctoral researcher at the University of Michigan. "I was struck by the wide differences in reactivity of the members of the haemoprotein family, despite the fact that the active part in all cases is the same. To me as a chemist, the idea that the fundamental reactivity of each haemoprotein could be so dependent on a surrounding protein molecule and a few amino acid residues nearby was extremely interesting." Thus began the journey from organic chemist to bioinorganic chemist and eventually to molecular biologist when Watanabe returned to Japan after five years overseas at Michigan and Princeton to take up a position at the prestigious Keio University Medical School, although this transition was not without its problems. "After so long in the US, I'd pretty much dropped off the radar in Japan, so most people assumed I was a Japanese American and kept talking to me in broken English!" he explains.

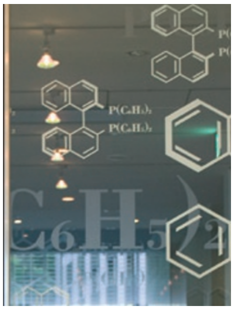
Since then Watanabe has devoted himself to modifying the oxidizing behaviour of haemoproteins — particularly myoglobin — by specific mutagenesis. For example, by a process of careful replacement of selected single amino acid residues in the myoglobin active site, he and his team have managed to create a synthetic enzyme that enhances the rate of hydrogen peroxide-dependent oxidation by a factor of over 1,000 to bring it into line with the level of reactivity more commonly associated with peroxidases. They have also replaced the iron porphyrin active centre in myoglobin with salophen units and introduced different metals, such as copper and rhodium, in place of iron. Another research theme centres on the design of synthetic organometallic enzymes to catalyse useful synthetic processes such as hydrogenation and the aryl coupling reaction. In this context, the Watanabe group have prepared alloys of gold and palladium within the protein complex ferritin — more commonly known in living systems as an iron storage receptacle. The performance of these metallobiocatalysts can be adjusted by modifying the structure of the ferritin at selected points using mutation techniques. These recent new directions have caused Watanabe to reassess yet again the way he describes himself: "I guess you'd say I'm more a biologist than anything now," he laughs, "but I started out as a chemist, and now there's this term 'chemical biologist' going around. That's probably about right."

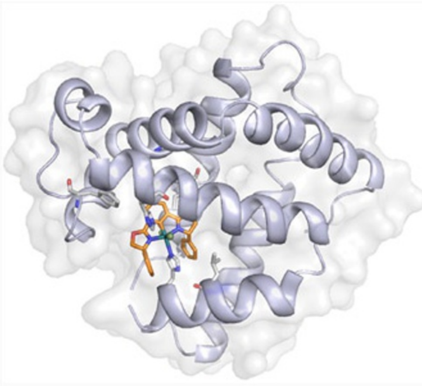
Polymer and materials science

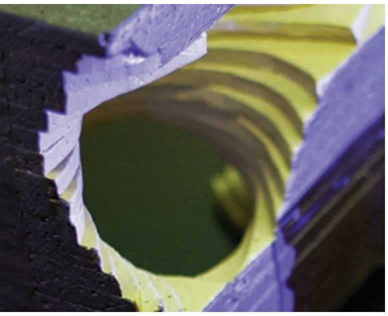
Yushu Matsushita (next page, top right) got an early start in his chosen field. While still in his fourth undergraduate year at Nagoya University, where he has spent his entire career, he realized that solution polymer science, the topic of his bachelor's dissertation, was a mature field and decided to look elsewhere. His eyes alighted on the emerging field of solid-phase triblock copolymers and a career was born. "I guess I just wanted to take a road that no-one else was walking," says Matsushita, "I was always told to find something that you are interested in and see where it leads."

Matsushita's work focuses on the fundamental micro- and macroscopic properties of complex triblock copolymers: polymer chains consisting of segments of three different chemical entities that do not have an affinity for each other. These complex structures adopt characteristic three-dimensional shapes due to competition among the repulsive forces of their constituents. Depending on the structure of the individual segments, the microscopic appearance can range from a very simple laminar structure through to rod-like arrangements and even more elaborate gyroid structures in which two of the segments form an entwined network while the remaining segment acts as a supporting matrix of defined thickness. The resulting structures can have astounding regularity, even to the point of delivering coherent X-ray diffraction patterns — behaviour more normally associated with a fully crystalline solid. "From the point of view of pure science, this is probably the most interesting result of all," comments Matsushita.

Yoshihito Watanabe, project leader of the Chemistry G-COE.







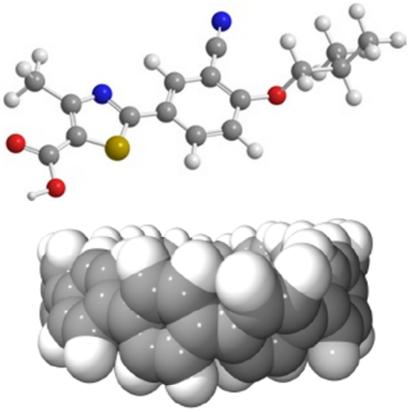
Elucidation and design of materials and molecular functions

A more advanced development of this idea is the self-assembly of 'ABC' stars — three anti-affinity polymer chains joined at a central node to form a three-point star. The nodes of adjacent stars are strung along an imaginary locus like beads on a string, and the microscopic appearance of the patterns formed from the many different combinations of polymers that can be created using this model follow the 12 archimedean tiling patterns, including regular honeycomb and kagome lattices through to more exotic quasicrystalline arrangements. With some regret, however, Matsushita notes that he has yet to synthesize all 12 patterns. A current area of interest is the synthesis of polymer–metal hybrids by generating nanoporous polymer materials from an A–B block copolymer and another polymer segment C to form a regular structure. Removing C by chemical treatment then creates a material containing voids into which metal atoms can be introduced. The resulting species function as photonic crystals, entities that are attracting much attention as potential materials for optical computers and optical cloaking devices. But for Matsushita, the joy is in exploring basic science and pushing back the boundaries of human knowledge. "Applications are important," he says, "but I leave that up to others. I'll just keep coming up with the ideas and doing things that interest me."

Synthetic organic chemistry

Kenichiro Itami (above left) is only 38, but he has already held the title of professor at Nagoya University for more than a year and has spent even longer playing down his reputation as the *Wunderkind* of Japanese chemistry. "It's not true!" he laughs, "it's flattering, but I don't take that stuff seriously at all." However modestly stated though, his curriculum vitae is far from usual. A product of the elite Kyoto University, Itami was head-hunted by 2001 Nobel laureate Ryoji Noyori to join the faculty at Nagoya University where he worked in Noyori's group for three years with more-or-less carte blanche to do as he pleased, before later starting his own lab. "I could hardly believe my ears," recalls Itami, "I mean, to chemists Noyori is a god, so when he told me 'just do something that interests you,' I was amazed." What interests Itami, it turned out, is the development of new synthetic strategies, methodologies and reagents carried out with a holistic view of the subject. "Traditionally, chemists have tended to divide our field up into natural product synthesis, methodology, catalysis or materials and so on, and this troubled me," he explains. "The way I see it, it's all synthetic chemistry. So I decided that if I ever got a laboratory of my own I would make it a place where basic research and applied research and research from other fields would feed off each other."

It's a broad vision in which new reactions and techniques developed in one part of the group — such as C–H activation or new protocols for cross-coupling reactions using inexpensive nickel catalysts in place of palladium-based compounds — are used in another part of the group to synthesize complex chemical entities, pharmaceutical candidate molecules and novel optoelectronic materials. Although Itami describes his approach as 'risky', it is already bearing fruit: the Itami group has developed a catalyst that dramatically shortens the synthetic route to Febuxostat, an emerging drug for hyperuricemia with expected annual sales of 100 billion yen; whilst the group's synthetic route to cycloparaphenylene — described as the 'shortest carbon nanotube' — is already garnering interest from both materials scientists and applied synthetic chemists alike. Then there are the new reagents developed by the Itami group and commercialized by Japanese and international chemical companies: seven and counting.



Febuxostat (top) and cycloparaphenylene (bottom). Two of the molecules synthesized by Kenichiro Itami's group.

It's a list of achievements that many chemists do not manage in their whole career, but Itami is only getting started. "I love it here at Nagoya," he says, "it's a fabulous place to do research. My dream is to lead a laboratory that not only creates interesting chemistry, but which also produces people who can make exciting contributions in many fields." And no one would believe he can't.

Nagoya University Global Center of Excellence (G-COE) Programs

Department of Chemistry, Graduate School of Science, Nagoya University

Department of Applied Chemistry, Graduate School of Engineering, Nagoya University

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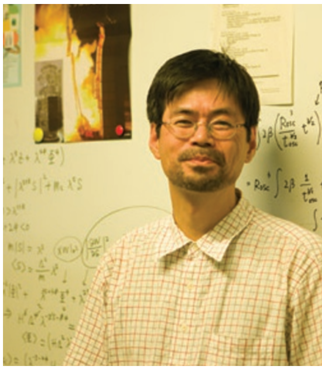


Where particle physics and astrophysics converge

A quest for the fundamental principles of the Universe — that is the bold mission of a Nagoya University Global Center of Excellence (G-COE) that brings together particle physicists, astrophysicists and mathematicians.

"The fundamental principles that have shaped the Universe," observes Naoshi Sugiyama, "reveal themselves in the minutiae of subatomic particles and the vastness of space. A dual perspective that encompasses particle physics and astrophysics, including solar terrestrial physics, is therefore useful in seeking a grasp of those forces. That is the kind of perspective that we are fostering in our centre of excellence."

Sugiyama, a professor of particle and astrophysical science at Nagoya University's Graduate School of Science, spearheads his centre's quest for fundamental principles of the Universe. The quest, he emphasizes, is a combination of education and research.

"We launched our program in 2008 as the successor of a centre of excellence that focused on cosmic history. That program ran for five years to 2007. A lot of our members, including myself, participated in the earlier program. We have thus inherited a great deal of research and educational momentum. In working to build on that momentum with new members working on solar terrestrial physics, we are redoubling our emphasis on education. This is an exciting opportunity for doctoral students of any nationality to secure well-funded positions in a cutting-edge scientific initiative. And we invite inquiries from potential participants."

Sugiyama's colleague Masaharu Tanabashi is equally upbeat about the educational possibilities engendered by the G-COE. Tanabashi, also a professor of particle and astrophysical science at the Graduate School of Science, welcomes the opportunity to provide students with international exposure.

"Funding through the centre," Tanabashi says, "enabled me to dispatch a student recently for a brief stay at Michigan State University. The visit was an eye-opening experience for the student and has alerted him to new avenues of inquiry in his research. My work is mainly in theoretical physics, so my students and I benefit especially from the expanded access to ideas that the G-COE has occasioned."

Michigan State University is one of several partner universities for the G-COE in North America, Europe and Asia. The centre also has close ties with the University of California, Berkeley, the University of Oxford and the University of Leicester. Its international advisers include Joseph Silk, the Savilian Professor of Astronomy at Oxford University, Thomas Appelquist, the Eugene Higgins Professor of Physics at Yale University, Takahiko Kondo, emeritus professor at the High Energy Accelerator Research Organization, Hajime Inoue, director-general of ISAS/JAXA, and Daniel Baker, professor of astrophysical and planetary sciences at the University of Colorado, Boulder, and director of that university's Laboratory for Atmospheric and Space Physics.

A Nobel Prize-winning tradition in particle physics

Highlighting Nagoya University's tradition in particle physics are a pair of Nobel Prizes. Two graduates of the university, Toshihide Maskawa and Makoto Kobayashi, together shared half of the 2008 Nobel Prize in Physics for their work on the origin of broken symmetry in subatomic physics and their discovery of a third family of quarks. Maskawa has joined the G-COE as a distinguished visiting professor to help establish the program.

Maskawa and Kobayashi both studied at Nagoya University under the seminal physicist Shoichi Sakata. The Sakata model was a highly influential forerunner of the quark model, and Sakata and his colleagues at Nagoya University were the first to predict neutrino oscillations.

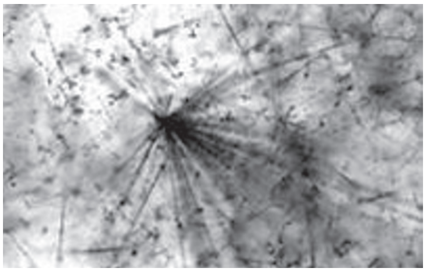
In related activity, researchers from Nagoya University have participated actively in the Japan High Energy Accelerator Research Organization's KEK B-Factory particle accelerator. That accelerator was instrumental in verifying the broken symmetry described by Maskawa and Kobayashi.

Another Nagoya University physicist, Kiyoshi Niu, discovered the first observational clue to the existence of charm quarks in cosmic ray showers. Niu, now an emeritus professor, made his discovery before researchers discovered charm quarks experimentally using a particle accelerator. The research group formerly led by Niu has continued in the trailblazing mode that he established. It made the first direct observation, for example, of tau neutrinos.

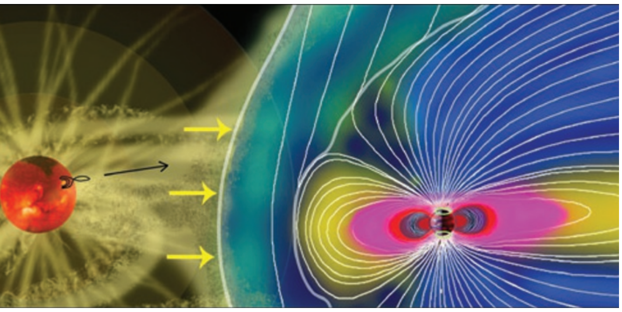
Founded on this strong tradition, Nagoya University continues to play a leading role in elucidating the origins of matter and space-time while collaborating in both theoretical studies and practical experiments with the B-Factory, the ALTAS and LHCf experiments at CERN, Switzerland and the OPERA experiment for neutrinos at the Gran Sasso Laboratory in Italy.

Southern eyes on the sky

Underpinning Nagoya University's observational capabilities in astrophysics is the unique network of eyes on the sky in the Southern Hemisphere. The centerpiece of that network is Nanten 2, which



Tracks of charged particles on a nuclear emulsion.



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Quest for fundamental principles in the Universe: from particles to the Solar System and the cosmos

occupies a site 4,800 metres above sea level on Chile's Atacama Plateau. Nanten 2 is the world's only wide-field telescope for picking up submillimetre signals. It monitors warm gas clouds, which yield valuable insight into star formation, supernovae and the activity at the centre of our Galaxy.

In the vanguard of the Nanten project since its inception has been Yasuo Fukui, a professor of particle and astrophysical sciences at the Graduate School of Science and director of the Nagoya University Southern Observatories network. He takes understandable pride in the project's accomplishments.

"Our observation teams in Chile," relates Fukui, "have conducted comprehensive surveys of molecular clouds in the Galactic plane, as well as the Large and Small Magellanic clouds. In addition, they have discovered an intriguing loop structure of molecular gas in the Galactic centre."

Complementing Nanten 2 is the Microlensing Observations in Astrophysics (MOA) project in New Zealand. Nagoya University leads a Japanese research group that conducts that project with four New Zealand universities. The partners operate a 1.8-metre optical telescope, MOA-II, at the Mt John University Observatory on New Zealand's South Island. They have made important discoveries in cooperation with groups at other observatories, including the lightest planet ever discovered outside our solar system.

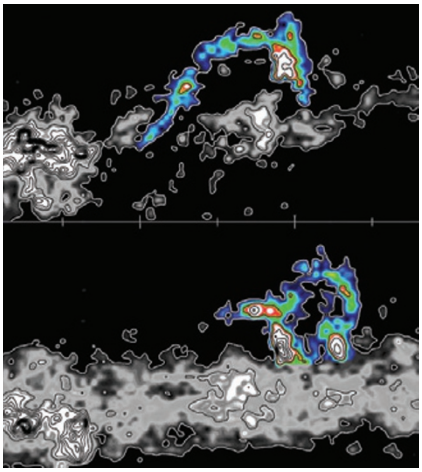
In South Africa, Nagoya University operates a 1.4-metre optical telescope in Sutherland with Kyoto University, the National Astronomical Observatory of Japan and the South African Astronomical Observatory. Nagoya University's fourth eye on the sky in the Southern Hemisphere is a millimetre-range observation unit in Antarctica. The university operates that unit in cooperation with Japan's National Institute of Polar Research at Showa Station on the Antarctic island of East Ongul.

Nagoya University's astrophysicists augment their understanding further through participation in Japan's satellite programs. They have played a central role in analysing the data gathered by the X-ray astronomical satellite *Suzaku* and by the infrared astronomical satellite *Akari*.

Between Sun and Earth

Occupying a crucial position between the minutiae of particle physics and the infinitude of the cosmos is the space between the Sun and Earth. Nagoya University's Solar–Terrestrial Environment Laboratory investigates phenomena in that realm, including the structure and dynamics of the Sun–Earth system, mass and energy flow from the Sun into Earth's upper atmosphere, and cosmic rays. The laboratory operates as part of a collaborative framework that encompasses close ties with numerous universities and research organizations in Japan and the Americas (United States, Brazil, Bolivia), Europe (Russia, Armenia, Finland, Norway, Sweden), Asia (China, Indonesia) and Oceania (New Zealand).

"The space that we study in the Solar–Terrestrial Environment Laboratory is 'near space,'" comments Kanako Seki, an associate professor in the laboratory. "So we're dealing with things that we can measure precisely using satellite probes, radar and other tools." Seki, an expert in upper-atmospheric physics, is especially excited about a project the laboratory is undertaking under the name Geospace Environment Modeling System for Integrated Studies (GEMSIS). "We are taking the initiative in conducting that project almost entirely on our own," says Seki. "That will mean building a geospace model combining numerical simulations and observational data. We are counting on the model to provide important new insights into the mechanism of energy and mass transport in geospace."



Distributions of molecular loop 1 (top) and loop 2 (bottom) in the Galactic centre observed using the Nanten telescope in Chile.

Like her colleagues, Seki welcomes emphasis on the education and international exchange that accompanies the G-COE designation. She mentions a student who recently delivered a paper at an international conference in Singapore, and says that she looks forward to seeing more students benefit from similar opportunities.

Nagoya University Global Center of Excellence (G-COE) Programs

Division of Particle and Astrophysical Science, Graduate School of Science, Nagoya University

Solar-Terrestrial Environment Laboratory, Nagoya University

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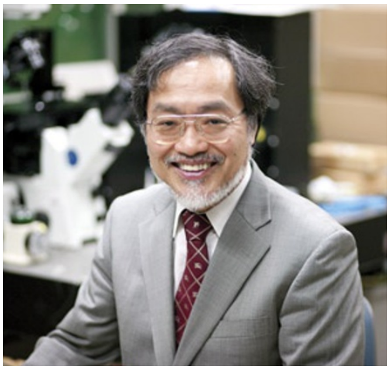
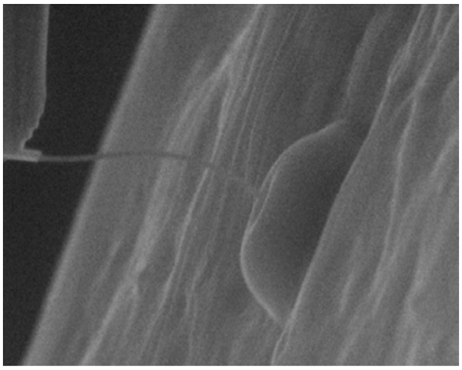
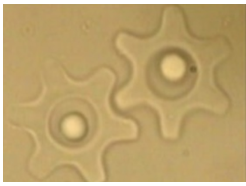
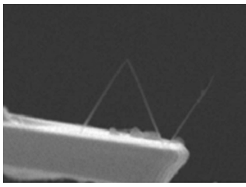








The cultural impact of 'small'

Nagoya University is a world leader in micro-electromechanical systems (MEMSs), and the university is reinforcing that leadership through a five-year education-and-research program with Global Center of Excellence (G-COE) funding from the Japanese government.

"We call our program the Center of Excellence for Education and Research in Micro–Nano Mechatronics," explains Toshio Fukuda, the program director. A professor of micro–nano systems engineering in Nagoya University's School of Engineering, Fukuda has garnered international acclaim for his contributions to mechatronics and robotics.

"Our centre," Fukuda continues, "carries on the work of an earlier centre of excellence at Nagoya University in the same discipline. We continue working to develop exciting new applications for micro- and nano-scale fabrication and to improve reliability and performance in established applications. That means fostering researchers who are eager and able to explore uncharted realms of technological possibilities. It also means allocating resources strategically to sectors where we assert special strengths, reaching across borders to leverage our resources through international collaboration and by fostering productive ties with corporate partners."

Fukuda is a passionate spokesman for the social and cultural ramifications of miniaturization. "Our lives change dramatically," he notes, "when size reductions reach a critical mass. 'Portable' phones the size of lunch boxes didn't attract many users. But when cell phones became small enough to fit in a pocket, everyone started using them."

Small is a many-splendored thing, as Fukuda details enthusiastically. "Performance improves in smaller packages. Oscillation becomes faster, and control becomes more precise. Think about the actuator in an automotive airbag system. At the heart of the actuator is a micro-scale electromechanical element for detecting the sharp deceleration characteristic of a collision. The micrometre-order tolerances in detection enable the actuator to provide the split-second response needed to save lives."

Life-saving smallness can even be big enough to hug. Witness the life-sized endovascular mannequin dubbed 'Eve'. A student of Fukuda, Seiichi Ikeda, developed Eve to evaluate the performance of robotic control devices for microcatheter surgery. The technology proved useful to physicians in preparing for endovascular surgery, and Ikeda has launched a venture business, FAIN Biomedical, to commercialize the invention.

Eve — the name deriving from 'endovascular evaluator' — is a patient-specific simulation of blood-vessel structure. Ikeda uses rapid prototyping based on computed tomography and magnetic resonance imaging to reproduce pertinent vasculature in a patient's head, upper torso or whole body. The resultant model features precision on the order of micrometres, allowing physicians to rehearse for endovascular surgery in blood vessels of less than a millimetre in diameter. Along with supporting refinements in surgical technique, Eve reduces the need for laboratory animals in endovascular training and research.

Nagoya University's researchers in micro- and nano-scale mechatronics are poised to produce more real-world breakthroughs in the same vein as Eve. The university has assembled experts in advanced materials, mechanical science, system measurement, control engineering and biomedical engineering. And those experts are joining hands with a global network of partners in academia and industry.

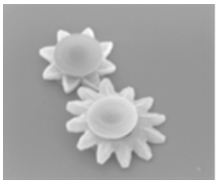
Cross-border partners

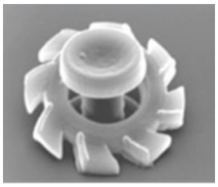
Fukuda and his colleagues are especially serious about demonstrating the international perspective denoted by the title of Global Center of Excellence. They dispatch researchers abroad to participate in international conferences and joint research projects, and they have stepped up their activity in recruiting doctoral students and postdoctoral fellows internationally. At the heart of their international activity is a close working relationship with the University of California, Los Angeles (UCLA).

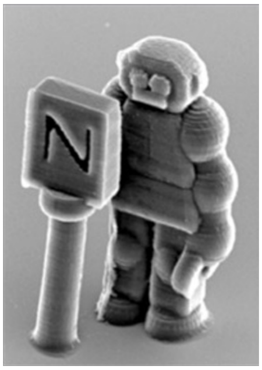
Cooperation between Nagoya University and UCLA in micro–nano mechatronics predates the establishment of the G-COE. The two universities have held three international symposiums in the field since 2007. Chih-Ming Ho, a professor in the UCLA School of Engineering and a pioneer in MEMSs, is a member of Nagoya University's Micro–Nano Mechatronics G-COE. Ho heads the Center for Cell Control, a nanomedicine development centre based at UCLA and operated under the US National Institutes of Health. Ho's centre acts as an interface for a great deal of the vigorous interchange between the two universities.

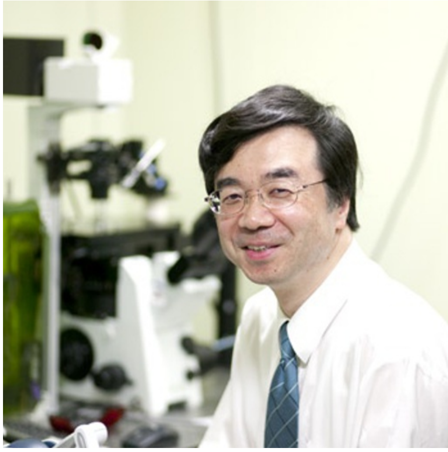
Fukuda and his colleagues are also serious about fostering close working relationships with corporate partners. A member of the G-COE who is especially active in joint research with corporate partners is Kazuo Sato. He heads the Integrated Mechatronics Devices Group in Nagoya University's Department of Micro–Nano Systems Engineering. Sato is prominent in anisotropic etching, a

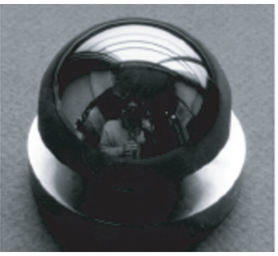
Eve, the endovascular evaluator. A mannequin for training, evaluation and simulation of endovascular surgery.

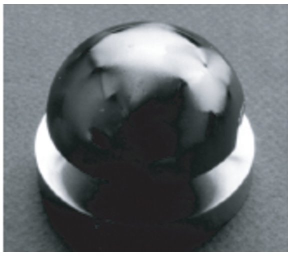


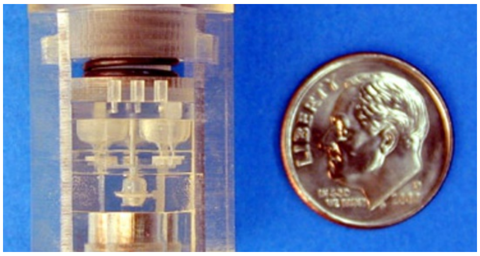












Education and research in micro–nano mechatronics

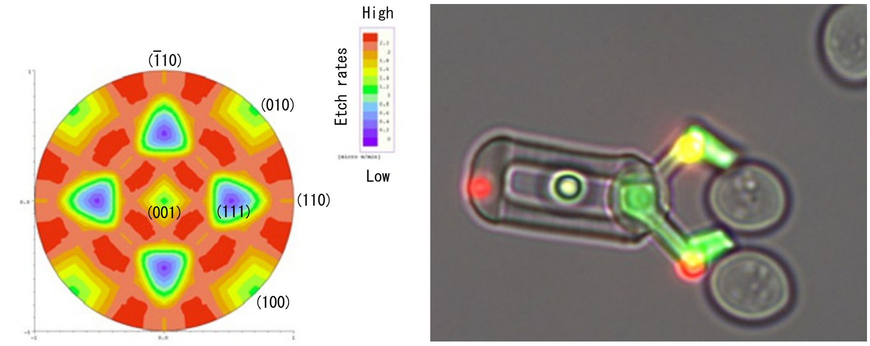
technology for fabricating microstructures — atom by atom — on crystalline substrates. And he is intimately familiar with corporate needs and expectations in his field. Before moving to Nagoya University in 1994, he spent quarter of a century at Hitachi's Central Research Laboratory.

"Researchers," he explains, "have used anisotropic etching to fabricate functional structures, such as diaphragms and cantilever beams for pressure sensors and for accelerometers. But the directional constraints that characterize anisotropic etching have limited the range of shapes that can be fabricated, and they require special attention in designing the etching processes. My research group here at Nagoya University has achieved advances in etching technology that have broadened the applicability of anisotropic etching."

Attesting to the Sato group's advances are a diversity of elaborate microstructures fabricated by the group on single-crystal silicon and quartz wafers. The group has used these microstructures in several practical applications, including a silicon micro-needle array for transdermal drug delivery, a micromachined flow sensor for medical applications, and a microsystem for on-chip testing of the tensile strength of micro-electromechanical materials. In addition, Sato's group and a corporate partner have commercialized an etching simulator and a related database.

Micromachines and microart

Advances in a different approach to microfabrication at Nagoya University are demonstrated by the remarkable creations of the irrepressible Koji Ikuta. A professor of microsystem engineering in Nagoya University's School of Engineering, Ikuta is something of a celebrity in Japan. He has used a technology that he calls 'integrated hardened polymer stereolithography' to create a series of micro-scale machines, medical devices and playful 'microart'. His works have appeared in science magazines and on national television, where they have captured the imagination of the general public and raised Ikuta's profile in the scientific community.



Two technologies developed for micro–nano mechatronics. (Left) Anisotropic etching of silicon by Kazuo Sato's group. (Right) An optically driven nano-robot fabricated by Koji Ikuta's group.

"My technology," Ikuta confides, "is a far advanced version of the stereolithography that manufacturers use in rapid prototyping. Focusing an ultraviolet laser beam on a polymer solution cures the polymer at the focal point of the laser. Moving the laser in accordance with design data fabricates whatever shape the data describes. I have refined stereolithography to allow for fabricating micro-scale three-dimensional moving objects such as gears and robot hands in a matter of minutes and at a resolution of 100 nanometres."

Medical research and therapy are natural applications for microdevices, and Ikuta has developed a series of promising biomicromachines. For instance, he has used two-photon nano-stereolithography to fabricate nano-forceps — controlled by optical trapping — for grasping and handling individual cells. Other medical devices that have emerged recently from Ikuta's laboratory include nano-scale needles for piercing cells, a microcatheter driven by the pressure of physiological saline solution for conducting intravenous endoscopic surgery, and a versatile modular micro chemical device called a 'biochemical IC chip', which contains micropumps and other micromechanical components for performing biochemical analyses and syntheses.

Nagoya University Global Center of Excellence (G-COE) Programs

Department of Micro-Nano Systems Engineering, Graduate School of Engineering, Nagoya University

Department of Materials, Physics and Energy Engineering, Graduate School of Engineering, Nagoya University

Graduate School of Medicine, Nagoya University

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Molecular targeted therapy

Nagoya University's Global Center of Excellence (G-COE) program in the Graduate School of Medicine adopts an integrated approach to finding solutions to life-threatening neurodegenerative diseases based on 'molecular targeted therapy'.

The G-COE for Integrated Functional Molecular Medicine for Neuronal and Neoplastic Disorders established in 2008 is one of Nagoya University's seven high-profile G-COE programs. Gen Sobue, dean of the Graduate School of Medicine and leader of the G-COE program, has discovered a molecular link between causes of cancer and neurodegenerative diseases. The findings are a major breakthrough in the treatment of these disorders. "We have demonstrated that certain functional molecules are common to both neurodegenerative disorders and cancer," says Sobue, who is also a professor in the Department of Neurology. "We refer to this as 'molecular targeted therapy' for the treatment of neuronal and neoplastic disorders."

New therapies for neurodegenerative disease

Sobue's team has received international acclaim for a series of crucial findings on the treatment of neurodegenerative diseases. Sobue developed a transgenic mouse model of spinal and bulbar muscular atrophy (SBMA), which is caused by mutations in the androgen receptor gene. SBMA affects males and is characterized by muscle cramps and gradual muscle wasting due to the degeneration of motor neurons in the brain stem and spinal cord responsible for muscle movement control. There is no effective treatment as yet.

"Castration led to symptomatic improvements in transgenic mice, and conversely, testosterone administration to female transgenic mice led to exacerbated symptoms," says Sobue. "These results opened up the possibility of therapy using hormones."

Based on these findings, Sobue's group examined the effect of androgen-blockade drugs on transgenic mice using leuprorelin (a luteinizing hormone-releasing hormone agonist that reduces testosterone release) and flutamide (an androgen antagonist that does not affect the release of testosterone or the nuclear translocation of androgen receptors). "Leuprorelin led to a dramatic improvement of the transgenic mice and totally prevented mortality, so this molecule shows potential for tackling SBMA," says Sobue.

Leuprorelin is already used for treating prostate cancer, and clinical trials for its use for treating SBMA have been completed. "Our phase-two trials showed that administration of leuprorelin inhibited functional deterioration of SBMA patients," says Sobue. "We have now started phase-three trials."

The ansamycin antibiotic 17-AAG is a heat shock protein 90 (Hsp90) inhibitor used in anti-tumour therapy. Sobue studied the potential of using 17-AAG for SBMA therapy based on a cultured cell model and the transgenic model for SBMA. "Administration of 17-AAG inhibited neuronal nuclear accumulation of the mutant androgen receptor and significantly improved motor phenotypes of the SBMA model mouse," says Sobue. "These results have widespread implications for other neurodegenerative diseases."

Amyotrophic lateral sclerosis (ALS) is a crippling, often fatal, neurodegenerative disease caused by the degeneration of motor neurons in the central nervous system responsible for voluntary muscle movement control. "About 90% of ALS patients have sporadic episodes," says Sobue. "The pathogenic mechanism of motor neuron degeneration and ultimately cell death in sporadic ALS is still not well understood."

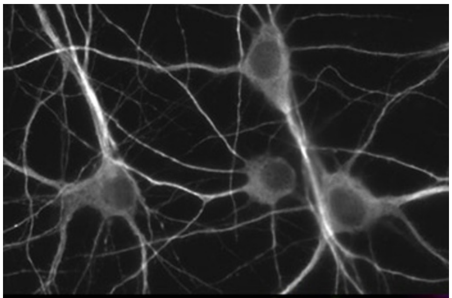
Sobue's team used laser-capture microdissection, RNA amplification and DNA microarray analysis to clarify the alternations of motor neuron-specific gene expression in sporadic ALS cases, and have compiled a gene database for degenerating motor neurons in sporadic ALS spinal cord. The results provide direct information regarding the genes responsible for neurodegeneration and neuronal death, and will be invaluable for devising new therapeutic protocols.

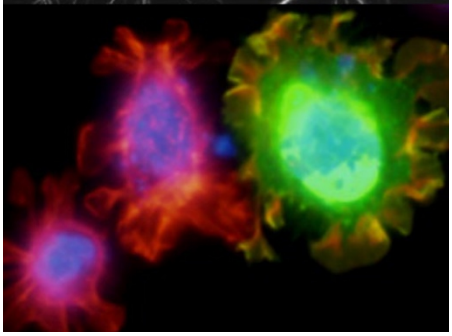
Targeting neurological disorders

Kozo Kaibuchi is assistant leader of the G-COE program and principal investigator of the polarity of neurons and migrating cells in the Department of Cell Pharmacology. "We are investigating functions and regulatory mechanisms of Rho-family GTPases and their effectors in organization of the cytoskeleton, and in migration, adhesion and polarization," says Kaibuchi.

Rho plays critical roles in regulating the cytoskeleton, adhesion, smooth muscle contraction and neurite retraction. However, the underlying mechanism had remained elusive until Kaibuchi and his team isolated effectors of RhoA, such as myosin phosphatase target subunit 1 (MYPT1), using an affinity column coated with RhoA in 1996. Rho-kinase phosphorylates MYPT1 and inactivates myosin phosphatase activity, leading to an increase in myosin phosphorylation for smooth muscle contraction and neurite retraction. "These were the first studies demonstrating how the Rho family regulates the cytoskeleton and cell adhesion," says Kaibuchi. In 2000, his team isolated collapsin response mediator protein 2 (CRMP-2) as a substrate of Rho-kinase, and found that CRMP-2 phosphorylation is involved in neurite retraction. "Rho-kinase is a promising drug target for neurological disorders including stroke and nerve injury," he says.

Neurons are highly polarized cells, most of which develop a single axon and several dendrites from common immature neurites. These two parts acquire specific characteristics that enable neurons to transmit intercellular





Integrated functional molecular medicine for neuronal and neoplastic disorders

signals from several dendrites to an axon. In 2001, Kaibuchi and his colleagues found that CRMP-2 induces the formation of multiple axons when overexpressed in hippocampal neurons. "This was the first example showing that a single protein regulates neuronal polarity," says Kaibuchi, who has played a central role in clarifying the molecular mechanisms underlying neuronal polarization.

Kaibuchi's project in the G-COE is challenging. He is looking for CRMP-2-interacting molecules by affinity-column chromatography coupled with liquid chromatography and mass spectroscopy. So far, he has identified synaptotagmin-like protein 1 (Slp1), which forms a complex with CRMP-2 and the tyrosine kinase TrkB. Slp1 is also a receptor of brain-derived neurotrophic factor and a regulator of the anterograde transport of TrkB for axon formation. "CRMP-2 is a new target for the treatment of Alzheimer's disease, schizophrenia and nerve injury," says Kaibuchi.

The causes of schizophrenia remain a mystery, although it is agreed that the disease is a neurodevelopmental and neurodegenerative disorder involving disconnectivity and disorder of the synapses. Kaibuchi is clarifying the pathology of schizophrenia by analysing molecular functions of susceptibility genes for schizophrenia, including CRMP-2 and disrupted in schizophrenia 1 (DISC1).

"By combining a proteomic approach with molecular and cellular biology and human genetics, we are probing the molecular network of the susceptibility gene products that account for pathogenesis," says Kaibuchi.

Researching the origins of disease

Masahide Takahashi of the Department of Pathology is another assistant leader of the G-COE program and also head of the Center for Neurological Diseases and Cancer. His research focuses on oncogenesis, the processes leading to cancer formation, and organogenesis, the study of organ formation.

In 1985, Takahashi reported the activation of a novel human transforming gene *RET* (receptor tyrosine kinase) by DNA arrangement. "*RET* is a critical component of cell signalling networks," says Takahashi. "*RET* governs physiological processes such as neural development in the enteric nervous system, kidney development and spermatogenesis, and even the progression of certain types of cancer."

RET has since been found to have additional roles. "Surprisingly, it turned out that this one gene is responsible for four syndromes." Takahashi has discovered important molecular mechanisms controlling the progress of these diseases. "We found that gain-of-function mutations of *RET* cause multiple endocrine neoplasia type 2, papillary thyroid carcinoma and medullary thyroid carcinoma, whereas loss-of-function mutations cause Hirschsprung's disease," he says. "We had to devise accurate mouse models to study the properties of *RET in vivo*, and then generate disease model mice."

Takahashi and his colleagues discovered that *RET* was activated by the family of ligands know as glial cell-derived neurotrophic factors, and that the co-receptors of one of these factors (GFRa) are necessary for *RET* activation. "Based on these findings, we succeeded in generating transgenic mice showing the Hirschsprung phenotype," says Takahashi.

Takahashi's team is also studying the role of an actin-binding protein, 'girdin', in cancer cell motility and angiogenesis. Actin is a component of the cytoskeletal system involved in the movement of cells and cellular processes. "Girdin is a binding partner of the serine/threonine kinase Akt," says Takahashi. Akt signalling has been found to be activated by tyrosine kinases including *RET*, and to regulate cancer invasion and metastasis. Takahashi identified girdin as the Akt substrate responsible for regulation of cancer invasion and metastasis, and postnatal angiogenesis.

Girdin has been demonstrated by Takahashi's group to co-localize with actin filaments in lamellipodia and stress fibres, and phosphorylated girdin has been found to accumulate at the leading edge of migrating cells. "Treatment with girdin siRNA resulted in disruption of stress fibre and lamellipodium formation," says Takahashi. "We also found that phosphorylation of girdin by Akt is necessary for directional cell migration."

The team also constructed siRNA-resistant versions of girdin incorporating silent mutations. "Girdin regulates vascular endothelial growth factor-dependent migration of human umbilical vein endothelial cells," says Takahashi. "We found that girdin regulates tube formation in these cells, and that girdin phosphorylation is necessary for postnatal angiogenesis *in vivo*." The researchers also found deformations in the cell structure of the hippocampus of girdin-knockout mice. "We have identified several molecules associated with girdin and we hope that the results of our research will lead to discoveries of diagnostic cancer markers and therapy for patients," says Takahashi.

Nagoya University Global Center of Excellence (G-COE) Programs

**Graduate School of Medicine,
Nagoya University**

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THE ASAHI SHIMBUN COMPANY

A medical approach to environmental issues

Nagoya University has adopted a medical metaphor in a new initiative aimed at diagnosing environmental issues and proposing therapeutic responses.

Interaction among the geosphere, hydrosphere, biosphere and atmosphere is an enabling condition for life on Earth, but the mechanisms of that interaction remain largely a mystery. Nagoya University combines extensive resources in geophysical, hydrospheric, biospheric and atmospheric sciences with social science resources in treating the environment as a biological organism.

Nagoya University's new initiative in environmental studies has received funding under the Japanese government's Global Center of Excellence (G-COE) program for five years from 2009 to 2013. The initiative dovetails with a highly successful undertaking conducted from 2004 to 2008 under the previous 21st Century COE program. Differentiating the new initiative from its predecessor are the emphasis on diagnostic and therapeutic approaches and the addition of social science disciplines, including urban planning and behavioural geography. Expertise in the social sciences will be crucial to therapeutic proposals for shaping human activity in accordance with environmental sustainability.

"The theme for our centre of excellence is 'From earth system science to basic and clinical environmental studies,'" reports Takeshi Ohta, a professor of forest meteorology and hydrology in Nagoya University's Graduate School of Bioagricultural Sciences. "That's sort of an unwieldy phrase, but it describes our approach well. We are aiming to move beyond narrow scientific inquiry and into the realm of holistic environmental studies. The term 'clinical' in our theme is a reference to diagnosing and treating environmental problems. The term 'basic' refers to the interdisciplinary expertise and organizational capabilities that we are fostering in connection with our clinical approach."

Tetsuzo Yasunari, the program leader and a professor at Nagoya University's Hydrospheric Atmospheric Research Center, emphasizes the positive interaction between clinical fieldwork and basic science. "Our activity in diagnostic and therapeutic work highlights phenomena that warrant careful attention in scientific inquiry and education. And our progress in fortifying the scientific foundation for environmental studies supports practical measures for promoting sustainability in the biosphere."

"The stepped-up emphasis on education is especially important in our new centre of excellence," adds Takeshi Nakatsuka, a professor of geochemistry in Nagoya University's Graduate School of Environmental Studies. "That means welcoming doctoral students from abroad who are interested in participating. And it means dispatching everyone to project sites for fieldwork."

A closely related program at Nagoya University welcomes master's degree students for studies in environmental science. The university's Global Environmental Leaders Program accepts ten students each year from outside Japan, mainly from Asia and Africa, and five from Japan. No Japanese-language skill is necessary, since the instruction and course materials are in English. The students enter the Graduate School of Environmental Studies and learn to analyse environmental issues and to devise countermeasures.

Three-region coverage

Nagoya University's new G-COE for environmental diagnosis and therapy encompasses on-site research in Japan, south and southeast Asia, and northeast Asia. In Japan, researchers are studying the ecology in and around Ise Bay, which stretches south from Nagoya. The activity in south and southeast Asia centres on a project in Laos for preserving biological diversity while maintaining traditional modes of work and living, and a project in the Himalayas for evaluating glacial movement and the collapse of glacial lakes. In northeast Asia, researchers are studying ways to reduce the environmental impact of rapid economic development in China and evaluating the taiga ecology and changes in the water cycle in Siberia.

"The geographical scope might sound sort of intimidating," concedes Yasunari. "But our members include researchers who have been conducting studies at the project sites. So this is a matter of continuing with ongoing fieldwork and upgrading that research by deploying additional resources."

The Ise Bay basin presents a mix of demographic and ecological trends typical of present-day Japan, where the population is shrinking and ageing. Pastoral villages around the bay are shrinking and even disappearing as young people decline to succeed their parents in agriculture or forestry. That leaves growing swathes of land untended, and the changing landscape poses environmental issues, such as declining biodiversity, for Nagoya and its suburbs and for the waters of the bay. Researchers from Nagoya University are working with municipal authorities

The city of Yokkaichi on Ise Bay, Japan. Known for its air pollution problem in the 1960s, the region is now facing another set of sustainability issues.

From earth system science to basic and clinical environmental studies

and non-profit organizations to develop a model for sustainability in the Ise Bay basin.

Highlighting the overseas projects being conducted through the G-COE is a comprehensive undertaking in Laos. In that nation, an age-old subsistence economy coexists with a newly emerging market economy. It is an uneasy coexistence, and it presents the familiar threats of social unrest caused by the demise of traditional lifestyles, diminished biodiversity caused by the conversion of forest to farmland, and changes in water and material cycles associated with changing land use. Nagoya University researchers are working with the National University of Laos and the Laos National Research Institute for Agriculture and Forestry to analyse those and other potential problems and to devise viable countermeasures.

Excellent local partners also fortify the project in China. There, researchers from Nagoya University are working with counterparts at several universities and research organizations, including Tongji University in Shanghai, Nanjing University and Tsinghua University in Beijing. They are collaborating in studying such issues as water resources management in the Huang He (Yellow River) watershed and China's dry northern regions; acid rain, windborne dust, smog and other environmental problems that transcend national borders; and characteristically urban challenges, such as automotive air pollution and sewage treatment.

An emphasis on fieldwork

Yasunari echoes Nakatsuka's emphasis on fieldwork. Characterizing the research in environmental studies at Nagoya University is a longstanding commitment to venturing into the field for on-site observation. Yasunari has trekked repeatedly through the Himalayas to examine the glacier record of past weather patterns. His research on climatology has taken him all across Asia, and he has monitored and modelled monsoon and hydro-climatological trends in several Asian nations. He expresses a determination to maximize opportunities for students and faculty to gain similar experience through the new G-COE.

Yasunari's colleague Hidefumi Imura brings a different kind of experience in fieldwork to the centre. Imura is a professor of urban environmental studies at the university's Graduate School of Environmental Studies. Before entering academia, he spent 14 years in national and municipal government agencies, where he participated in framing environmental policy. Imura is thus familiar with the policy-making aspects of environmental management. In addition to his hands-on experience in the Japanese civil service, he has studied environmental policy-making in other Asian nations, and he has written extensively about environmental policy in the context of economic development.

At Nagoya University's Environment G-COE, Imura works on the therapeutic side. He coordinates work on devising means of ameliorating environmental issues identified by his colleagues on the diagnostic side. That includes applying the lessons of his continuing work in energy- and material-flow analyses of urban activity, life-cycle assessments of civil infrastructure and modelling of human–environment interactions. Imura, incidentally, serves concurrently as the program leader of the Global Environmental Leaders Program, so he is in the vanguard of measures for internationalizing Nagoya University's overall activity in environmental science.

Agriculture in Luang Phabang Province, Laos. The mosaic landscape is made up of shifting cultivation fields.

"We are laying a foundation," says Imura, "with our Global Environmental Leaders Program and with our centre of excellence. It is a foundation of expertise and leadership for future environmental planning and management in Japan and throughout Asia. This is a two-way street. We in Japan possess valuable experience in reconciling development with environmental protection, and we share that experience with counterparts in developing nations through these programs. We gain valuable insight, meanwhile, from our partners in other nations. This is a genuine example of achieving synergies through pursuing shared goals in sustainability."

Nagoya University Global Center of Excellence (G-COE) Programs

Graduate School of Environmental Studies, Nagoya University

Department of Biosphere Resources Science, Graduate School of Bioagricultural Sciences, Nagoya University

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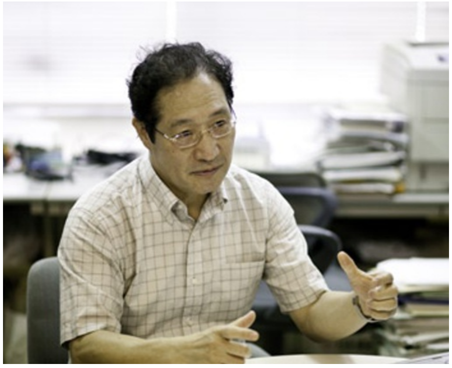

A scientific look at plasma technology

Nagoya University is an international centre for plasma research. Osamu Takai of the Graduate School of Engineering and Masaru Hori of the Plasma Nanotechnology Research Center lead the world in the generation, analysis and application of plasma technology in next-generation nanotechnology.

Takai is developing advanced applications of 'solution plasma' — plasma that discharges not in air, but in liquid. "The key characteristic of solution plasma is that the discharge occurs in liquid," says Takai, a member of the Research Center for Materials Backcasting Technology and the Department of Materials, Physics and Energy Engineering at Nagoya University. "Solution plasma is usually used for welding, machining and electrolysis in liquids. We want to take this technology to the next level for nanofabrication and synthesis of nano-materials."

Takai demonstrated the first solution plasma discharge in a liquid using a pulsed power supply developed at Nagoya University. "The advantages of solution plasma are that the reaction speed and mass transfer are high, and that electrode damage and thermal fugacity are low," says Takai. He has used solution plasma processing to produce novel metallic nanoparticles including gold, platinum–iron and carbon nanoballs for applications in magnetic storage and biotechnology.

Chlorine, ozone and ultraviolet (UV) light are widely used for sterilizing water. However, these agents have problems related to safety, efficiency and cost. "Solution plasma produces an intense UV emission that we have used to achieve the total destruction of *Escherichia coli* and *Staphylococcus aureus* bacteria in less than 30 seconds," says Takai. "Water treatment is an important application."

Takai's plasma expertise also has him involved in biomimetic materials processing for the development of biomimetic nanotechnologies. "We use organosilane self-assembled monolayers to prepare surfaces with controlled chemical properties including reactivity, hydrophobicity and isoelectric point, and with controlled nanostructures," says Takai. He is applying this self-assembled monolayer (SAM) technology, which is enhanced by the use of microwave plasma, in nanofabrication processes to replace conventional photo and electron resists. His SAMs can cover large-area substrates of up to 200 mm across by a simple and inexpensive chemical vapour deposition (CVD) process.

Takai has used SAMs to produce superhydrophobic surfaces for applications including automobile parts, textiles, building materials and medical equipment. "Our microwave plasma-enhanced CVD system makes it possible to manufacture A3-sized sheets with superhydrophobic surfaces at a rate of 2,000 sheets per hour," says Takai. The preparation of such surfaces also involves vacuum UV irradiation using a xenon excimer lamp system produced by the venture company n-Factory.

Hori's goal is to quantify plasma processing. He is director of the Plasma Nanotechnology Research Center at Nagoya University and a member of the Department of Electrical Engineering and Computer Science. "Nagoya University has a 50-year tradition of research on plasma technology," he says. "Our challenge is to meet the needs of nanotechnology manufacturing where large-scale integration technology is going from 40 nm to 20 nm, and eventually to the 10 nm scale, requiring accuracy of 1 nm — that is equivalent to the size of only four hydrogen atoms."

However, the conditions used for a given plasma process are not universal. "Plasma is an extremely important tool in the electronics industry, but it's not a science," says Hori. "Semiconductor manufacturing entails investments of hundreds of millions of dollars. These costs could be reduced if we could determine the species of radicals generated during plasma processing."

Hori and his colleagues have developed an 'atom/molecule' sensing system that allows not only optimization of device processing but also the fully autonomous fabrication of nanodevices. The 'ubiquitous plasma monitoring system' consists of a compact vacuum UV monochromator, a micro-sized hollow cathode lamp and a 2.7 mm-diameter probe installed in the plasma. This allows the measurement of atoms, such as hydrogen, and radicals, such as carbon-fluoride (CF_x), in the plasma. The system is being commercialized by two of the university's venture companies.

Hori is using this new technology to fabricate maze-like structures of carbon nanowalls with aspect ratios of around 300. "These nanowalls will be used in new types of solar and fuel cells, and as superhydrophilic biotemplates," Hori says.

The Plasma Nanotechnology Research Center is part of the Tokai Region Nanotechnology Manufacturing Cluster project, which includes all the major universities in the Aichi, Mie and Gifu regions, and 56 companies and local governments. "Our goal is to produce innovative materials and devices to support the automobile, aerospace and machine industries," says Hori. The project has a budget of 80 million dollars over five years.

Hori is also building the Plasma Science Network and Advanced Plasma Nanotechnology Science Foundation, which will have 28 affiliates in Japan and 20 overseas. "Sharing knowledge on plasma technology is critical for achieving our goals," he says. "There have been 18 Nobel Prizes awarded for tools such as the scanning tunnelling microscope. A deeper understanding of plasma science will hopefully produce ideas of a similar calibre."

Research Center for Materials Backcasting Technology, Nagoya University

Plasma Nanotechnology Research Center, Nagoya University

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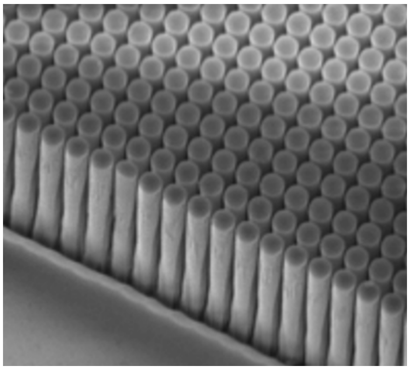


World-class medical care in the palm of your hand

Nagoya University is fostering a new generation of cooperation in medical technology at its Innovative Research Center for Preventive Medical Engineering.

To contribute to advances in the quality of life by promoting progress in preventive medicine — that is the founding mission of Nagoya University's Innovative Research Center for Preventive Medical Engineering (PME), a centre funded by the Japanese Ministry of Education, Culture, Sport, Science and Technology (MEXT). Established in 2007, the centre bridges the medical, engineering, academic and corporate sectors.

The impressive resources at the centre include a stellar cast of corporate members: Fujitsu, a leader in information technology active in medical informatics; Furukawa Electric, a manufacturer of fibre-optic products with interests in medical equipment; ITOCHU Corporation, a prominent trading house skilled in organizing projects and commercializing technologies; NGK Insulators, a leader in ceramics for medical applications; Olympus, the world's largest supplier of gastrointestinal endoscopes; and Toyota Motor Corporation, which participates in diverse initiatives in coupling mobility with healthcare.

Work with these corporate partners is complemented by resources in medicine, engineering and information science at Nagoya University. The university and corporate participants undertake joint research in groups devoted to diagnostic and surgical technologies, microdevice technology, informatics, medical systems, healthcare technology and information systems.

Health care in daily life

"Traditional healthcare," quips Yoshinobu Baba, a core member of the PME centre, "has meant getting sick at home and going to a hospital to get well. We want to eliminate the distance between people and healthcare. Ideally, we'd like to keep people from getting sick at all. And when they do get sick, we want to detect, diagnose and treat their problems in the early stages."

Baba is a professor of chemistry in Nagoya University's Graduate School of Engineering. An interest in making DNA analysis faster and more compact stirred Baba to develop electrophoretic chips on glass and plastic substrates. He has earned renown with his biochips for isolating individual molecules of DNA and steering them through arrays of nanofabricated pillars. A research project on single DNA molecule sequencing technology based on these nanofabricated devices has recently been accepted by Japan's largest funding program for world-leading innovative research and development in science and technology.

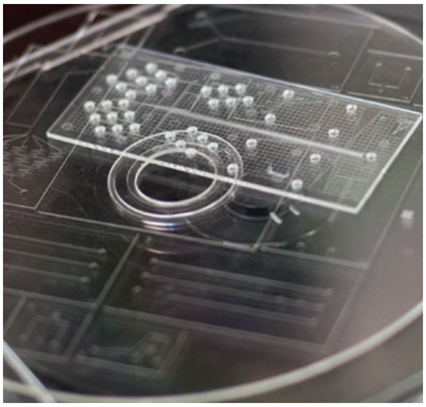
Recently, Baba developed a technology for sorting cells in blood on a biochip using optical pressure from an infrared laser. A bioactive marker stains cells that match a specific criterion, such as cancer stem cells. When irradiated with a laser, the unmarked cells are pushed away, while the stained cells are unaffected. Baba is also experimenting with quantum dots and other nanoscale technologies for miniaturizing diagnostic and analytical systems.

Size figures prominently in the guiding vision for the PME centre. The motto for the centre is 'World-class medical care in the palm of your hand'. The idea is to make diagnostic devices small enough and fast enough to provide unobtrusive health monitoring in the home and even on the run: while jogging, for instance, or even while driving to work.

Seiichi Matsuo, director of Nagoya University Hospital and another core member of the PME centre, emphasizes that the most important outcome of research at the centre is the establishment of new preventive medical systems by combining information technology systems for medicine and health with medical devices developed by the centre.

Nagoya University Hospital forms part of an extensive medical network that includes a number of major hospitals in the Nagoya region. The network is Japan's largest, supporting over 20,000 beds. The Nagoya University Hospital and the Nagoya medical network are set to apply Nagoya University's preventive medical system in an effort to prevent cancer, metabolic syndrome and the spread of pandemic influenza.

"Big, slow equipment," notes Baba, "means that people need to go to the hospital for diagnosis. Most of us tend to procrastinate, of course, in regard to hospital visits. And that can mean critical delays in the detection of incipient problems. That's why I'm working to make medical devices smaller, faster, simpler and more affordable. Within a few years, some of our technologies could be making a real contribution to helping people stay healthy."



A biochip for DNA electrophoresis.
These miniature diagnostic devices, developed by Yoshinobu Baba, form the basis for a new project on single DNA molecule sequencing.

MEXT Innovative Research Center for Preventive Medical Engineering, Nagoya University

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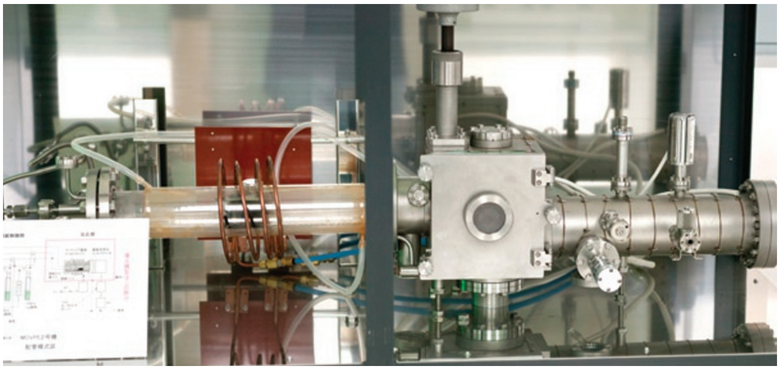

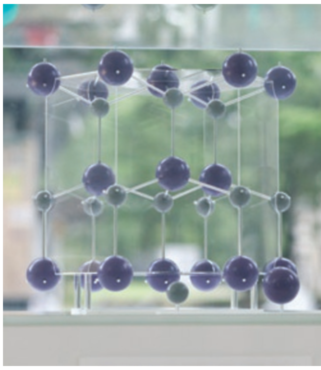

Industrial–academic collaborations going global

Nagoya's proud economic strengths are supported by effective collaborations between businesses and academia, in which Nagoya University plays key roles as a catalyst, a leader of global networks and a provider of promising research seeds.

The Japanese model of technology transfer

The Greater Nagoya region, encompassing the prefectures of Aichi, Mie and Gifu, is known for its long-standing manufacturing prowess — it produces approximately 10% of Japan's total economic output. Avid and effective collaborations between industry and academia have greatly contributed to the robust economy.

Possibly the best example of Nagoya-based collaboration is the invention of high-performance blue light-emitting diodes (LEDs), which many people thought would be impossible. After 20 years of effort, Isamu Akasaki, an emeritus professor of Nagoya University, succeeded in 1989 in developing the illuminant device based on a gallium-nitride (GaN) semiconductor.


©J-TEC

Autologous cultured epidermis for treatment of burns. The technology for keratinocyte cultivation developed by Minoru Ueda is being commercialized by the Nagoya University spin-off J-TEC.

Akasaki's work came to light in 1986 when Toyoda Gosei, an automotive parts manufacturer in Aichi, started joint development with Akasaki. The government also provided considerable funding. Thanks largely to Akasaki's patents, Nagoya University has become the biggest earner of patent income among Japanese universities.

Akasaki is one of Nagoya University's many top scientists who embrace entrepreneurship: Ryoji Noyori, a professor of chemistry at Nagoya University and a Nobel laureate in 2001, has also lent his expertise in asymmetric synthesis to a number of companies.

Regenerative medicine is another field of technology transfer pioneered in the Greater Nagoya region. In 2007, Japan Tissue Engineering (J-TEC) became the first Japanese company to receive government approval to develop and sell a tissue-engineered cellular product — autologous cultured epidermis for the treatment of serious burns. The company's core technology is based on the expertise of Minoru Ueda, a medical professor at Nagoya University. J-TEC is one of about 30 venture companies spun out from Nagoya University.

Growing international partnerships

Nagoya University is exploring opportunities for unconventional partnerships. It acts as a gateway to transfer technology and research seeds from the university, local research communities and the government offices in the Tokai area to the US and other countries, and to accept international research results in return. "The relationships among manufacturers, academics and the municipal government are traditionally so strong that collaboration often occurs naturally," says Takashi Miyata, trustee and vice president of the university. This is exemplified by Nagoya University's close ties with the Greater Nagoya Initiative, a local government program established to entice investment from abroad.

Blue LEDs light the clocktower on the Toyoda auditorium. The tower is the symbol of Nagoya University, illuminated with the captivating light of the blue LEDs invented by Isamu Akasaki.

Nagoya University's leadership is not limited to local activities. It has initiated the creation of the Academic Consortium 21, a worldwide network of universities that promotes high-level cooperation in education and research. Nagoya University also knows that establishing a firm foothold abroad is essential. In 2008, it founded a non-profit organization called the Technology Partnership of Nagoya University in North Carolina to promote industry–university collaboration.

Miyata says the most imminent and important concern is education for overseas students. Exploiting Nagoya's strength in automotive engineering, Nagoya University organizes an intensive summer school that boasts visiting lecturers from top companies and from within the university. The program, entirely in English, has become so popular that the number of participating students from abroad doubled to 30 this year. Separately, Nagoya University also plans to launch special courses in aviation engineering for students from Vietnam and other Asian countries. "From now on, we'd like to strengthen our outreach to Europe, and also enhance our endeavours to build firmer relationships throughout Asia," says Miyata.

Comprehensive support gears up

Having begun its global expansion earlier than other universities in Japan, Nagoya University has established effective organizations to support industry–academia collaborations.

Back in 2000, Nagoya University enacted its Academic Charter, stipulating the fundamental objectives for research and education, as well as the university's contribution to society. To achieve these goals, the Headquarters for Industry, Academia and Government Cooperation was established under the direct supervision of the university president. The headquarters hosts the Intellectual Property Section, responsible for managing the transfer of technology from research to market.

In 2006, the headquarters added the Unit for Industry, Academia and Government Cooperation, which became the umbrella organization for the Intellectual Property Section and the newly established Networking Section and Ventures Promotion Section. The International Technology Transfer Section was created in 2007 to accelerate international collaborations.

The headquarters boasts 50 staff, making it one of the largest technology transfer teams in Japan. Japanese national universities became more aware of intellectual property issues after becoming Independent Administrative Institutions in 2004. Under the new government policies, the universities are required to increase their competitive and private funding, although the majority of funding still comes from the government. Nagoya University was one of the pioneers in stipulating official rules for handling intellectual property as a university.

The headquarters supports a number of collaboration projects, including the Nano-Technology Manufacturing Cluster, one of the projects of the Japanese government's Knowledge Cluster Initiative. The manufacturing cluster aims to make the Greater Nagoya region a global centre of environmentally friendly nanotech manufacturing. The region has also won two out of 19 Industrial Cluster projects sponsored by the Japanese government. One of the projects is designed to create new manufacturing industries in the Tokai area, an area on the Pacific Coast that includes Greater Nagoya. The other, the Tokai Bio-Factory project, has been established to create new biotech industries based on local manufacturing expertise. The headquarters also supports Aichi Prefecture's initiative to construct a synchrotron facility.

The new educational role of the university

Amid intensifying competition, Nagoya University is adding value to its role by providing new educational courses and meticulous career consulting.

The Japanese government's bold initiative to produce 10,000 postdoctoral fellows between 1996 and 2000 had a dramatic effect in opening the doors of graduate schools. The outcome, however, has created serious problems — with academic posts now limited and postdoctoral researchers resisting the transition to private enterprise. Due partly to the sluggish economy, companies have also been shying away from hiring PhD holders under the preconception that they are rigid and difficult to work with. The result has been the proliferation of PhD holders without jobs that fulfil their abilities.

To address this difficult issue, Nagoya University has been acting as a consultant to "encourage postdoctoral researchers and doctoral students to find the best possible job opportunities anywhere, including outside the academic world," says Yutaka Takeda, a professor and head of the Networking Section at the University–Industry Collaboration Office. The career program was strengthened in 2008 when Nagoya University was identified as one of 12 universities to receive funding from the Japanese government's initiative to foster young people who can contribute to society. The new headquarters now runs these placement programs.

Over the past three years, Nagoya University has successfully helped 200 PhD holders find suitable employment — the highest achievement among the 12 target universities — ranging from industry–academy coordinators, museum curators and science writers, to patent office staff and roles in venture companies. The career program, managed by the Headquarters for Industry, Academia and Government Cooperation, now has about 600 registrants, 40% of whom are from Nagoya University and the rest from elsewhere in Japan and abroad.

The university is also supporting unique extension courses to re-educate industrial engineers. Engineers from automobile companies come to Nagoya University's Center for Embedded Computing Systems to polish their software development skills. The university has formed a consortium with Mitsubishi Heavy Industries and other regional aircraft developers to foster engineers who can take a leadership role in international aircraft development projects. These initiatives are also part of the regional collaboration program to enable people to obtain management skills in comprehensive agricultural businesses.

"A university's mission is changing. We need to offer new types of education and support to contribute more to society," says Miyata.

Initiatives for Industry, Academia and Government Cooperation, Nagoya University

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All the world is here

Nagoya University offers world-class teaching and research across a full range of academic disciplines in a unique atmosphere of intellectual freedom.

It is a truth universally acknowledged that a single university producing over half of its country's Nobel Prize-winners in a century must be doing something right. While the creation in 2008 of four new Japanese-born science Nobel laureates was a cause for national celebration, feelings of pride were especially strong at Nagoya University as three of the four recipients announced in that year — Makoto Kobayashi, Toshihide Maskawa and Osamu Shimomura — spent some, or all, of the formative years of their research careers at Nagoya University. Such an achievement may seem extraordinary to some, but to observers at Nagoya University, or *Meidai* as it has been nicknamed, such high accolades have become almost par for the course. When one counts the Nobel Prize won in 2001 by Ryoji Noyori, Nagoya University is responsible for producing four of seven Japanese-born Nobel Prize-winners in the twenty-first century. With such an astonishing hit-rate, Nagoya University is clearly onto something special. So what is the secret of its amazing success?

"To be honest, I don't really know," says Yoshihito Watanabe, one of the vice presidents of Nagoya University, "but I think it's something to do with the academic freedom that exists at *Meidai*. Nagoya was the last of the seven imperial universities to be established, and this drew in a large number of younger professors, especially in physics and chemistry. As a result, although the people at the top were all outstanding academics, they were not regarded as being *erai*," he explains, using the Japanese word for treating someone with deference based solely on their age or position. "So a culture grew up of students being able to challenge the professors and develop new ideas by themselves in an atmosphere of scientific freedom. This is quite different from other Japanese universities, where the senior professor is often a very imposing figure and research is carried out within a formal and rather rigid framework."

Excellence in depth and breadth

Not unreasonably, such high-profile recognition of the strength of scientific research at Nagoya University has somewhat stolen the limelight of late. However, in addition to top-level excellence in science, the university offers a full portfolio of world-accredited undergraduate and graduate schools spanning engineering, law, medicine, languages and culture, as well as liberal arts, economics and social sciences, all supported by high-class infrastructure and facilities commensurate with the reputation and pedigree of *Meidai*. Nagoya University prioritizes educational excellence coupled with ambition and vision: students are encouraged to not only study for their own benefit, but also to ask how their skills and abilities can be used to benefit the local community and society in general.

As well as being unabashedly high-minded, the learning environment at Nagoya University is international too. Of the more than 15,600 students enrolled in undergraduate and postgraduate programs, around 1,350 are foreign students hailing from 78 different countries on all five continents. It's a record of which most Japanese universities would be proud, but Watanabe is not satisfied and has set an ambitious target of more than doubling the number of foreign students attending *Meidai* to 3,000 by 2020. "We want to create a truly international environment at Nagoya University, where it is impossible not to meet overseas students," he explains. "In such an environment, both Japanese and foreign students will be able to learn from each other and gain a better understanding of each other's language and culture. But it's not just about increasing numbers, we want to attract the very best overseas talent to come to Nagoya University and stimulate Japanese students here." An indication of what this kind of approach could achieve can be seen by looking at Watanabe's own Chemistry Global Center of Excellence program where active recruitment of top-class overseas talent has already resulted in the intake of a significant number of foreign students, who now work alongside their Japanese colleagues. The results speak for themselves: improved scientific English communication skills, greater confidence in presenting at international conferences and better all-round day-to-day interactions with their overseas peers.

Global 30: The big chance

The move to greater internationalization has been given a tremendous boost by the selection of *Meidai* for funding under the Global 30 program. Introduced in 2008 by the Japanese government, the Global 30 program is an initiative that aims to increase the number of foreign students studying in Japan from the current level of 130,000 to more than 300,000 over the next ten years. In the first round, a total of 13 institutions across Japan, including Nagoya University, were selected to participate in the project, which carries substantial annual funding of 200–400 million yen

Nagoya University life. The university maintains a friendly and accessible atmosphere through its extensive range of student services and facilities.

per recipient. It's an opportunity that *Meidai* has grabbed with both hands. "We see the Global 30 program as our big chance to get ahead in internationalization," says Watanabe. "It fits right in with plans we had been making for a while, and without the additional funding we would not have been able to realize them." Whereas some universities in Japan submitted applications for the scheme out of a sense of duty and without much enthusiasm, for *Meidai* it was viewed as a once-in-a-lifetime opportunity to catch up with the likes of the US and Europe in attracting overseas talent.

Japanese no obstacle

Funding from the Global 30 program has made possible a root-and-branch renewal of the way Nagoya University carries out teaching, and in the classroom as in the lab, the plans are bold. Under the direction of Ichiro Yamamoto, a specialist in atomic energy engineering, a vice president of Nagoya University and director of the Institute of Liberal Arts and Sciences, new courses, taught in English, are being designed to open up the *Meidai* experience to foreign students who might previously have been dissuaded from applying due to worries about the language barrier. Whilst Japanese will not be necessary for sitting classes, overseas students will receive intensive Japanese language support to help them get the most out of their time in Japan and to help with day-to-day living. Admission to the newly designed programs for overseas students will be by competitive examination with the first round of tests scheduled for autumn 2010. The first students are expected to arrive on campus in October 2011 — a date chosen to accommodate the schedules of overseas students, many of whom, unlike Japanese students, do not graduate until after April.

Students from all over the world attend Nagoya University. The university currently hosts students from 78 countries.

Local students are part of the new order too. Japanese applicants to Nagoya University will be required to take the test of English as a foreign language prior to entry — not, as Yamamoto is quick to point out, as a requirement for admission but in order to determine which of the new English language programs, including a 'survival' course for students needing the most help, they would be encouraged to take. "Our long-term aim is to be able to run all our courses in parallel in both Japanese and English and let students decide which version they wish to take," says Watanabe. This initiative will be supported by the creation of 21 additional academic posts at associate and full professor levels for outstanding non-Japanese staff, on top of which the university is already creating a series of original teaching materials in English for undergraduate courses. In a number of departments, such as chemistry, teaching from English-language textbooks has already been standard for some time.

In recent years, the university has also been actively seeking to strengthen its academic ties with other countries, particularly in the Asia-Pacific region. Building on its extensive network of international exchange involving 80 partner institutions in 18 countries, Nagoya University has set up offices in Freiberg in Germany, North Carolina in the US, Shanghai in China, Hanoi in Vietnam, Ulan Bator in Mongolia, Phnom Penh in Cambodia and Tashikent in Uzbekistan. These office provide a direct pathway into *Meidai* for applicants from these countries. Pastoral support for applicants is not being neglected: the university plans to offer generous scholarships and free tuition to the most outstanding students from abroad and has embarked on a program of expanding the stock of campus- and university-managed housing, which will allow Nagoya University to offer accommodation to 100% of new foreign students for a full year rather than the current six months. New campus brochures in both Japanese and English are being designed to increase accessibility. Even campus signage is scheduled for a bilingual make-over so that students can find their way around. Nagoya University itself, however, already appears to know exactly in which direction it wants to go.

International Exchange and Cooperation Headquarters, Nagoya University

Full contact details » page 22

CONTACT INFORMATION FOR NAGOYA UNIVERSITY

President, Nagoya University p.1

**International Planning Division,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-2044
Web: www.nagoya-u.ac.jp/en/

**Research Strategy & Promotion Office,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-747-6479
Web: www.respo.provost.nagoya-u.ac.jp/e/

Nobel laureates p.2

**Department of Physics, Graduate School
of Science,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8602, Japan
Tel: +81-52-789-2862
Web: www.eken.phys.nagoya-u.ac.jp/index.html

**Department of Chemistry, Graduate
School of Science, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8602, Japan
Tel: +81-52-747-6477
Web: www2.chem.nagoya-u.ac.jp/index.phtml.en

**Research Center for Materials Science,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8602, Japan
Tel: +81-52-789-5907
Web: www.rcms.nagoya-u.ac.jp/Intro/

Biology G-COE Office p.4

**Office of Advanced Systems Biology,
Division of Biological Science, Graduate
School of Science, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8602, Japan
Tel: +81-52-789-2976
Web: www.bio.nagoya-u.ac.jp/gcoe/English/index.html

**Office of Advanced Systems Biology,
Graduate School of Bioagricultural
Sciences, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-747-6447
Web: www.bio.nagoya-u.ac.jp/gcoe/English/index.html

Chemistry G-COE Offices p.6

**Department of Chemistry, Graduate
School of Science, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8602, Japan
Tel: +81-52-747-6477
Web: gcoe.chem.nagoya-u.ac.jp/index.php

**Department of Applied Chemistry, Graduate
School of Engineering, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8603, Japan
Tel: +81-52-789-2731
Web: gcoe.chem.nagoya-u.ac.jp/index.php

Physics G-COE Office p.8

**Division of Particle and Astrophysical
Science, Graduate School of Science,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8602, Japan
Tel: +81-52-788-6195
Web: www.gcoe.phys.nagoya-u.ac.jp/index_e.html

**Solar-Terrestrial Environment Laboratory,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-788-6195
Web: www.gcoe.phys.nagoya-u.ac.jp/index_e.html

Micro-Nano G-COE Office p.10

**Department of Micro-Nano Systems
Engineering, Graduate School of
Engineering, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8603, Japan
Tel: +81-52-788-6041
Web: www.micro-nano.jp/en/

**Department of Materials, Physics and
Energy Engineering, Graduate School of
Engineering, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8603, Japan
Tel: +81-52-788-6041
Web: www.micro-nano.jp/en/

**Graduate School of Medicine,
Nagoya University**
65 Tsurumai-cho, Showa-ku, Nagoya,
466-8550, Japan
Tel: +81-52-788-6041
Web: www.micro-nano.jp/en/

Medicine G-COE Office p.12

**Graduate School of Medicine,
Nagoya University**
65 Tsurumai-cho, Showa-ku, Nagoya,
466-8550, Japan
Tel: +81-52-744-1946
Web: w3serv.nagoya-u.ac.jp/coemed/en/index.html

Environment G-COE Office p.14

**Graduate School of Environmental
Studies, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-3465
Web: w3serv.nagoya-u.ac.jp/envgcoe/index-e.html

**Department of Biosphere Resources
Science, Graduate School of Bioagricultural
Sciences, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +82-52-789-4059
Web: w3serv.nagoya-u.ac.jp/envgcoe/index-e.html

Plasma Technology p.16

**Research Center for Materials Backcasting
Technology, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-4699
Web: www.plasma.engg.nagoya-u.ac.jp/english/index.html

**Plasma Nanotechnology Research Center,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-4420
Web: mbt-center.numse.nagoya-u.ac.jp/en/index.html

MEXT Innovative Research Center for Preventive Medical Engineering p.17

**MEXT Innovative Research Center for
Preventive Medical Engineering,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-5499
Web: www.pme.coe.nagoya-u.ac.jp/

Initiatives for Industry, Academia and Government Cooperation p.18

**Initiatives for Industry, Academia and
Government Cooperation,
Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-5545
Web: suishin.jimu.nagoya-u.ac.jp/eng_top.html

International Exchange and Cooperation p.20

**International Exchange and Cooperation
Headquarters, Nagoya University**
Furo-cho, Chikusa-ku, Nagoya,
464-8601, Japan
Tel: +81-52-789-2044
Web: www.iech.provost.nagoya-u.ac.jp/en

Excellence in education and research

Meijo University researchers lead the world in innovative research on pharmacology, speech recognition, carbon nanotubes and blue nitride light-emitting diodes.

Meijo University is the largest private university in central Japan. Its eight undergraduate schools and ten graduate schools offer a wide choice of courses including law, business management, economics, human studies, science and technology. agriculture, pharmacy and urban science.

The roots of Meijo University go back to 1926 with the establishment of the Nagoya Science and Technical School by Juichi Tanaka. Now, Meijo University is a modern university at the heart of Nagoya, with close to 16,000 undergraduate and graduate students studying at one of the three spacious campuses of Tempaku, Yagoto and Kani.

President Hiroshi Shimoyama emphasizes his philosophy for Mejio University — 'university social responsibility'. "This vision will be realized by developing our five fundamental roles: education, research, careers for graduates, contribution to society, and financial and human resources," says Shimoyama.

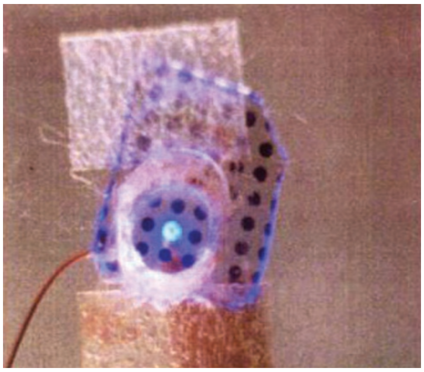
Meijo's International Exchange Center offers guidance to the university's 350 foreign students, and arranges visits for domestic students to more than 50 universities in Europe, the US and Asia.

An illuminating discovery

Meijo University has a long history of conducting leading research over a wide range of topics. Blue light-emitting diodes (LEDs) have proliferated tremendously over the last few years. The person responsible for this 'blue renaissance' is Isamu Akasaki, a professor of Meijo University's Department of Materials Science and Engineering. He pioneered semiconducting gallium-nitride (GaN) LEDs.

"I first started working on gallium-nitride in 1974," says Akasaki. "GaN looked most promising for short-wavelength optical devices." However, the path to realizing blue LEDs was long and bumpy. "In the early days, it was not possible to grow high-quality GaN crystals and we could not control their conductivity," says Akasaki. "The realization of GaN-based p–n junction blue LEDs took many years. In 1985, we finally grew extremely high-quality single crystals of GaN, and then in 1989 we succeeded in p-type doping them." These achievements led to the invention of the world's first GaN p–n junction blue/ultraviolet LED.

These breakthroughs triggered unprecedented world-wide activity in blue and ultraviolet light-emitters. Akasaki recalls that in the early days, many groups withdrew from nitrides because it was difficult to grow GaN compared with GaAs and other traditional 'III–V' semiconductors. Whilst at the Matsushita Research Institute Tokyo, Akasaki succeeded in growing single-crystal GaN by molecular beam epitaxy in 1974, and hydride vapour-phase epitaxy in 1976. However, the crystals contained many cracks and pits. "In 1979, after careful thought, I decided to adopt metalorganic vapour-phase epitaxy for growing GaN on sapphire substrates," says Akasaki.

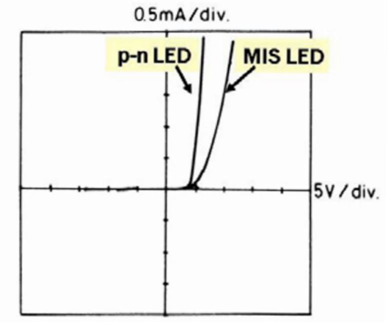


The first GaN p–n junction blue LED on a sapphire substrate in 1989. The LED (centre) emitted blue light when subjected to an electric current.

From 1981, Akasaki pursued his research at Nagoya University and after extensive efforts managed to produce crack-free, high-quality GaN epilayers using a low-temperature buffer of aluminium-nitride. "The next problem to resolve was p-type doping," says Akasaki. "Zinc doping did not produce p-type conduction. In 1988, we noticed that magnesium had a shallower energy level compared with zinc, which would be advantageous for activation at room temperature." Akasaki and his group finally achieved magnesium doping using a compound called 'bis-cyclopentadienyl-magnesium' as a magnesium source. Irradiating the samples with an electron beam produced low-resistivity p-type GaN.

Even though Akasaki's first demonstration of his blue LEDs was in 1989, applications continue to emerge. "Ultraviolet light-emitters operating at a wavelength of 260 nm will find applications in medicine for the selective destruction of bacteria in the body. Other areas to watch are treatment of atopy, and photodeodorants for refrigerators and vehicles."

A professor of Meijo University since 1992, Akasaki continues to initiate projects on GaN and



Current-voltage characteristics of the p–n junction LED and a conventional metal-insulator semiconductor (MIS) LED. The ground-breaking LED was developed by Isamu Akasaki and his group.

gallium-indium-nitride (GaInN) heterostructures, now for solar cell applications. “These structures would allow the capture of a larger proportion of the energy in sunlight,” says Akasaki. “But growing good-quality GaInN alloys with high molar fractions of indium-nitride is proving to be difficult, and may require us to go back to our roots; just like I did when I was thinking about the most appropriate method for growing GaN in the 1970s. Nitrides are challenging but still mysterious compounds.”

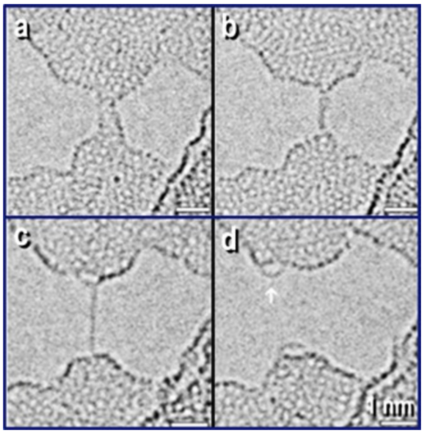
Carbon secrets

Sumio Iijima is internationally renowned for the discovery and crystallographic explanation of carbon nanotubes in 1991. Carbon nanotubes are atomic-sized tubes of graphite carbon with unique mechanical and electronic properties.

“The first time I used an electron microscope was in 1963 as a graduate school student at Tohoku University,” says Iijima. “A couple of years after getting my PhD from Tohoku, I went to Arizona State University and worked in electron microscopy for 12 years in John Cowley’s group. I returned to Japan in 1982 to lead an ERATO project on high-resolution electron microscopy of clusters. I was in fact based here at Meijo University. Then after the project, I joined NEC in 1987 because they agreed to provide funding for a special high-resolution electron microscope, which universities could not afford.”

Prior to the discover of carbon nanotubes, Iijima worked on a wide range of materials including amorphous carbon and glass carbon, which was used for tuning and setting up high-resolution microscopes. “The discovery of carbon nanotubes was serendipitous but not an accident,” says Iijima. “I had extensive experience of working on carbonaceous materials.” Indeed, Iijima had been working on ‘onion’ structures in graphite, which were critical evidence of the structure of C_{60}, a carbon cluster discovered by Harry Kroto and Richard Smalley in 1985.

The discovery of high-temperature superconductors in 1986, however, put all other materials research in the shade. “At the time I was working on determining the structure of superconducting oxides,” says Iijima. “I was disappointed that I could not make a significant contribution to this hot new field. Initially, I did not want to get involved in C_{60} because I was afraid that it may just end up being another ‘high-temperature superconductivity’ fever; I was, however, interested in the growth and crystalline properties of C_{60}. So my work on C_{60} led to the discovery of carbon nanotubes in 1991, even though there was little interest in Japan about this discovery at the time. Apart from Smalley, it took some time before experimentalists showed any significant interest.”



Formation of a monatomic carbon string during electron beam irradiation. The belt of carbon atoms between two graphite particles in a thin film of graphite (a) becomes narrower during electron microscopy (b,c), eventually resulting in a monatomic string of carbon atoms (d).

The applications of carbon nanotubes are wide ranging. “Flexible electronics, with appropriate matrices, are a potential application,” says Iijima. “I have never exaggerated the applications of carbon nanotubes. But needless to say, we need close interaction with industry.”

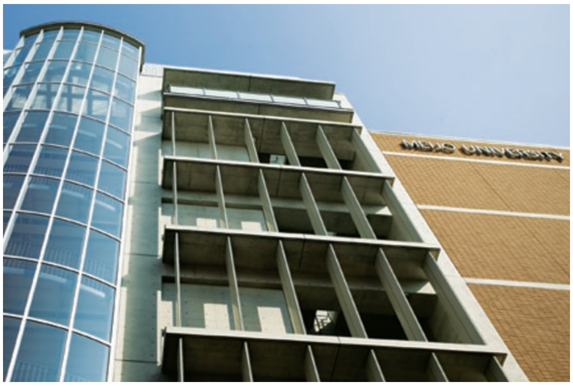
Iijima takes an active role in encouraging youngsters to take an interest in science and engineering. “We need to invest more in education,” says Iijima. “I regularly take part in seminars and gatherings for high-school children. In particular, I attend meetings arranged by the ‘Super Science High School’ affiliated with Meijo University.”

Communications for the future

Meijo University researchers have made major contributions to modern telecommunications, electronic devices and novel functional materials.

A world without portable telephones is now unimaginable. Cellular phones are ubiquitous, enabling users to communication with each other over thousands of kilometres in crystal-clear sound. But the proliferation of modern communications terminals would not have been possible without the findings of specialists in acoustic signals. One such specialist is Fumitada Itakura in the Department of Information Engineering.

Itakura has spent his 40-year career on the development of encoding, generation and recognition for speech and acoustics signals — a core technology in a modern multimedia-information society. He is a pioneer of statistical signal processing and its use for synthesizing and analysing speech.



“I did my doctorate in speech processing at NTT’s Electrical Communications Laboratory in Tokyo between 1968 and 1972,” says Itakura. “I was not particularly interested in speech and acoustics at the time, but they offered me a scholarship, which I accepted with alacrity, and the rest is history.”

In 1972, Itakura completed his doctorate on ‘Speech Analysis and Synthesis based on a Statistical Method,’ which included speech spectral and format estimation by the now well-known maximum likelihood method.

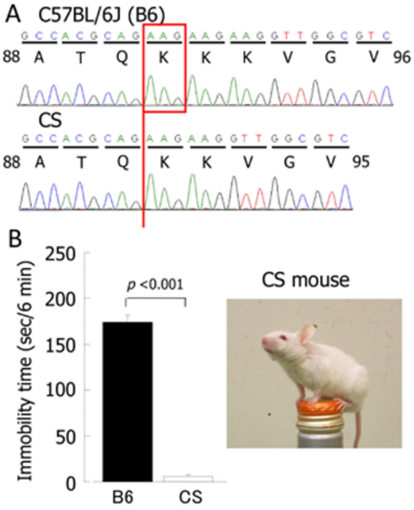
Then in 1973, Itakura travelled to the US and worked as a resident visitor at the Acoustics Research Department of Bell Labs until 1975. “I was invited to work there because Dr James Flanagan had read one of my papers on signal compression down to 3.2 kb/s,” says Itakura. “That is about 20 times smaller than the uncompressed 64 kb/s signal.” In 1975, Itakura developed speech analysis and synthesis based the line spectral pair representation, which is used in nearly all modern mobile telephone systems.

Other achievements include the invention of the ‘PARCOR’ vocoder and design of a speech synthesis chip in the early 1980s. Itakura returned to Japan in 1975 to take up a position at the Speech and Acoustics Research Section at NTT, and in 1984 took a professorship at Nagoya University.

How does he view the future of speech recognition technology? “I envisage two main applications,” says Itakura, “tremendous improvements in technology for recognizing people’s voices for translation, for example. Another area is speech recognition in noisy environments such as operating theatres, where surgeons could use on-line voice recognition to give orders or acquire information. That is, helping professionals.”

Diagnosing mental disorders

Toshitaka Nabeshima is professor of the Department of Chemical Pharmacology, and a pioneer in the analysis of the behaviours of specially conditioned mice to understand the reasons for mental disorders in humans. The mice are raised from naturally occurring variant genes, transgenic genes or knockout genes. Nabeshima’s research on critical topics such as drug addiction, for which he has found new genes related to drug dependence, is recognized internationally. “My colleagues and I were the first to use specially conditioned mice to study mental disorders in humans,” says Nabeshima. “We have used mice to identify the gene responsible for manic behaviours in mice.”



Mutation of the *Usp46* gene in mouse chromosome 5 of CS mice. CS mice without the *Usp46* gene show altered responses to inescapable situations, such as much reduced immobility in the forced swimming test.

His mice display free-running periods of longer than 24 hours, and rhythm-splitting in darkened environments. The sleeping rhythms of his mice are also different from mice with normal circadian rhythms. Abnormalities in circadian rhythms are associated with abnormalities in the circadian system and sleep patterns.

Nabeshima and his colleagues showed that these mice have an extremely low immobility time in both the ‘tail suspension test’ and ‘forced swimming test’, which are widely used for examining antidepressants and depression-like behaviours. The researchers exploited quantitative trait locus genetic analysis to identify that the gene encoding ubiquitin-specific peptidase 46 (Usp46) is responsible for such behaviours.

Usp46 is associated with a wide range of behavioural functions governed by the GABAergic system. Nabeshima’s results may therefore contribute to a deeper understanding of the neural and genetic mechanisms related to mental disorders associated with this gene. “Our results will shed light on similar behaviours in humans,” says Nabeshima.

Meijo University

Tempaku-ku, Shiogamaguchi, 1-501 Nagoya,
468-8502 Japan

Tel: +81-52-832-1151
Web: **www.meijo-u.ac.jp/english/**

A wealth of technology

Nagoya Institute of Technology (NIT) alumni have made tremendous contributions to the manufacturing and development of functional ceramic materials and innovative architectural analysis.

The NIT is located in the heart of the industrially prosperous Aichi Prefecture — home to globally recognizable corporations including Toyota Motor Corporation, Mitsubishi Heavy Industries and NGK Insulators. For the past 31 years, Aichi has been number one in the shipment of goods in Japan, totalling a mammoth 41 trillion yen or 14% of Japan's total shipments.

The NIT's roots go back to the Nagoya Higher Technical School, established by the Japanese government in 1905. In 1949, the school merged with the Aichi Prefectural College of Technology, leading to the establishment of the NIT.

Over the past 100 years, approximately 60,000 students have graduated from the NIT and joined local companies to participate in building modern-day Aichi, now a base for global manufacturing industries.

A long history of contribution to society

Engineers at the NIT's mechanical engineering department produced the first automobile in 1915, before the existence of any car manufacturers in Japan. Now with around 350 faculty members, 4,500 undergraduate and 1,500 graduate students, including a total of about 400 international students, the NIT is ranked as one of Japan's leading technology-based universities.

"Our graduates have played a major role in the growth of many corporations that have become household names," says Takatoshi Kinoshita, vice president for research. "Pioneering NIT graduates include Taiichi Ohno, who devised the Toyota Production System and later became executive vice president, Toru Nagashima, who developed aramid fibres at Teijin where he currently acts as chairman, Miyoshi Okamoto, who joined Toray Industries and created a microfibre material with the texture of suede known as Ecsaine or Alcantara, and Masanao Shiomi, who played a central role in the development of Toyota's Prius car."

The NIT continues to play a leading role in research and development on national projects and in collaboration with local industries as well as local governments in Aichi and Gifu. The NIT's collaborative initiatives are led by the Research Center for Nano-Devices and Systems and the Ceramics Research Laboratory.

"Our contributions to ceramics research are reflected by our ranking as the top university in Japan in ceramics according to a survey published by Thomson Reuters," says Kinoshita. "Furthermore, NIT professors are ranked at the top in Japan for procuring funding per individual faculty member."

Recent technological highlights include the development of a covering for producing easy-to-grip volleyballs, which were used at the Beijing Summer Olympics in 2008. The volleyballs are covered with hollow silica nanoparticles synthesized by Masayoshi Fujii of the Ceramics Research Laboratory.

The Department of Architecture and Design was established in 1905, and is the second oldest architecture department in Japan. "In addition to producing prominent architects of modern structure, our institute has also made major contributions in the analysis of the original structures of Japan's castles," says Akio Mizutani of the architecture department. "For example, our alumni Hisashi Kido contributed to the restoration of Nagoya Castle, and Akira Naito to Azuchi Castle, which was built by the famous Nobunaga Oda in 1579."

Why has the NIT produced so many pioneers in its 100-year history? "Perhaps it's the strong-mindedness of our students," says Mizutani. "The climate here in Aichi — cold winters and hot and humid summers — may also be a factor."

Excellence in ceramics

Masayuki Nogami is chairman of the Institute of Ceramics Research and Education (ICRE). "This region of Japan has a long and rich history of producing ceramic products such as tea cups and saucers, which we call *seto-mono*," he says. "We evolved in this environment and took ceramics from a technology to a science. Our graduates are at the helm of internationally renowned fine ceramic industries such as Noritake and INAX."

Building on its 100-year history of excellence in ceramics, the NIT is one of a select few institutes in Japan offering specialized courses in the field. "The ICRE has 25 professors dedicated to teaching and research in ceramics," says Nogami. "This makes us one of the largest ceramics departments in Japan, if not the world."

Nogami and his colleagues are focusing on ceramics research in the areas of electronics and optical fibres for information technology-related materials, cell implantation technology, and the generation and conversion of energy.

Recent findings include the development of lead-free piezoelectric ceramics for use as resonators, electrolytic materials exhibiting

Volleyballs covered with hollow silica nanoparticles. This easy-grip covering developed by Masayoshi Fuji of the Ceramics Research Laboratory was adopted as the official covering for volleyballs at the 2008 Olympics in Beijing, China.

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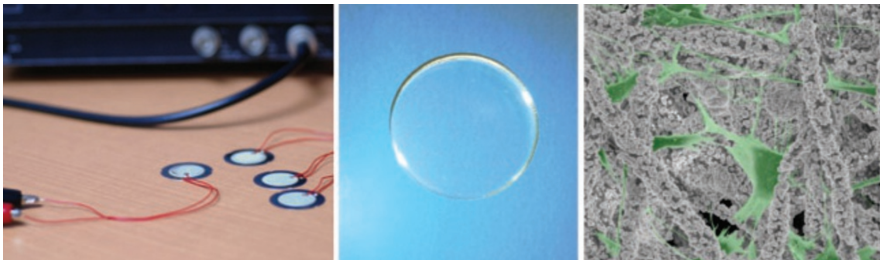


Three innovations stemming from advanced ceramics research at the NIT. (Left) A lead-free piezoelectric resonator for electronics. (Centre) A glass electrolyte for fuel cells. (Right) An organic–inorganic hybrid fibrous scaffold for bone regeneration.

high electrical conductivity at around 100 °C for use in fuel cells, and artificial ceramic scaffolds that act as seeds for the growth of bone, which could be used for the treatment of children with bone problems.

The ceramics used in electronic equipment often contain lead, cadmium, mercury and other toxic elements that are harmful to the environment and which are sources of pollution in recycling. In 2008, Kenichi Kakimoto succeeded in producing lead-free KNbO$_3$ piezoelectric ceramics using well-sintered KNbO$_3$ nanopowders by controlling the nanostructure of ceramics. These materials will be used for fabricating piezoelectric resonators for electronics applications.

The development of low-temperature fuel cells is important for solving the world's energy and environmental problems. Polymer-based fuel cells face many problems related to robustness and stability. Nogami has developed a proton-conducting P$_2$O$_5$-SiO$_2$ glass electrolyte exhibiting extremely high electrical conductivity of approximately 0.1 siemens per centimetre at around 100 °C. This is a surprising result because conventional ceramics are considered to be insulators. This new conducting ceramic material is now being used for the development of fuel cells operating at about 150 °C.

Ceramic bones and teeth are important for medical therapy. Toshihiro Kasuga is developing biodegradable scaffolds for bone reconstruction and tissue engineering. Kasuga has produced silicon-releasable microfibre meshes by an electrospinning technique for guided bone regeneration. The scaffolds made it possible to grow osteoblast-like cells, and to grow and differentiate mesenchymal stem cells. Cells grow in three dimensions on organic–inorganic hybrid fibrous scaffolds coated with nanoapatite. This technology could be used to implant ceramic scaffolds into children with bone disorders, which would then grow in size as the child grows older.

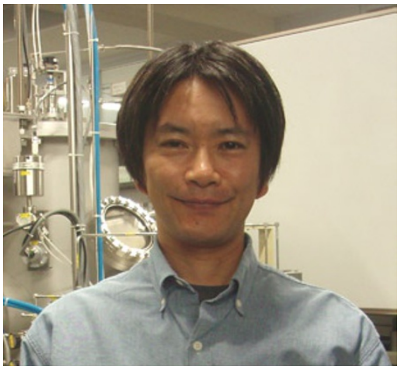
"The ICRE was created to break down inter-departmental barriers within the NIT," says Nogami. "We collaborate with the National Institute of Industrial Science and Technology, the National Institute for Materials Science, the Japan Fine Ceramic Center, the Imperial College London, the ENSCI and University of Limoges in France, and the University of Erlangen-Nürnberg in Germany. This is a unique approach towards education and research in ceramics."

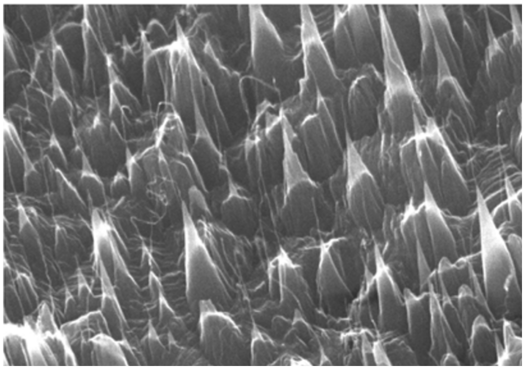
The success and highly innovative approach to ceramics research at the NIT was recognized by the Japanese government with the awarding of special funds for a highly competitive 21st Century Center of Excellence program. Recently, the government awarded the NIT with 'TIDA' developmental grants for undergraduates, where 30 highly motivated students are selected for private tuition in ceramics, including visits overseas during the summer vacation.

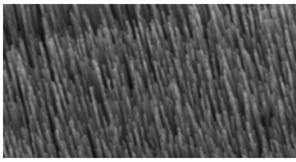
In addition, the NIT has initiated an international training program for graduate school students. The funding for this program is used to support 5–10 graduate students, postdoctoral researchers and assistant professors to study abroad for periods of up to one year.

"Our unique programs are designed to nurture the ceramics engineers of the future," says Nogami. "Our graduates find key roles in related industries in Aichi and other parts of Japan."

The NIT is evolving to meet the challenges of an ever-changing educational landscape. "I think that it will be important for us as an educational institute to not only conduct research and education but also study the effects of our technology on society," says Minoru Takahashi, vice president and executive director for academic affairs. "An understanding of core technologies is important, but equally important is deeper recognition of their relevance and effect on the world we live in. Our *kachi-kan*, or degree to which we value a particular technology, will be important."







Nanomaterials

Masaki Tanemura is a nanomaterials scientist who plays it cool. The synthesis of nanomaterials such as carbon nanofibres (CNFs) typically requires temperatures exceeding 500–1000 °C, but Tanemura has developed a unique procedure for creating CNFs at room temperature. The inspiration for this work came from observing geological forms in which sharp peaks are created by rain erosion around a durable headstone.

Tanemura uses a beam of argon ions in place of rainfall to bombard a carbon-coated sample, eroding the surface to sculpt a regular series of sharp peaks with dimensions of the order of 500 nanometres. In the majority of cases, a hair-like CNF is formed on the tip of each of the peaks, aligned with the direction of the incident ion beam. These CNFs are thought to grow by redeposition of carbon atoms that have been ejected from the carbon film on the surface of the growing peak and which diffuse into the lengthening CNF. These ion-induced CNFs have a wide range of applications, including use as tips for scanning probe microscopy (SPM).

The low temperature of preparation means that the CNF can be grown on commercially available silicon SPM probes coated with carbon, permitting the mass-fabrication of SPM probe tips more cheaply and with greater standardization than achievable using conventional 'hot carbon' methods. Tanemura has developed this process in collaboration with the optics company Olympus. The fact that the CNF growth occurs at low temperatures allows the use of many more materials — such as plastics — to be used as the solid support for the carbon film. This has led to the creation of arrays of CNFs on polyimide supports, which Tanemura and his collaborator Shu Ping Lau are testing as a mechanically flexible electron emitter for X-ray sources and displays.

Growing the CNFs in the presence of a supply of metallic atoms also opens the door to the creation of regular nanoscale zinc-oxide peaks on plastic supports, a technology that is being investigated for use in ultraviolet random lasers and spintronics devices.

Biomechanics

Takeo Matsumoto wants to know the mechanism of the process by which the thickness and diameter of arterial walls changes in response to increases in blood pressure. At short time scales, arteries contract through active myogenic responses to restore vascular resistance against passive dilation caused by the pressure increase. Over the long term, artery walls thicken through active remodelling to maintain their hoop stress at a physiological level.

"My work really is all about what happens when cells and tissue are subjected to stress and how they adapt," Matsumoto explains. "We want to know how and why this happens and understand the process at a tissue, cellular and even cell-organelle level. Ideally we would like to be able to understand the genetic reasons behind this behaviour as well."

To shed light on the matter, Matsumoto, assisted by his collaborator Kazuaki Nagayama, measures the microscopic stress and strain released when a short ring-like segment of aortic wall is cut in a radial direction, and relates this to the relative stiffness of the two elements — elastic lamina and smooth muscle — that alternate in layers to make up the wall structure. Using scanning microindentation testing, the team has shown that stress is not released fully by the radial cutting, and a significant amount of stress still resides in the wall at a microscopic level.

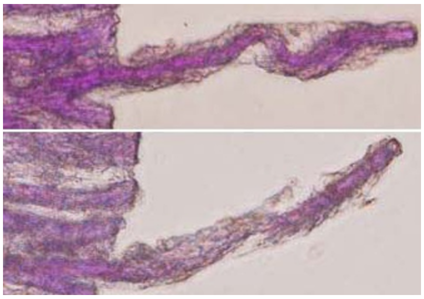
Matsumoto and his team have devised a method for calculating the Young's moduli of single isolated smooth muscle cells and elastic laminae by measuring the force required to stretch them between two specially made glass capillaries of known spring constant. This method was recognized by the awarding of the Japan Society of Mechanical Engineers Medal in 2002.

The group has also developed a technique for mapping the three-dimensional internal structure of smooth muscle cells. The method involves precise rotation of a cell held by a micropipette under a microscope coupled with tomographic technology. Matsumoto hopes that this will help him to further understand the fundamental processes governing the mechanical adaptation.

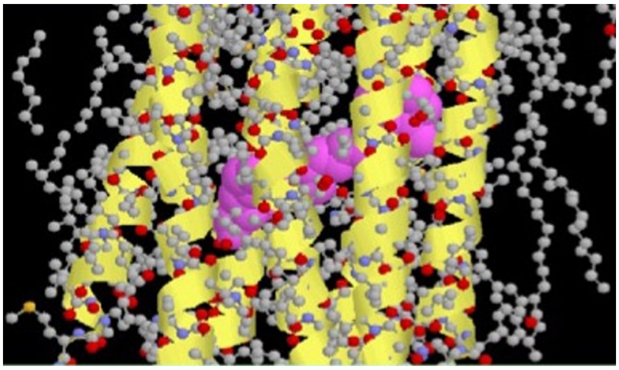
Biophysics

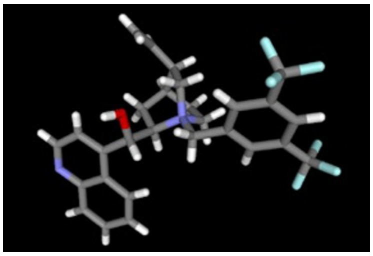
Hideki Kandori knows there is more to his field than meets the eye. Originally a physics major from nearby Kyoto University, he has spent the past eight years at the NIT investigating the fundamental behaviour of a class of light-harvesting protein complexes known as rhodopsins.

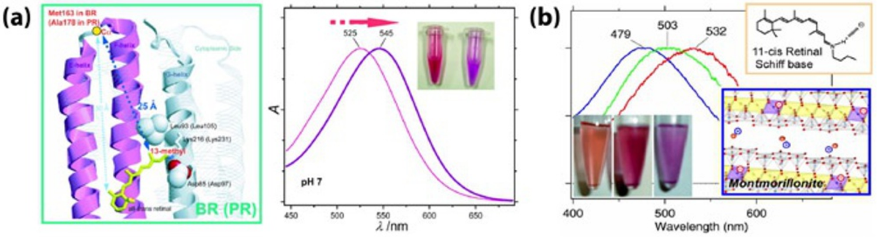
A conjugate of the protein opsin and the organic molecule retinal, known as a derivative of vitamin A, rhodopsin is found in animal retinae and is the key element in the conversion of light energy into electronic signals that are interpreted by the brain as visual images. However, when incorporated in certain transmembrane protein assemblies of some bacteria, rhodopsin can also convert light energy into chemical energy.



An elastic lamina of porcine aorta. Takeo Matsumoto's group investigates stress and strain in each lamina under physiological conditions.







Specific color tuning of the rhodopsin chromophore in mutant protein (a) and montmorillonite clays (b).

The molecular machine called a proton pump drives hydrogen ions across the cell membrane via a specific pathway provided by the protein. Using Fourier transform infrared spectroscopy, Kandori and his team examined bacteriorhodopsin — the world's smallest pump consisting of only 4,000 atoms — and found that the proton-pumping process is profoundly influenced by the presence of water molecules bound within the pathway. They observed single molecules of water by this technique, and found the presence of functional water controlling the unidirectional flow of protons from inside to outside the cell. To achieve this crucial result, the team used isotopically labelled 'heavy' water, which allowed observation of the crucial vibration of the oxygen–deuterium bonds of the water bound in the transmembrane protein. "The discovery of the role of strongly hydrogen-bonded water in the operation of bacteriorhodopsin and the related pumps is one of our most important findings, and our method is now cited in a popular biochemistry textbook," notes Kandori.

But this is not the end of the group's study of rhodopsin. Work is under way to investigate novel ways in which rhodopsins can be synthesized and used. Recently, they have discovered a method for generating rhodopsin-like materials from retinal chromophores and montmorillonite clays, and are now investigating the interaction of rhodopsins with nanomaterials. Curiosity-driven research is the name of the game. "When my students ask me what research they should do I tell them: 'surprise me'," says Kandori.

Organic chemistry

Norio Shibata is fascinated by fluorine, or more accurately, in organic molecules that contain fluorine. The ninth element in the periodic table has a special place in organic chemistry as it is approximately the same size as hydrogen — the simplest atom and one that is present in all organic compounds — but is much better at drawing electrons towards itself from another atom to which it is bonded. This means that organic molecules in which hydrogen atoms have been replaced with fluorine are virtually the same size as the original compound but have a very different electronic profile, which can lead to profound changes in physical and biological properties.

"I always wanted to create molecules with really high pharmacological activity," says Shibata, "so I started working on organofluorine chemistry." But getting even one fluorine atom into an organic molecule is easier said than done. Shibata has developed a method using catalysts derived from naturally occurring species such as the *Cinchona* alkaloids. These chiral phase-transfer catalysts solubilize the inorganic bases used in the reaction.

The Shibata group have also developed an original reagent called FBSM that transfers one atom of fluorine as part of a fluoromethyl unit. FBSM has been successfully commercialized and is now widely used in laboratories around the world. A bigger challenge still is creating molecules incorporating more than one atom of fluorine. Very recently, Shibata's team made a major breakthrough with a highly efficient procedure for adding a trifluoromethyl unit — three fluorine atoms attached to one carbon atom — to an important class of molecule called azomethine imines in high yield and with very high three-dimensional structural selectivity. The product of these reactions can be converted into biologically active molecules, and the Shibata process has become a benchmark for efficiency in the field.

But Shibata is still not satisfied. His other passion, asymmetric catalysis using chiral Lewis acids, has been pressed into service in the search for new and ever more efficient methods for fluorination. "There's still so much left to do," Shibata explains. "What about molecules with two fluorine atoms bound to adjacent carbon atoms? Or multiple trifluoromethyl groups? Or three contiguous fluorine atoms arrange asymmetrically? I'd love to make pharmacologically active compounds with those kinds of structures."

Nagoya Institute of Technology

Gokiso-cho, Showa-ku, Nagoya,
466-8555 Japan

Tel: +81-52-735-5007
Web: **http://eng.nitech.ac.jp/**

Master technology, create technology

The Toyohashi University of Technology (TUT) is a young and energetic institute with a mission to create new paradigms for global industrial innovation by nurturing engineers, scientists and researchers. President Yoshiyuki Sakaki plans to maintain the TUT's status as a frontrunner in engineering-based research by dramatically expanding research facilities and creating new tenure-track positions, with allocations for overseas researchers.

"In Japan, the TUT is recognized for its academia–government–industry style of research," says Sakaki. "It would not be an exaggeration to say that we pioneered joint research and education projects with industry. We created models that many other universities now follow." In line with national government policy, the TUT was reorganized as an 'Independent Administrative Institution' in April 2004, giving it greater autonomy in planning education, research and staff recruitment.

The TUT has a student population of around 2,100, with 250 teaching and research staff and 150 administrative personnel. A mission-oriented institute, the TUT focuses on such areas as robotics, information technology, electronic and optical devices, advanced materials and environmental sciences and technologies.

The success of faculty members in achieving their goals is reflected in statistics showing that TUT researchers were ranked seventh in Japan in procuring research funding between 2000 and 2004, second in the number of patents accepted per faculty, and eighth in paper citations.

The TUT is located at the heart of the city of Toyohashi, about 90 minutes from central Tokyo by Shinkansen bullet train and within easy access of Chubu International Airport near Nagoya. Toyohashi is known as one of Japan's most comfortable cities in which to live — the city has a mild climate, spectacular beaches in Omotehama, annual festivals, thriving agriculture and famous historic monuments such as the *Futagawa Shuku Honjin* — a famous inn used by travellers on the *Tokaido* route linking eastern Japan to Tokyo during the Edo period.

Industrial trends show a growing demand for graduate school students. These industrial needs are reflected in the emphasis on graduate school programs run by staff with industrial backgrounds at the TUT. Approximately 50% of the 2,200 students at the TUT are enrolled in graduate school courses. "One fifth of our faculty members have worked in industry," says Sakaki. "Also, the number of students per faculty is much lower than at other universities. Our 'spiral-up' education system, highly interdisciplinary doctoral programs and regular two-month internships for fourth-year undergraduate students are the key ingredients for a stimulating environment not only for our students, but also for our faculty and industrial collaborators."

The spiral-up education system epitomizes the TUT's unique approach towards education, enhancing the education experience for undergraduates from both traditional academic-based high schools and modern technical colleges. The emphasis at technical colleges is on specialized practical training in engineering, including electrical, electronics and mechanical engineering. About 80% of the TUT's undergraduate students are from technical colleges.

Students from academic-based high schools enter the university at the first-year level and attend basic courses in science and engineering over their first two years. Students from technical colleges enrol as third-year undergraduates, joining existing undergraduates moving up from the second year and undertaking two years of basic and specialized education.

"Our two-month internship is one of the unique features of our spiral-up education system," says Sakaki. "This gives students an excellent opportunity to experience industrial environments first-hand. This internship is very popular among students, as well as staff and companies."

After completing their undergraduate studies, about 80% of students go on to graduate school to study for a master's degree. "Here, the students learn how to actually fabricate devices and use sophisticated equipment," says Sakaki. "Our students are extremely good at device fabrication and other such aspects of research. Highly motivated students continue on to the doctoral course. This is the spiral-up education system."

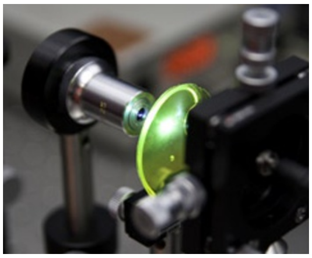
Community and international outreach

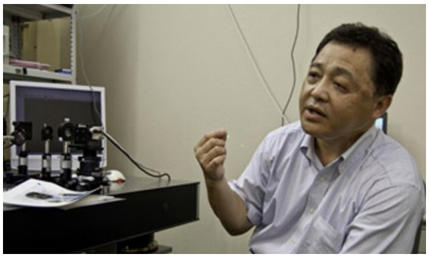
The emphasis on education and research based on industry–academia integration is again visible in the TUT's exchange and cooperation programs with the local community, where industrial engineers are invited to give lectures to students. TUT staff also give regular refresher courses in areas such as the fabrication of semiconductor devices to company employees.

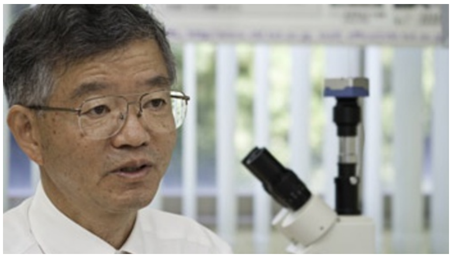
International exchange — for both students and faculty — is an important element of education and research at the TUT. Currently, more than 200 international students and 30 researchers are studying and working at the TUT, supported by 51 exchange agreements with overseas institutes ranging from Tsinghua University in Beijing, China, to the University of California, Berkeley in the US and the Institut Teknologi Bandung in Indonesia.

"We have developed a solid network of successful exchange programs with universities in Asia," says Sakaki. "We intend to expand our agreements to include more institutes from Europe and North America. We offer master's and doctoral courses in English."

The International Center for Engineering Education Development (ICCEED) was







established in April 2001 and is a testament to the TUT's contribution to international exchange and education. "This is the first institute for international cooperation in engineering education," says Sakaki. "It is a recognition of our tradition of excellence in international exchange activities. We are working with governmental and other organizations in Japan to create and initiate education programs overseas."

> **"We have developed a solid network of successful exchange programs with universities in Asia. We intend to expand our agreements to include more institutes from Europe and North America."**

The TUT has supported the Japan International Cooperation Agency in projects including the 'Higher Education Development Support Project' in Indonesia, the 'Cooperation to Pathumwan Technical College Project' in Thailand, and the 'Cooperation to Promote Riyadh Technical School of Electronics to a College Project' in Saudi Arabia. In cooperation with the Japan Indonesia Forum of Science and Technology, the TUT currently supports the 'Institut Teknologi Bandung Reform Support Project' through the Overseas Economic Cooperation Fund (formerly the Japan Bank for International Cooperation). The 'Three New Engineering Departments (Mechanical Engineering, Electrical Engineering and Chemical Engineering) Project' at Lampung University in Indonesia is a sole initiative of the TUT.

"We have decided to appoint a specialist from Osaka University in 2010 to manage and expand our activities related to the ICCEED," says Sakaki, "which is important for our contributions to international education."

Technology for society

The TUT's eight research centres conduct research in areas including intelligent sensing systems, advanced photonic information memories, and agrotechnology and biotechnology. These facilities highlight the strengths of the TUT and its commitment to working with industry to tackle real-life problems.

World-class research facilities at the TUT for the design and fabrication of large-scale integrated (LSI) circuits and microelectromechanical systems (MEMSs) form the basis for its selection by the Japanese government for one of the highly competitive and prestigious Global Center of Excellence (G-COE) programs. The G-COE project at the TUT is entitled 'Frontiers of Intelligent Sensing'. "This program enables us to train and educate graduate students to push the frontiers in 'intelligent sensing'," says Makoto Ishida, vice president for research affairs and leader of the TUT's G-COE program. "We want to produce new concepts for sensors based on a multidisciplinary approach to create new 'sensing architects' by integrating knowledge of biological information, medicine, environment and agriculture."

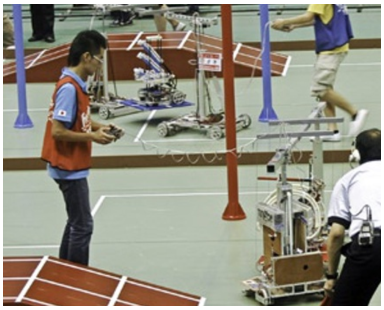
"Toyohashi is also a major agricultural hub," says Ishida. "We have ongoing sensing projects, funded by local investment banks, to support local farmers. For example, our multi-modal sensor chips, composed of a thermal sensor, pH sensor and electroconductivity sensor, are being used to monitor the condition of farm animals and precipitation in the air. These technologies would not have been possible without our highly skilled students and support from the government and industry."

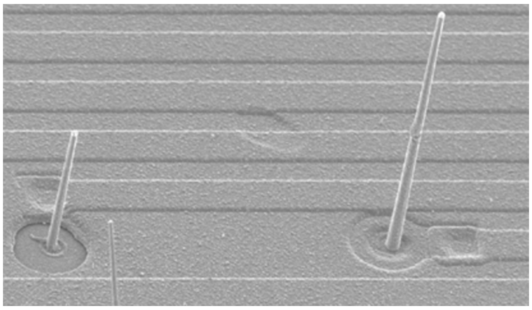
The G-COE is addressing three frontiers: sensing architecture, intelligent sensing systems, and establishing a global education and research base. "The LSI and MEMS facility is at the heart of this program," says Ishida. "Sensing is a key technology in the twenty-first century. We can contribute to many areas, including care for the elderly in our ageing society, disaster prevention and relief, energy and environmental problems, and security."

The G-COE educational program for doctoral students is a global initiative with collaborators including researchers at the University of California Irvine and Berkeley, the Korea Institute of Science and Technology, the Swiss Federal Institute of Technology Zurich, and the Interuniversity Micro Electronics Center in Belgium.

The Toyohashi Probe

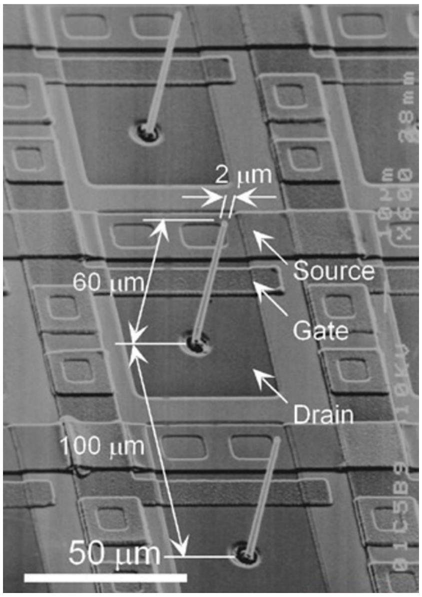
Ishida's research at the TUT's state-of-the-art LSI facilities was first brought to the world's attention in the late 1990s following his pioneering experiments on 'Toyohashi Probes' — arrays of out-of-plane silicon nanowires grown selectively on silicon integrated circuits. "The referee of our manuscript on silicon nanowires initially rejected our paper because he did not believe it was possible to do what we had described," says Ishida. "However, the paper was eventually published after I sent supporting material showing the precise procedure for the growth."





The silicon wires have subsequently been developed for use as nerve potential sensors forming part of a new biometric technology.

Ishida and his colleagues produce silicon wires by evaporating a thin layer of gold onto a silicon wafer, which is then annealed to produce tiny droplets of a gold-silicon alloy. The substrate is then placed in the vacuum chamber of a gas–source molecular beam system and heated to 700 °C. Finally, the heated silicon wafer with the gold-silicon dots is exposed to disilane (Si_2H_4) gas to saturate the dots with silicon, which causes silicon atoms to precipitate on the droplet surface. These precipitates accumulate to form out-of-plane silicon wires.



The Toyohashi Probe. Out-of-plane silicon nanowires developed by Makoto Ishida's group form the basis for the revolutionary and easy-to-fabricate probes for nerve potential sensing.

The procedure can be achieved relatively easily using existing processes for the fabrication of complementary metal-oxide semiconductor (CMOS) devices. "Since our vapour–liquid–solid growth procedure is compatible with the CMOS fabrication process," says Ishida, "we can integrate sharp silicon wires with CMOS circuitry without any significant effect on the performance of the silicon devices. It has opened up a whole new world for multiple-point measurement of nerve potentials of the brain and cells."

Ishida and his colleagues are now focusing on exploiting the unique characteristics of their Toyohashi Probe for a range of novel applications. "Life science is a major area for our probes," says Ishida. Recent developments include the use of the Toyohashi Probe for drug delivery and the nerve block test — *in vivo* administration of lidocaine solution (a sodium channel blocker) to the sciatic nerve of a rat. Using their novel vapour–liquid–solid growth method, Ishida's team have produced silicon-dioxide microtubes of 2.5–6.4 micrometres in diameter and 20 micrometres in length for the nerve block test.

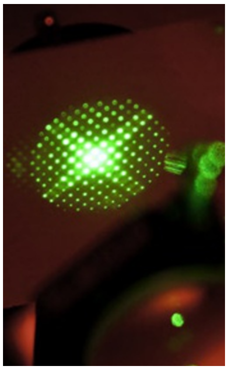
This high-profile technology is expected to lead to a deeper understanding of the response of single neurons to specific biochemicals, and to facilitate analysis of the brain cortex.

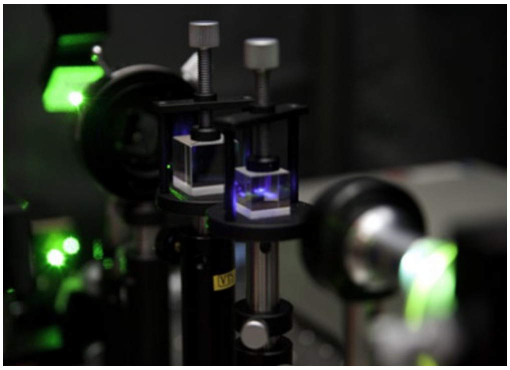
Next-generation optical memory

Mitsuteru Inoue graduated from the TUT 30 years ago, and is now director of the Research Center for Advanced Photonic Information Memories. Inoue's specialty is magneto-optics, and recently he stunned the world of data storage by developing collinear phased-locked holographic memory — a basis for next-generation data storage. "Current high-density, commercial optical storage disks have a capacity of typically 27 gigabytes and a transfer rate of about 38 megabits per second," says Inoue. "Our holographic memory has terabyte-class capacity and is capable of data rates of one gigabit per second. Whereas conventional optical disks can store about ten movies, our approach allows us to store more than 200."

Both the capacity and data transfer rate are critical for next-generation optical memory. In the approach used by Inoue and his colleagues, the high capacity and high speed is possible due to the processing of two-dimensional data pages and multiplexing holograms. "We use a multi-level phase-modulated data page instead of the 'greyscale' data pages used in the development of conventional holographic memory," says Inoue. "Our collinear phase-locked holography approach is based on phase interference between the signal beam and a phase-locked beam that passes along the same path as the signal beam."

Inoue says that his group's new holographic memory will find applications in many aspects of daily life, such as keeping medical records over an entire lifetime, and producing archives of programs in the news and entertainment industry. "I am proud to say that this technology was all made in Japan, but for use by the world," says Inoue. "We had tremendous support from the government, industry and of course our excellent students. We have set up a TUT venture





company called Optware to take our prototypes to the next stage." Inoue expects a commercial product within the next five years.

Visualizing colour blindness

"The development of dichromatic spectacles is another example of the fruitful results we have obtained through industry, academia and government collaboration," says Sakaki, "as well as underscoring our mission-orientated approach to education and research."

An estimated 6–8% of males in Europe and 200 million people worldwide are afflicted with some form of colour blindness, or colour vision deficiency (CVD). Individuals with CVD find it difficult to distinguish between similar intensities of red and green, which is a serious problem when reading critical information such as disaster response maps, traffic lights and information on notice boards in airports and railway stations.

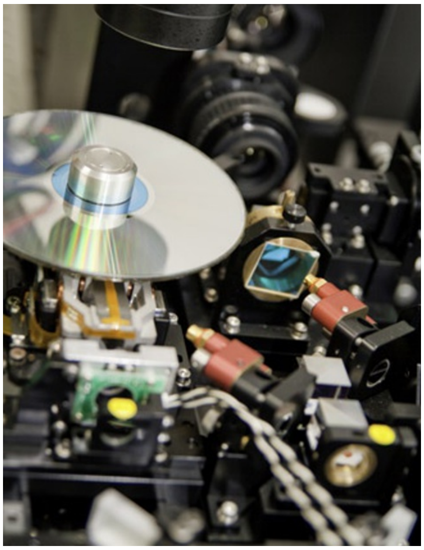
Needless to say, it is imperative to design documents and notice boards for universal colour access. The problem, however, is defining which combinations of colours to avoid. Designers and publishers with normal colour vision do not have a facile means of checking which colour combinations are confusing for people afflicted with CVD.

Shigeki Nakaguchi, presidential advisor and faculty member of the TUT's Department of Information and Computer Science, has devised a simple but highly effective means of visualizing confusing colour combinations using dichromatic spectacles. "These magic glasses, which go under the product name of 'Variantor', were developed as part of a national project," says Nakaguchi. "Our software enabled simulations of the optimal thicknesses of thin films for the optical filters used in the glasses. The actual filters were produced by vacuum deposition."

Nakaguchi's research showed that users wearing the filters have colour discrimination that falls between the CVD types of protanopes (sufferers with defective red cone cells in the retina) and deutanopes (those with defective green cone cells), confirming that the filters are suitable for universal colour design. The Variantor was launched overseas in 2008.

Continued adaptation

With a vision for maintaining its standing as a technology-based university, the TUT is planning to implement major changes for 2010. "We will launch our new Interdisciplinary Advanced Electronics Research Institute next spring," says University President Sakaki. "This is a major undertaking for us. We will expand the current LSI and MEMS facilities so that we can house 100 researchers. We will also invest in human resources by creating ten new tenure-track posts at the TUT. We have allocated some of these positions for female engineers and scientists, and highly motivated researchers from overseas." The new institute, which builds on the achievements of the G-COE program, will be a fusion of microchip technology and cutting-edge knowledge in life sciences, agriculture, medicine, information technology, the environment, social sciences and robotics.



Next-generation holographic memory. Collinear phased-locked holographic memory developed by Mitsuteru Inoue's group provides dramatic increases in data storage and access speed.

"We will also restructure our doctoral course education to reflect changes in industrial needs," says Sakaki. "Our Toyohashi Model is a tailor-made curriculum for supporting research students at each stage of their education. Our Baton Zone, like the relay baton in a race, is our interface between the TUT and industry."

Sakaki is himself a molecular biologist who led Japan's contribution to the international collaboration on sequencing the human genome at the turn of the century. He is an emeritus professor of the University of Tokyo, where he completed his undergraduate and doctoral degrees. He also acted as director of the RIKEN Genomic Sciences Center and president of the Human Genome Organization from 2002 to 2005.

"From my long experience in international collaboration and cooperation, I recognized that biotechnology and life sciences in Japan have largely relied upon imported technology," says Sakaki. "Japan must strive harder to nurture its own seeds of technology. An important reason for accepting the position of TUT president was that I believe the TUT is an excellent institute to nurture ideas and technology to achieve these goals. We are a mission-orientated university. We master technology in order to create technology. I am confident we will succeed in realizing the goals of our missions of the future."

Toyohashi University of Technology

1-1 Hibarigaoka, Tenpaku-cho, Toyohashi,
Aichi 441-8580, Japan

Tel: +81-532-47-0111
Web: **www.tut.ac.jp/english**

"Master Technology, Create Technology" at TUT, Japan

TOYOHASHI
UNIVERSITY OF TECHNOLOGY

TUT, Toyohashi University of Technology was founded in 1976, and its aims are to conduct research on advanced technologies and to educate students in such technologies with an emphasis on graduate studies.

What and How Will You Learn?

With our distinctive "spiral-up" education system, students will be repeatedly given both basics and specialties, including Mechanical Engineering, Electrical and Electronic Information Engineering, Computer Science and Engineering, Environmental and Life Sciences, Architecture and Civil Engineering. One special advantage of studying at our university is that we offer opportunities to gain practical experience in industry as an intern for two months. This takes place during the course of undergraduate studies after BS thesis work and before entering a master's course. The purpose is to familiarize you with Japanese industry and help you to understand the real working environment many students will eventually face. This is one example of how our university emphasizes the practical use of technology.

Admission

To be a student of TUT, students are able to take the entrance examination for undergraduate 1st year, undergraduate 3rd year, Master's programme and Doctoral course. Admission of research students and part-time students is open from April to January.

Scholarship

About 70 percent of international students at TUT receive some kind of scholarship, and concentrate on their study and research. International students are able to apply for Japanese Government Scholarships, JICA scholarships, or the JDS programme before coming to Japan, and private-funded scholarships after coming to Japan. Students may apply for tuition and admission fee exemption.

Student Support

The International Student Centre provides counseling and advisary services for international students concerning problems in their studies and everyday life. And for information on student visas, hospitals, daily life, traveling in Japan or having fun, any questions are welcome at the International Affairs Division. The members of the International Affairs Division are all friendly and ready to support you.

Contact Us

International Affairs Division, Toyohashi University of Technology
Tempaku Toyohashi 441-8580, JAPAN
Tel: +81-532-44-6577 Fax: +81-532-44-6557
Web page: http://www.tut.ac.jp/english/
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Tenure-Track Faculty Members to Participate in
"Program to Foster Young Researchers in Cutting-Edge Interdisciplinary Research"

Toyohashi University of Technology invites international applications for 10 special-assignment faculty positions in the "Program to Foster Young Researchers in Cutting-Edge Interdisciplinary Research", adopted as a part of the "Promotion of Independent Research Environment Improvement for Young Researchers", supported by the FY2009 budget for the promotion of science and technology.

Positions available: Ten special-assignment faculty members will be appointed, mainly tenure-track special-assignment assistant professors, but in some cases, associate professors.

Invited research areas: This program is intended to promote interdisciplinary research in different areas: intelligent sensing chip technology and photonic information device technology, which serve as basic electronic technologies, as well as cutting-edge areas of application (life science, medical care, agricultural science, environment science and technology, information communication, robotics, etc.). We wish to appoint researchers who specialize in either basic electronic technology or cutting-edge areas of application and are capable of carrying out interdisciplinary research.

Qualifications required: A doctorate (i.e., Ph.D.). Experience in the above-mentioned research areas.

Scheduled date of appointment: Early 2010

Appointment period: The term of appointment will be until 31 March 2014.

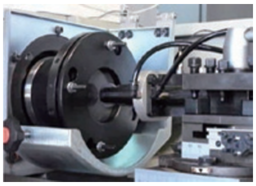
Compensation, etc: Successful applicants will receive an annual salary of approximately 5 to 7 million yen.

Research environment: Research funding of 5 million yen (in the first year) and 2.5 million yen (in subsequent years).
An additional 5 million yen (as startup funds).

Appointment as tenured faculty members: The appointment of researchers as tenured faculty members (associate professors) will be implemented in the fifth year.

Deadline for applications: Applications must arrive no later than Friday 6 November 2009.

*Please find a complete description of the position and the application information at our official website:
http://www.tut.ac.jp/wakate/public/kobo_en.html



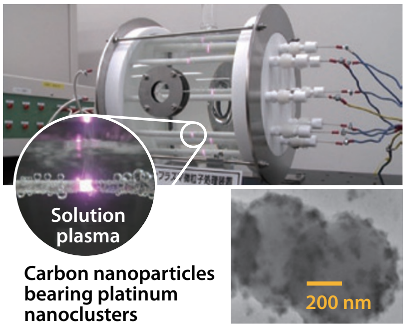
Tokai Knowledge Cluster Initiative

A knowledge cluster initiative spearheaded by Nagoya University and the Nagoya Institute of Technology aims to establish a centre for nanotechnology research and development in Japan's Tokai region, encompassing the city of Nagoya and the prefectures of Aichi and Gifu.

The Tokai Knowledge Cluster Initiative has been promoting the innovation of high-level, environment-friendly functional materials and devices since 2003 towards the realization of a safe and comfortable society based on advancements in science and technology.

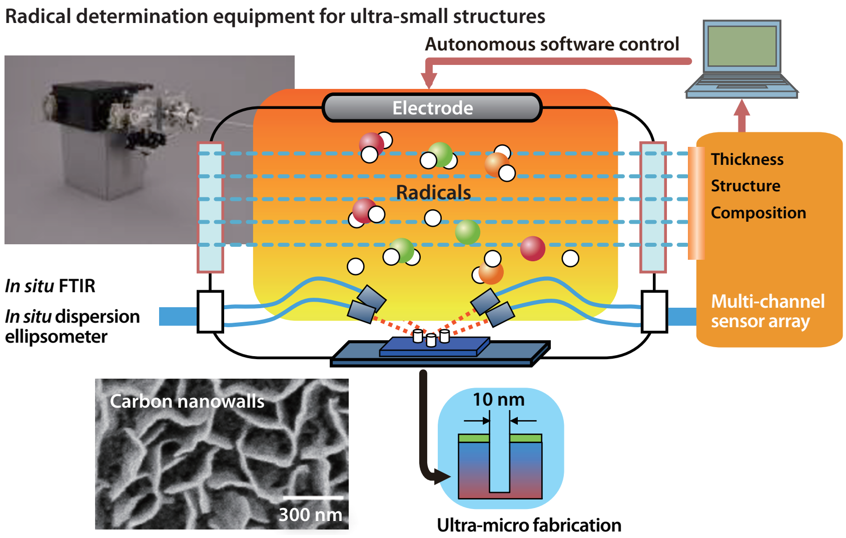
The initiative has seen the development of the world's first radical monitoring equipment. This device, developed by Nagoya University's Masaru Hori, is an absolutely necessary part of an autonomous controllable plasma system. Carbon nanowalls, a unique form of carbon with applications in the next generation of solar cells, have been successfully grown using equipment based on this concept.

A major focus of the initiative is research on plasma technology, which has formed the basis for extensive collaboration among Japanese institutions as well as joint activities with 20 international organizations. An example of the advanced technologies being pursued under the umbrella of the knowledge cluster is the solution plasma technology developed by Osamu Takai of Nagoya University. This new processing method, which uses a plasma immersed in liquid, has improved the controllability of manufacturing for various nanoparticles and has potential applications in a range of surface finishing technologies.



Multi-electrode solution plasma reactor. A new processing system developed by Osamu Takai.

The Nagoya Institute of Technology has also made major contributions to the knowledge cluster through the innovation of environmental technologies such as the substrate fabrication technology developed by Takashi Egawa. This fabrication process produces silicon wafers bearing epitaxially grown gallium nitride films, which are used as substrates in a range of high-technology applications such as power and solid-state illumination devices. This technology has made it possible to prepare six-inch wafers, improving on Egawa's previous technology for producing four-inch wafers. Yoshimi Watanabe at the institute is developing a grind stone, a kind of functionally graded material produced under centrifugal force. The grind stone will be used in the drilling of carbon fibre-reinforced plastics in combination with a special tool being developed in parallel.



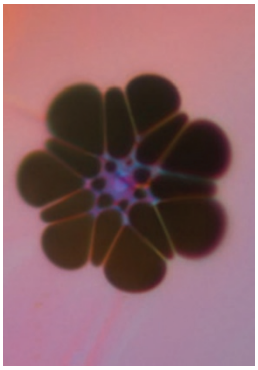
The world's first autonomous plasma nanotechnology manufacturing system. The radical determination equipment developed by Masaru Hori is an integral part of this advanced manufacturing system.

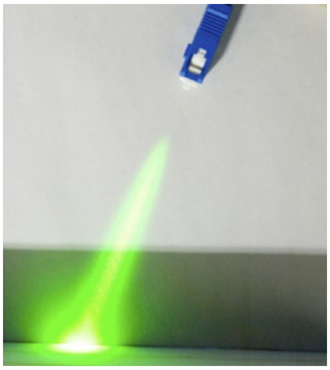
To facilitate innovative research, the knowledge cluster will have access to the 'Knowledge Hub', where the new Chubu Synchrotron Radiation Facility is to be constructed (due for completion in 2012). This new facility, essential for advanced nanotechnology research, will be made available to industries, universities and research centres in the Chubu region of central Japan, and is expected to promote the creation of new industries in the area.

Aichi Science & Technology Foundation

Aichi Trade Center West Annex,
2-4-7 Marunouchi, Naka-ku, Nagoya, Aichi
460-0002, Japan

Tel: +81-52-231-1656
Web: **www.astf.or.jp/english/**





The Toyota spirit of research and creativity

The Toyota Technological Institute (TTI) is the smallest, but perhaps the most unique college of technology and science ever built in Japan. Opened in 1981, its some 50 faculty members routinely conduct top-level research and provide quality education to around 460 selected undergraduate and graduate students. The TTI is operated with the support of Toyota Motor Corporation, which regards the TTI as one of its contributions to society.

Although the TTI's history is short, its origin dates back to the philosophy of Kiichiro Toyoda, the founder of Toyota Motor Corporation (TMC). His main goal when he established the company in 1937 was to produce high-quality automobiles and to one day become one of the major car makers of the world. Although Toyoda died in 1952, his successors have made his dream come true, with TMC now ranked as the top auto maker in the world. Toyoda believed that education and research are essential in order to create original industrial technology, and he had a dream of building a college when TMC reached some stage of success. This wish of Toyoda was realized in 1981 with the opening of the TTI in Nagoya. At its inauguration, the TTI adopted as its founding concept the words of Sakichi Toyoda, Kiichiro's father: "Respect the spirit of research and creativity and always strive to stay ahead of the times." Sakichi Toyoda is one of Japan's best-known inventors, who laid the basis for the Toyota group through his invention of weaving machines and their industrial utilization. His spirit of creativity has been passed on to TMC and its group companies, and also serves as the guiding principle of the TTI. Tatsuro Toyoda, the second son of Kiichiro and a former president of TMC, now serves as chair of the TTI's Board of Trustees.

Unique educational programs to foster leading engineers and scientists

The TTI admits only a small number of selected students each year: 70–80 high-school graduates and 15–20 students with work experience are accepted into the undergraduate program, 30–40 students are admitted into the master degree program, and there are places for up to 12 students per year in the PhD course. This small body of students, just 460 in total, is taken care of by some 50 top-level faculty members. This means that every student receives attention, with ample opportunities to interact with professors and easy access to experimental facilities. Moreover, the TTI's tuition fee is similar to that for Japan's national universities and scholarships are made readily available. All new undergraduates spend their first year in the campus dormitory, where they develop friendships, learn from each other and build their personalities.

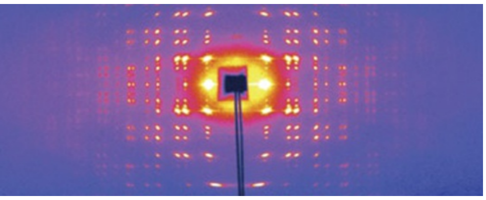
The TTI's cleanroom. Students at the TTI gain direct experience in the manufacture of integrated circuits.

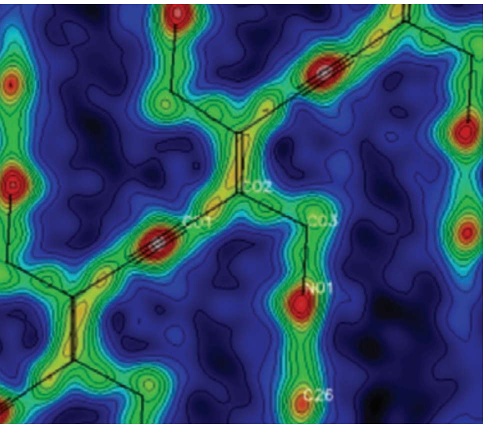
Cross-disciplinary basic engineering and hands-on experience

The trend is apparent that most of the major issues that technologists should cope with today are so complicated that they can be solved only by a cross-disciplinary combination of technological components. In view of this trend, the TTI offers undergraduate students a 'hybrid engineering' program in which they learn first the common grounding of engineering, and then select a specific field in a later stage from material sciences, mechanical and electrical/electronic engineering, and informatics. This program was formulated under Akira Ikushima, the current President of TTI. The TTI also believes that engineering education cannot be complete without offering ample opportunities for each student to learn from hands-on experience both on campus and in industrial environments. Each student is required to undertake two industrial internships, some even with US companies. These solid programs provide students with the capabilities needed for practical development and are accredited by Japan's accreditation board.

Rich research experience and global context at graduate school nurture techno-industrial leaders of tomorrow

The TTI opened its graduate school in 1984 with its first master degree program. The PhD program was initiated in 1995 by inviting professors of research excellence. In 2003, the TTI's sister institute, TTI-Chicago, was opened in





the US as a focus on basic computer sciences. TTI-Chicago accepts graduate students from all over the world, including some from the TTI for regular courses. Professors in Chicago also offer course lectures to TTI students over the internet. The TTI's graduate students experience both top-level research on campus and also unique internships in industry or at overseas institutions to fully develop their talents to be the techno-industrial leaders of tomorrow.

Unique schemes for research from nano-sciences to intelligent vehicle technology

Following the motto of Sakichi Toyoda, the faculties of the TTI "strive to stay ahead of the times" through their creative research. Since its inception, the TTI has recruited high-level researchers from industry and academia, including NTT, Hitachi, Toyota Motors, IBM and Osaka, Kyoto, Nagoya, Tokyo and Tohoku universities.

The TTI has built in unique schemes to promote research, such as the 'principal professorship', in which 'a super-elite' professor gets a starting grant of about one million US dollars. Researchers are able to secure funding from the TTI's internal research fund and also by securing competitive research grants from the Japanese government. In addition, many researchers conduct high-level research in collaboration with industrial partners with many leading companies offering support. The TTI ranks 12th in Japan for per-capita earning of external funding.

Technology highlights

Our society faces critical problems and challenges; protection of the environment, smarter use of energy and natural resources, and the construction of dependable social systems for transportation and information technology infrastructure are representative examples.

The TTI faculties are committed to making contributions to solving some of these issues by promoting research ranging from nanotechnology to system science. Many of these cutting-edge research programs take place in the TTI's eight research centres and projects, which are heavily supported by the Japanese government.

For example, at the Advanced Photon Technology Center, Yasutake Ohishi, Kazuya Saito and Akira Ikushima are investigating the material science and photonic device aspects of glass fibers. Ohishi demonstrated the first continuous-wave operation of a green fibre laser based on terbium doping. A fibre in which the cross-sectional structure looks like a flower has also been developed (see photos top of left page).

Kohji Tashiro at the Polymer Science Center studies the nano-scale structures of polymers, and has mapped the density of electrons in polymers for the first time using X- ray diffraction studies at the Spring 8 synchrotron facility.

Masafumi Yamaguchi at the Super-High Efficiency Solar Cells Center has long worked on tandem solar cells. With Sharp, he achieved in 2005 a solar energy conversion efficiency of 39%, then the world's highest. With Daido Steel, Daido Metal and Sharp, he also developed a concentrator system for solar energy conversion (see photo above).

At the Sustainable Mechanical Systems Center, Masatake Higashi and his team are developing new CAD methodology and materials processing technology for next-generation machines.

Seiichi Mita at the Advanced Intelligent Systems and Devices Center is developing autonomous vehicles by the intelligent processing of data from laser radars and other sensors on the vehicle, which will ultimately serve to improve traffic safety.

Hiroyuki Sakaki, well-known for his pioneering work on quantum dots and wires is working with Itaru Kamiya, Masamichi Yoshimura and others to explore nano-scale devices and materials.

The TTI's international approach and TTI-Chicago

The TTI is acutely aware of the need for communication and collaboration between individuals of different backgrounds and nationalities, in order to develop the innovative ideas that will lead to the technologies of the future. Students at the TTI are provided with ample opportunities for developing cross-cultural communication skills both through intensive courses in English and through experience overseas. The TTI has partnership agreements with a number of overseas universities, including the University of Arizona. In 2003, the TTI set up a sister institute, TTI-Chicago (TTI-C), in collaboration with the University of Chicago. TTI-C now has a faculty of 20, headed by David McAllester, working mainly in computer science. TTI-C hosts graduate students from the TTI and provides a regular internet course in machine learning. TTI-C also conducts joint research with TTI at the forefront of computer science.

Toyota Technological Institute

2-12-1 Hisakata, Tempaku-ku,
Nagoya 468-8511, Japan

Tel: +81-52-802-1111
Web: **www.toyota-ti.ac.jp**