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MESSAGE

My First Message as President

FEATURE

Neurotechnology
– Knowing the Brain, Using the Brain –

Research Hotline
UPDATE FROM THE CUTTING EDGE (January–March 2009)

In Brief

My First Message as President

Tamotsu Nomakuchi

President
National Institute of Advanced Industrial Science and Technology (AIST)

1. Introduction

I am Tamotsu Nomakuchi, and I became President of AIST this April. Until March, I was chairman of the board of an electric manufacturer, Mitsubishi Electric Corporation. My unpredicted appointment as President of AIST must have surprised not only the people who work at AIST but also those who watch AIST from the outside with interest and expectations. In fact, I myself am just as surprised as everybody else. How did I arrive at my decision to assume the post of President? I would like to start by explaining my views on innovation today, and its increasing importance for us.

After finishing my master's course in physics in 1965, I started working at Mitsubishi Electric Corporation. I was assigned to its research laboratory and ever since then, up until I became the president, I spent most of my time in the R&D departments, first as a researcher, then a manager, and later as an executive officer. When I first joined the company, Japan was still importing technology from the advanced countries of Europe and the United States. It was in the mid-80s that Japan began to have confidence in its technology, and even started overestimating itself so as to feel there was nothing more to learn from others. However, in the 90s the land bubble burst, and the economic stagnation called "the lost decade" of Japan started. It was a period when the confidence in our economy was shaken, affected by influences such as of the US pro-patent policy or of the rise of Korea and China.

Even during this stagnated period, however, there existed groups of corporations, a good example being the automobile manufacturers that established their firm technological foundation and continuously increased their presence worldwide. These companies emphasized their own characteristic technologies and intellectual properties, and this approach spread, leading to the economic re-growth period of Japan in the new century. We are presently in an economic crisis said to be unprecedented in history. I believe, however, that it could certainly be overcome by measures based on world-leading R&D, giving high priority in technology and intellectual property. It has been my conviction that in management which values technology and intellectual property, it is essential to rightly evaluate R&D human resources, to arrange the working environment to allow their creative activities, and to make possible a wide use of the outcomes. When I was company president, I deliberately supported and encouraged people engaged in R&D activities such as innovation. In present times when industrial competition is internationalized and global issues such as environmental problems are increasing, I always consider that such management could be meaningful and beneficial also for major national/public research institutes. This view is what probably led me to accept such a responsible position of AIST President, at the very last moment.

I believe my task is to lead and support AIST researchers so that they can produce abundant results that could make possible the sustainable development of Japan and our global community, as well as be widely useful for industry and business, regardless of size from small, medium to large enterprises.

2. Basic research, its present–day significance

Last May, at the symposium commemorating the launch of the academic journal of AIST, *Synthesiology*, I was given an opportunity to present a keynote lecture along with President Nakashima of Future University-Hakodate. In preparing for the lecture, I looked through the website of AIST, and pondered on the meaning of *Synthesiology*. I agreed with the views of Dr. Hiroyuki Yoshikawa, then President of AIST, explained in the premier issue, and I gave a lecture titled "Basic Research, Its Present–day Significance." What is presented as *Type 2 Basic Research* in his article sounds similar to what we traditionally refer to as "application research" or "objective basic research." Dr. Yoshikawa's argument that all research activities that aim at solving issues on a scientific level should be rightly considered as basic research impressed me, and I thought it to be indeed timely and persuasive.

To produce results which truly lead the world, enhancement of basic research is essential. The industry, however, is obliged to concentrate on product realization research and improvement research in order to survive the fierce business competition of global scale, and it has little reserve to go back and pursue basic research. The gist of my talk was that industry is looking with great expectations at advanced, leading and fundamental research results of AIST and of universities. Especially AIST, having the interdisciplinary research unit system, is able to conduct more comprehensive research than universities. Now we are in the time of open innovation, and of industry-academia–public institute collaboration. AIST, as a central player of such a time, must definitely take leadership.

3. Realizing a society of sustainable development

I listed four different points of expectations for AIST at the end of my aforementioned lecture. They were: 1. to be the driving engine of leading R&D, anchoring the concept of *Full Research*, 2. to disseminate diversified research results worldwide, 3. to train and foster engineers and researchers who would link universities with businesses, 4. to challenge the issues of the 21st century.

After joining AIST in April and after hearing of the varied activities of AIST, I have realized that there is an important point to be added to the list. That is: 5. to provide basic and fundamental knowledge which would contribute to the sustainable development of human society. I first realized, after becoming a member of AIST, that the 15 research institutes previously under the former Agency of Industrial Science and Technology, beginning with the Geological Survey of Japan established in 1882, had been scientifically and technologically fulfilling the roles "to observe", "to search" and "to create" for the modernization of Japan. Now that human interest spreads widely to the outer space and deep into the Earth, and materials we handle increase in variation, I feel that the mission and responsibility of AIST have grown even greater.

I would like to elaborate further on each of my points of expectations for AIST.

Firstly, concerning point 1, although I have not yet finished hearing of all the activities of the research units, I have realized that there is a high motivation of researchers overall for product realization. This, I think, shows the keen awareness of the predecessors including former President Yoshikawa who have seriously addressed issues at the time of, or even prior to, the establishment of AIST. In order to challenge difficult issues, research that goes back to the basics is indispensable, and in order to find reliable methods for realizing the end products, innovative collaboration with many researchers of diverse technological fields is essential. If this collaboration or synergy circle spreads not only within and outside AIST in Japan but also around the world, great outcomes could be anticipated.

Concerning diversified results of point 2, I believe, besides the obvious new products and systems, basic database, standards, and technical papers which sustain the industrial and social infrastructure are also excellent results. They may seldom be praised by people of the time, but I believe they have greater value than how they are appreciated superficially.

Concerning point 3, I feel that exchanging personnel, be it permanent or temporary, should be more active with universities and companies. I would like to make this an important assignment of the institute management in order to strengthen collaboration of AIST with the outside world, as well as to allow broad and flexible career planning options of researchers.

Concerning point 4, as issues become expanded in scale, symptomatic measures using the accumulated technologies may be necessary. However, I would like to emphasize a top-down approach with comprehensive viewpoints by AIST, which could seldom be taken in private sectors. Moreover, AIST can transmit its research results and contribute in establishing a guideline to solve new issues such as the environmental problems.

New technologies are born every day and they are integrated with others, opening a new horizon of science and technology. Issues that need to be addressed on a global scale are increasing, and the societal systems are in transition. Since AIST strives for the realization of a society of sustainable development, the opportunities for our contribution, I believe, are enormous, and our responsibility is significant.

Technologies for Measuring and Interfacing the Brain and Nervous System and their Application to Industry

The important role of brain research

The brain and nervous system, along with the human genome, are major themes of current life science research and development. These are attracting interest not simply because they are on the frontier of research but because the mechanisms involved are deeply related to the nature of human activity, society, and economy. Of course it is the genome that decides the forms of living organisms, but the neurological workings are what give the resulting beings their individuality. The genome and the brain and nervous system are in a cross-antagonistic relationship (see Fig. 1); human society is formed taking advantage of both. Research and development activities at AIST are being carried out in order to gain a good understanding of their characteristics and to develop technologies for applying them to everyday life.

The life science research field at AIST is pursuing research aimed at achieving the strategic targets (Fig. 2) set for fiscal 2008. The research and development introduced here on "Technologies for Measuring and Interfacing the Brain and Nervous System and their Application to Industry" deals mainly with the third strategic target, "technology for measuring and assessing human functions."

Technology overview

The brain is made up of neural circuits having nerve cells (neurons) as their elements. Understanding how these circuits function is one of today's most important scientific challenges. At AIST we are taking up this challenge directly, as we actively conduct research into monitoring brain states by measuring brain activity. If we succeed in understanding brain states, we should be able to measure and determine what an individual is thinking and feeling at a given time.

If we can measure human brain activity simply and noninvasively, we will be able to know brain states readily. This kind of measurement is made possible using light topography and brainwave monitors. One method for higher-precision measurement of brain activity over time and space is functional magnetic resonance imaging (fMRI). The brain is an organ that receives stimulation from the outside (environment), decides a reaction to the stimulation, and issues motor commands. A developed brain can respond to external stimulation not uniformly but with individuality. Recent research using fMRI has been able to measure brain responses when experiencing or becoming aware of something for the first time.

By making use of such methods, we have been able to learn much about what goes on inside the brain, but have not yet reached the point of being able to measure in detail the workings of neural circuits as they exchange electrical signals. The use of nerve electrodes is a key technology here. They allow us to take detailed measurements of electrical changes in various parts of the brain. By using nerve electrodes to measure brain activity in animals, we have been able to learn the process by which the decision to act is formed. Further, by analyzing activity in brain areas related to visual information, we can now determine accurately what the subject is viewing. Techniques like these can be applied to developing interfaces between brain consciousness and external machines (BMI, brain-machine interfaces).

Because of the brain's complex

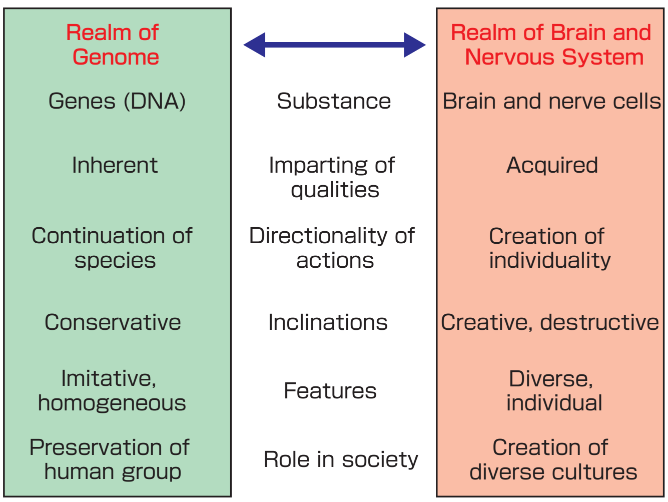

Fig. 1 Workings of the genome versus the brain and nervous system

Strategic targets		Technologies developed to date	Research priorities in FY2008	Targets
Focus areas in Life Science field	1	Protein network analysis technology; glycoanalysis	**Drug discovery and biomarker development support technologies** - Convergence of bioinformatics, structural biology, and chemical biology - Convergence of biology, IT, and nanotechnology (Established Biomedicinal Information Research Center as successor of Biological Information Research Center, and merged Human Stress Signal Research Center with Health Technology Research Center)	Promote preventive medical care and develop early diagnostic technology Realize tailor-made medical care based on genome information
Focus areas in Life Science field	2	Cartilage, bone, heart, liver regeneration technology	**Cell control technology** - Based on explaining cell formation, division, and signal transmission mechanisms (Extend to development of regenerative medicine technology using iPS cells)	Realize safe and effective medical care by developing high-precision diagnostic methods and regeneration techniques
Interdisciplinary focus areas	3	Technologies for measuring and assessing human functions	**Application to health services** Realize technologies for restoring functions in aged and physically disabled, for maintaining and improving functions in nondisabled, and for enhancing life environment (To be extended to service engineering by fusion with the information and electronics field)	Achieve extended healthy longevity by means of technologies for assessing and restoring human functions
Interdisciplinary focus areas	4	Technology for producing pharmaceutical raw materials using genetically-modified plants	Technology for energy-saving, low-environment-load production of materials - Useful materials production by environment field convergence and use of biological functions (Development of biomass utilization technology by fusion with Environment and Energy fields)	Produce highly functional bio-products by materials production process using biological functions

Fig. 2 Strategic focus in fiscal 2008 (Life Science field)

structure, even with nerve electrodes it is very difficult to analyze in detail the principles by which neural circuits operate. Research is thus being carried out in which artificially cultured nerve cells are induced to form circuits autonomously and the nature of those circuits is analyzed. We have discovered the existence of periodic electrical activity in such a circuit even without external stimulus, and have learned the kind of network structure it forms, called a small world. By connecting not a brain but this artificial neural circuit to a robot, we have shown the possibility that a form of learning takes place.

Industrial applications and cross-discipline cooperation

Various applications come to mind once it becomes possible to measure the brain and nervous system in this way. By connecting brain signals to an external instrument such as an artificial hand, it should be possible to restore lost motor functions or enable the indication of intentions. Another possibility is to stimulate the brain with nerve electrodes for quicker rehabilitation. Further, being able to understand the brain's "feelings" will enable psychological measurements in various situations, which would be useful for developing products matched to the rich emotions and complex consciousness of human beings. If the principles of brain functioning can be understood with

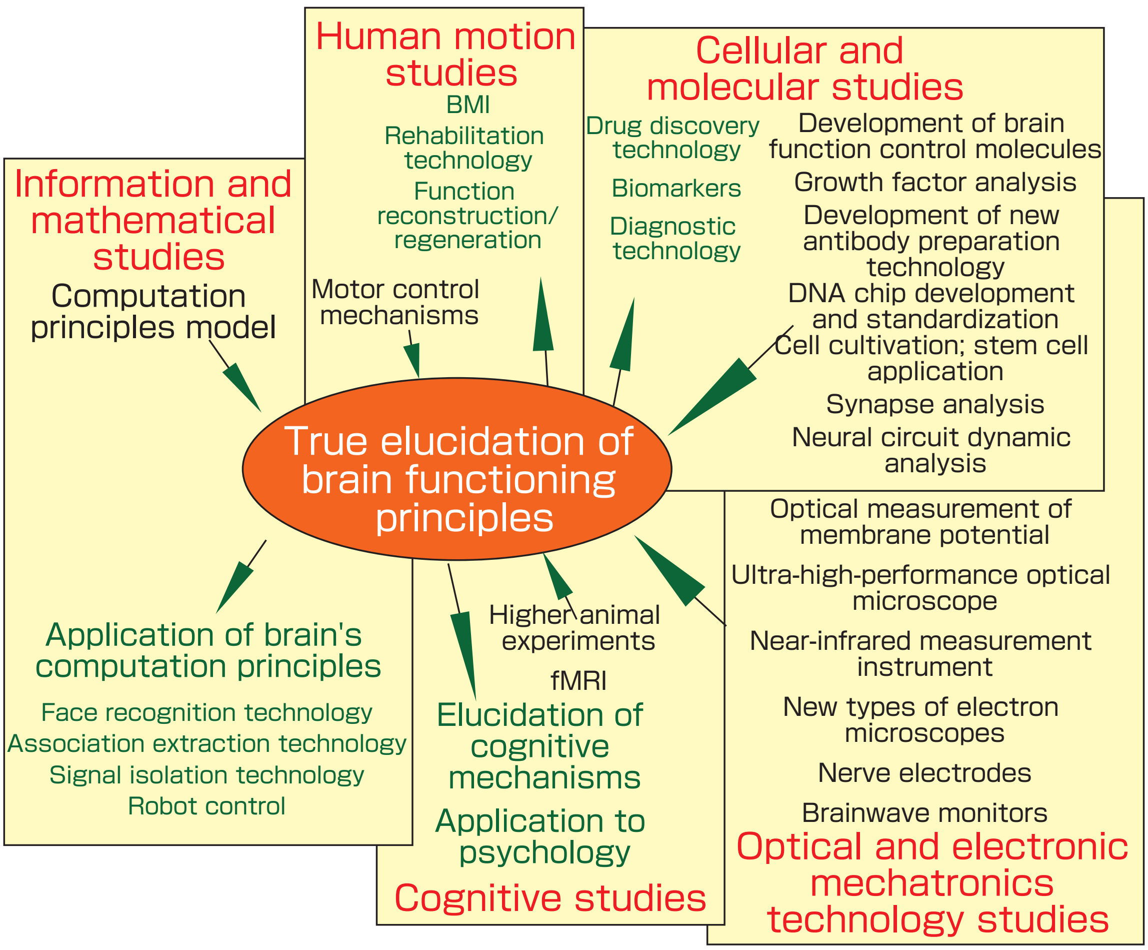

Fig. 3 Advancement of research on the brain and nervous system

a bit more precision, the creation of new information processing technology may be more than just a dream.

These applications cannot be accomplished by the technology fields introduced here alone but will require cooperation across a wide range of disciplines, including biotechnology, electronic engineering, mathematics, information engineering, mechanical engineering, materials science, and medicine. At AIST, besides bringing together experts from these fields in our laboratories, we are forming cooperative arrangements with researchers in corporations and universities, in an effort to reach the product stage as early as possible.

Laying the groundwork for commercialization

Going from research results to actual provision to society of useful products and systems requires the "commercialization of research results" through tie-ups with private corporations and the creation of venture businesses. When creating products from research results on brain and nervous system measurement and interface technologies, direct impact on human beings (individuals) is unavoidable. For this reason sufficient scientific backing and safety must be assured; moreover, it is vital to guarantee strict information management and create a system that people can use with peace of mind. For carrying out this kind of new product development quickly while giving due attention to safety assurance, the preparation of public development guidelines is an important step.

The Ministry of Economy, Trade and Industry in collaboration with the Ministry of Health, Labour and Welfare started a project to draft medical equipment development guidelines in fiscal 2005. The purpose of the project is to devise guidelines in advance giving the essential performance requirements of medical equipment being developed for eventual release as products, and to facilitate compliance with the inspection standards of the Pharmaceuticals and Medical Devices Agency as well as with international standards. The hope is that the guidelines will make it easier for medical products to be developed quickly that meet the needs of the public. AIST is also involved in this project, proposing guidelines for various kinds of devices. Starting this fiscal year, we have also begun devising nerve electrode development guidelines in view of recent progress in brain research and its application development. (See References.)

Brain and nervous system measurement and interface technology, being a highly advanced subject that deals with the brain, and having the usefulness of being directly involved with human living, has seen a recent acceleration of worldwide research and development activity. In order to keep accurate track of this situation and go from research results to product development as quickly as possible, it is important to carry out surveys of overseas research trends and studies aimed at obtaining a comprehensive overview of basic, application, and product realization activities. AIST researchers are also actively participating in the research work of outside organizations involved in such issues (New Energy and Industrial Technology Development Organization, Japan Science and Technology Agency, etc.), and are cocntributing to the development of this field in Japan. (See reports in references.)

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Development of a Peripheral Nerve Interface Electrode

Expectations for neural interface technology

Technology that measures neuronal activities by inserting electrodes in the cerebral cortex and uses the measured signals to control a mouse cursor on a computer display, artificial hands or other external devices is known as neural interface technology. Its potential for restoring motor functions or sensory functions lost due to accident or disease is raising hopes in medical and welfare fields for future revolutionary prosthetic and medical treatment techniques.

Problems with cerebral nerve interfaces

Neural interfaces used for such purposes as electroencephalography are noninvasive, but suffer from relatively poor spatial and temporal resolution of signals. The type of neural interface that uses electrodes inserted in the brain and measures neuronal activities is more effective, but might leave behind irreversible lesions in the cerebrum because of the need to implant electrodes in brain tissue. Other problems with this type of neural interface include the difficulty of obtaining information about individual organs.

Toward a viable peripheral nerve interface

Believing that an effective solution to these problems lies in designing a neural interface that attaches not to the cerebrum but to peripheral nerves, we have been working with Prof. Makoto Ishida of Toyohashi University of Technology to develop an electrode for a peripheral nerve interface. Our electrode under development should have the capability of simultaneously measuring the action potentials of individual nerve fibers in a peripheral nerve bundle. Earlier proposals for measuring peripheral nerve activity were based on the use of sieve electrodes, needle point holder-shaped electrodes, and cuff electrodes; but these and other attempts have been unable to meet the requirement for low-invasive measurement that is also able to distinguish the activity of individual nerve fibers.

To date, applying the selective Vapor–Liquid–Solid (VLS) growth technique[1] to electrode development, we have succeeded in forming a structure like that shown in the electron microscope photograph (Fig. 1, left). The resulting electrode combines an unprecedented low-invasive design with ease of incorporation on an integrated circuit substrate. Moreover, using an array of metal microelectrodes having similar recording surface area as this electrode, we have confirmed the ability to take localized measurements of evoked action potentials in single peripheral nerve fibers (Fig. 2) for all-or-nothing responses. The measured signals attenuated with increased distance from the signal source, showing that the technology we have developed for simultaneous measurement of action potentials in multiple neurons[2] is able to isolate action potentials for individual nerve fibers.

In the future, we hope to enable use of this peripheral nerve electrode for measuring nerve activities and for

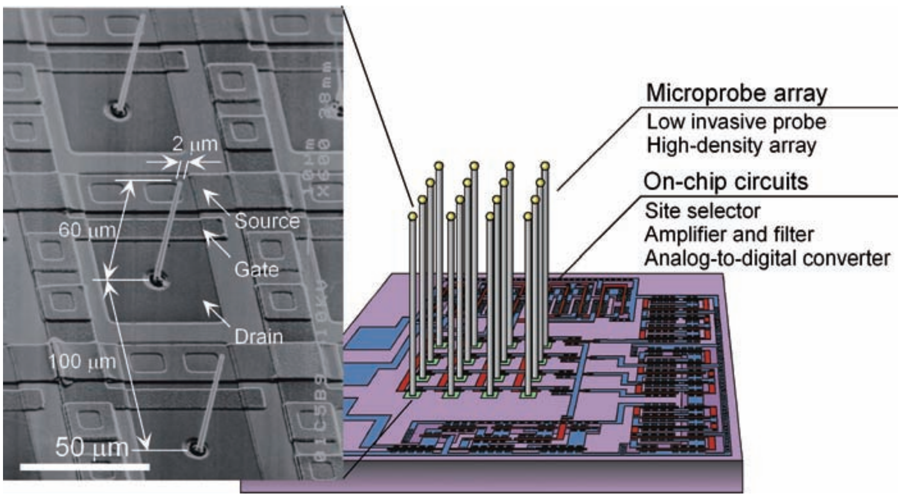

Fig. 1 Microprobe electrode array fabricated by VLS growth
This is an electron microscope photograph of the microprobe electrode array under development (left). Conventional microelectrodes are thick, typically from several tens to a hundred micrometers in diameter. The microprobes shown here are extremely fine with a diameter of only 2 micrometers, for low-invasive use. Moreover, these microprobes can be grown on a semiconductor substrate (right).
(Photo and illustration provided by Makoto Ishida, Toyohashi University of Technology)

controlling them by electrical stimulation, so that the technology can be applied to assisting and restoring organs whose functionality is impaired due to diseases and other causes.

Institute for Human Science and Biomedical Engineering

Hidekazu Kaneko

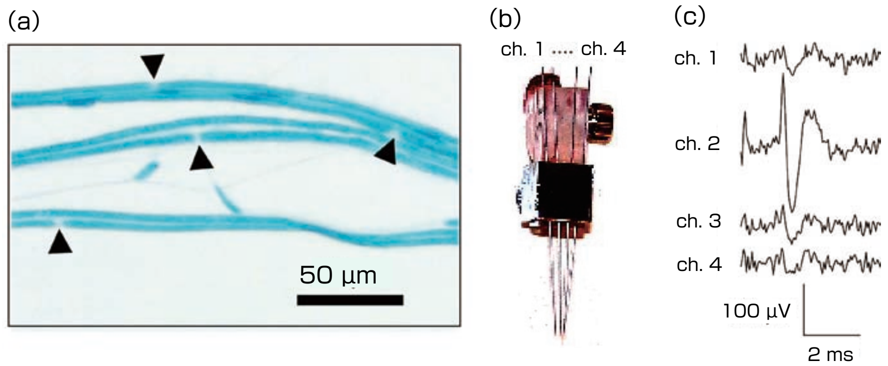

Fig. 2 Measurement of action potentials in a single peripheral nerve fiber
On myelinated peripheral nerve fibers, action potentials occur at the Ranvier nodes (the triangles in tissue sample (a)). Using a microelectrode array (b) consisting of metal microelectrodes arranged at approximately 0.5 mm intervals, we were able to take localized measurements of evoked action potentials in single nerve fibers (c) for all-or-nothing responses.

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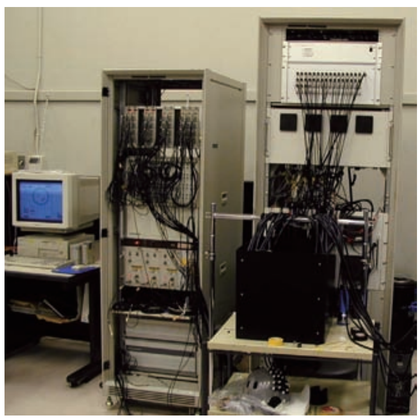
Near Infrared Imaging of Brain Activity Using Scattered Light

Noninvasive measurement of brain activity

Recently, some excellent imaging methods, including functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), have developed and achieved remarkable progress for noninvasive measurement of brain activity. These techniques can measure the brain activity in the whole brain with high spatial resolution. On the other hand, they need high limitation on the subject's movements, and to stay inside the narrow gantry for a certain time. Some subjects feel tense and uneasy, to affect the results or make it difficult to perform the measurements. Compared to such approaches, imaging systems applying near infrared spectroscopy (NIRS), while not offering the high spatial resolution and information on deep brain, does not require special gantry and enabling low-restraint measurement, with the subject encumbered only by optical fibers.

Near infrared imaging

Near infrared light of wavelengths in the range of 700 to 900 nm shows comparatively high penetration through the living body. Within this range, the optical spectrum of oxy-hemoglobin, containing large amounts of oxygen, differs from that of deoxy-hemoglobin, which contains smaller amounts. By using the difference, The principle of near infrared spectroscopy (NIRS) is

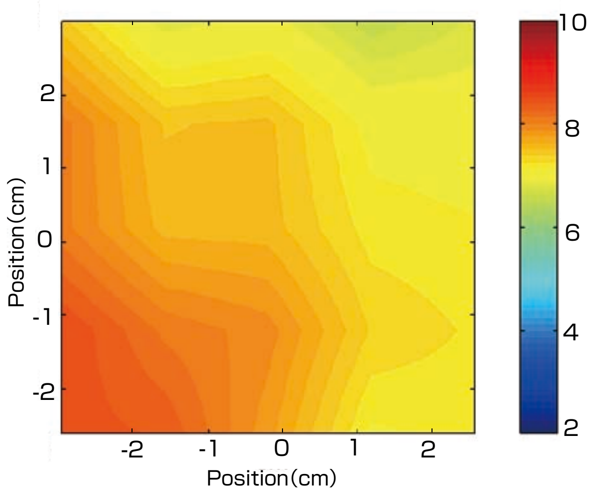


Time-resolved diffuse optical tomographic system

to obtain information of the changes in hemoglobin concentration and oxygen saturation by using this difference. Based on this principle, NIRS imaging system is composed by a number of source-detector pair.

Two types of methods are used mainly in NIRS imaging, continuous wave (CW) and time-resolved (TR) methods. CW-NIRS system is consisted of CW light(usual laser light) sources and usual optical detectors, that is, simple, compact, and low in cost. It is possible to measure real-time over extended periods. The time-resolution is sufficiently fast to track even the rapid metabolic changes in the brain. Optical mapping system using CW-NIRS have developed and commercialized as optical topography and functional NIRS (*f*NIRS), etc. These systems are applied not only to research on brain activity but also to motion measurement and other kinds of measurement.

However, because the light is strongly scattered by hemoglobin or tissue, the detected light travels much longer optical path compared with the distance between the source-detector distance before reaching the detector. Since CW-NIRS system has no way to measure the length of optical path (mean optical pathlength), The images generated from the measurement indicate the amount of change in the product of "hemoglobin concentration" and " mean optical pathlength".



DPF map of the human motor area with the wavelength of 799 nm.
(normalized for distance between light source and detector)

Time-resolved measurement

The mean optical pathlength can be obtained as the average optical pathlength by applying "time-resolved (TR) measurement". TR-NIRS system is composed of ultra-short light pulse source and high-speed detector. Shown in the photo is a time-resolved diffuse optical tomographic (TR-DOT) system capable of time-resolved measurement on as many as 32 channels at once. It consisted of a time-correlated single photon counting system with 25 ps resolution and pulsed laser diodes emitting ultra-short light pulses with a pulse width of about 100 ps at three wavelengths. It measures the waveforms after they have been transformed by scattering and absorption in from the living organism. The mean optical pathlength is determined from the measured waveform. The image in the figure shows the DPF map of the human motor area with the wavelength of 799 nm in the right temporal lobe of a human head. DPF map is distribution of normalized mean optical path length by the source-detector distance. The color of the figure indicate how many times greater the mean pathlength is than the source-detector distance. For example, the central part of the motor area, in the center of the figure, is indicated in orange, meaning that the light reached the outside of the subject after traversing a path approximately 7 times longer than the source-detector distance.

TR method, however, has a disadvantage on especially low time resolution. Since the signals measured by the method have been weakened by scattering and absorption in the living subject, data must be accumulated until a sufficient signal-to-noise ratio is obtained. For the brain activity measurement, the order of the change in hemoglobin concentration and oxygen saturation is said to be milliseconds order. Our group is working to develop a method in which the mean optical pathlength data obtained from TR measurement is reflected in CW-NIRS measurement to obtain quantitative data.

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Development of a System for External Device Control by Cognitive Brain-Machine Interface (BMI)

Toward enhanced "Quality of Life" (QOL)

In today's society of low birthrate and an aging population, neurotechnology research aimed at improving the quality of life (QOL) for people with brain or physical disabilities is an important mission for researchers wanting to contribute to society through their studies of the brain.[1],[2] Over the past several years, brain-machine interface (BMI) technology, which connects the brain directly to the external devices, has attracted attention as one way of realizing enhanced QOL. Prominent in the popular image of BMI are motor and sensory BMIs for assisting lost motor or sensory functions. Our development, however, is focused rather on cognitive BMI, probing the mysterious human cognition.

Cognitive BMI and decision prediction

Cognitive functions include a variety of mental activities such as memory and inference, but our development is focusing first of all on one of the simplest cognitive function models, the decision-making process when faced with two choices. The technology we are developing tries to predict this decision based on activity in the brain. For people with severe brain or spinal cord disabilities that prevent them from writing and talking, becoming able to express simple choices such as Yes/No or Right/Left can greatly improve their ability to communicate with others.

We started by training the monkey, as animal model, in a Go/No-go task. In this task, depending on the difference in color of visual cues presented in a peripheral visual field, the monkey decided either to move its eyes to the cue (Go) or not to look at it (No-go). After learning was established, we recorded neuronal activities from the monkey's brain area known as the superior colliculus while the monkey performed the task.[3] We then studied in detail the probability of correspondence between the final action and the neuronal activities and succeeded in representing the process by which a specific decision occurs in the brain as a time-based change in the virtual decision function (VDF) (Fig. 1). By observing variations in this function, we are able to predict the Go/No-go decision in the brain in just 0.15 seconds after presenting the cue. This indicates that the decoding of the decision in the brain is completed at least 0.1 seconds earlier than the actual eye movement.[4] Moreover, the decision can be predicted with the same speed even when the expression of that decision by moving or not moving the eyes is delayed by 1 second or so.[5] It is possible, in other words, to decode thinking in the brain even when it is a matter of simply "having the thought in the mind."

"Mind's Eye" project

Currently we are starting to experiment with control of external devices based on the decoding of decisions in the brain. As a first step, we began the "Mind's Eye" project. Our goal in this project is to develop a system in which a movable camera is operated by decision states in the brain. Already we have succeeded in creating a system that moves the camera quickly in the correct direction using, as simulated real-time data, the brain activity during the interval when

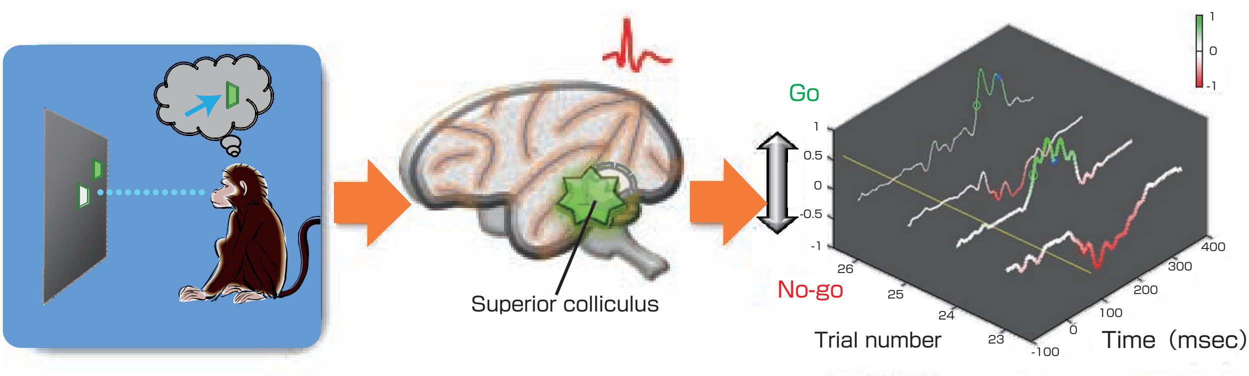

Fig. 1 Predicting decision based on neuron activity recorded from the superior colliculus while a monkey performs Go/No-go tasks

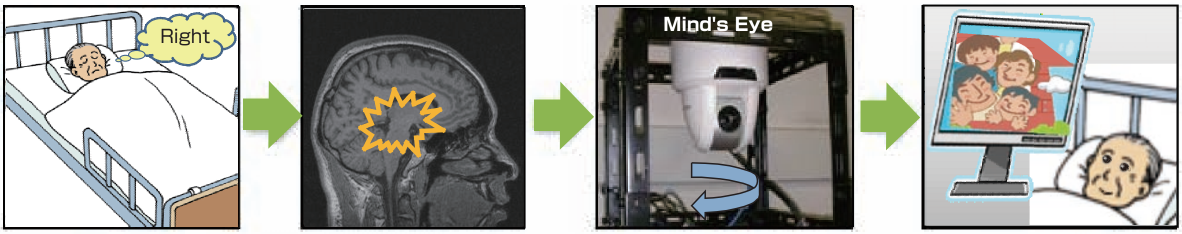

Fig. 2 Concept of Mind's Eye technology for controlling camera movement based on brain activity

the monkey is still thinking in the brain whether to move its eyes to the right or left. Following on the animal experiments, we plan to establish technology for real-time interactive camera control. We are also proceeding with introduction of noninvasive brain activity measurement technology such as electroencephalogram (EEG) and/or near-infrared spectroscopy (NIRS) for human subjects. In the future, we hope to make use of the Mind's Eye so that even people confined to a hospital bed can have exchanges with their family and friends in remote places as if they were in the same room together (Fig. 2).

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A Semi-Artificial Neural Network Made with Cultured Nerve Cells

Neural engineering and other attempts to transmit information directly between the nervous system and artificial systems have been increasingly successful in recent years. In informatics engineering, meanwhile, breakthroughs are being sought in the area of flexible, autonomous bio-intelligence. As interdisciplinary convergence proceeds from the directions of both life sciences and information engineering, it is important to take an integrated approach that merges the frameworks of each area. One such attempt is embodied cognitive science, with its emphasis on self-organization of intelligence through interaction between living systems and their environment via their body. The ability to analyze and control that process is also itself a component technology of brain-machine interfaces (BMI). From this point of view, we have conducted research concerning a system in which a semi-artificial neural network made with cultured neurons interacts with its environment.

A self-organizing neural network

Neurons, even when artificially cultured, elongate their neurites and form synaptic connections with each other to reconstitute complex networks. In this kind of semi-artificial network, we discovered that neurons having many synaptic inputs and play the

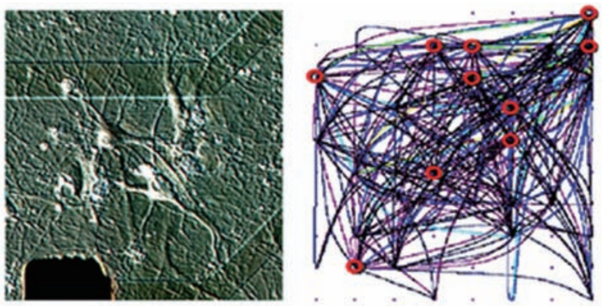

Fig. 1 (left) Neural network generated from cultured rat hippocampal neurons on the 26th day of culturing. (right) Map of neuronal connections showing visually the neurons from which input is received by neurons (dots) for which electrical activity was recorded.
○ indicates a "hub" cell receiving a large amount of input.

role of hubs, and those specific structures are formed by self-organization [1] (Fig. 1). The genetically specified connections are initially abolished, but a neural network then self-adjusts its structure depends on its own electrical activity. The self-organizing reconstituting ability of a neural network is an important element both for BMI and for autonomous intelligence.

Neuro-robot development

We next embodied such a neural network with a robot[2] (Fig. 2). As a system for analyzing the interaction dynamics between a neural network and its environment, it provides a useful experimental system for the information processing and analysis of neural information code required in BMI. Moreover, by creating a framework in which neural networks behave in the environment through the body of a robot and by giving "meaning" to electrical activity in a neuronal network, it is an attempt to create human intelligence in a culture dish. To date, we have developed a neuro-robot system called VITROID. The robot sensor information is input into a neuronal network, where spatio-temporal patterns of the network activity in response to this input are processed, and robot motor control is performed using the results of this processing. Currently we are seeking to shed light on the process of interaction between the neural network and the outside world in the instinctive action of collision avoidance.

Controlling neural dynamics by cell manipulation technology

We have also developed technologies for freely arranging neural network patterns, and for localized neural network segmentation using a focused femtosecond laser without damaging electrodes, among our other attempts to devise methodologies for manipulating living neuronal networks[3] (Fig. 3). We have taken up the challenge of using laser tweezers for direct manipulation of molecules in synapses, as an attempt to control the dynamics of neuronal networks.

By integrating cell manipulation techniques with informatics technology and robotics, we can enable to link the behavior of functional molecule with higher-order brain functions at the neuronal network level. We hope that such integration will pave the way for engineering that contributes to cyborg technology and artificial intelligence.

Our attempts in the field of neuro-robotics are useful as engineering that broadens human feelings, while also delving into the philosophical topic of what it means to be human.

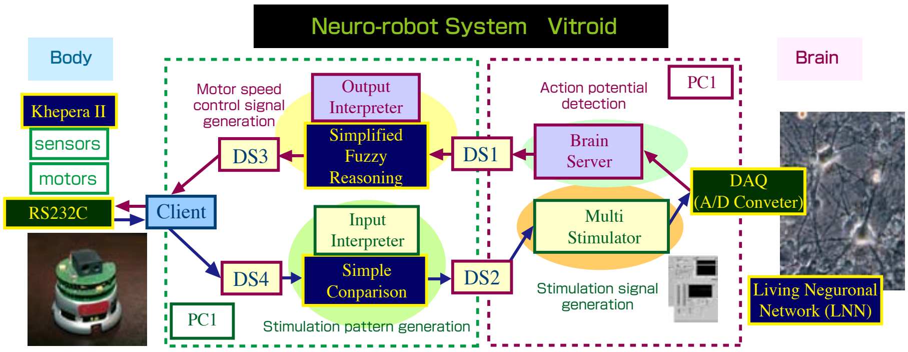

Fig. 2 Structural diagram of neuro-robot VITROID
A living robot system using cultured nerve cells as brain and near infrared a small mobile robot with sensors as body

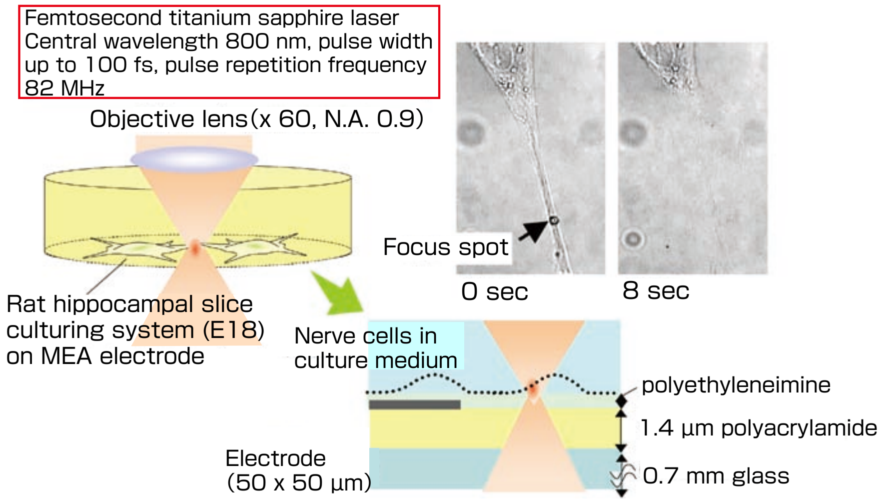

Fig. 3 Technology for localized neural network segmentation using a focused femtosecond laser
This method makes possible selective cutting of the desired neurites without damaging the nerve electrodes.

Research Institute for Cell Engineering

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[3] C. Hosokawa *et al.*: *NeuroReport*, 19 (7), 771-775 (2008).

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"Brain Information Map" Creation and Use

Representation in the brain of multi-dimensional decision-making

When we select one of multiple choices, we make the decision by considering attributes of the choices before us. When buying a car, for example, we decide not only based on price but by taking into account performance and other factors. How is this kind of multi-dimensional decision-making represented in the brain?

Using the activities of 323 neurons recorded individually by my fellow researchers from the frontal cortex of a monkey, the author developed a method for visualizing how multi-dimensional information is represented in the brain. The monkey had been trained to remember the position of a visual stimulus presented for a split second in the monkey's peripheral vision, and according to a certain rule, thereafter either to look at that position or to look elsewhere. This task required two-dimensional decision-making, deciding where the stimulus was located and whether or not to look at that position. First we represented the activity of the 323 neurons by means of a 323-dimensional vector. Since the behavior of the 323-dimensional vector cannot be understood intuitively, we reduced the number of dimensions by principal component analysis. The data structure after this operation is what we call a brain information map.

An example of such a map is shown in Fig. 1, which represents the decision as to where the stimulus was located. The vector end-points at approximately 0.2 seconds following the presentation of the stimulus were plotted on this map for each stimulus position, after reduction to two-dimensional vectors. The same positions as those presented on the screen were then replicated on the brain information map. Performing the task also required deciding whether to look or not to look at the stimulus position. When we projected vectors for the two conditions "look" or "not look" on a map closely reflecting these decision-making differences, the difference in vector directions was most pronounced at approximately 1.5 seconds after presentation of the stimulus. By looking at multiple dynamic brain information maps in this way, we were able to visualize the representation in the brain of multi-dimensional decision-making from the neuron data.

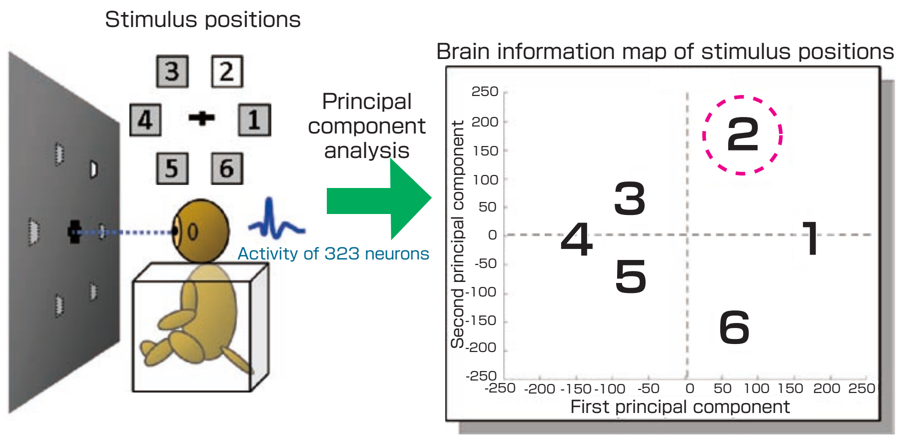

Fig. 1 Brain information map created from neuron activity in a monkey performing a behavioral task
The actual stimulus positions are seen to align closely with positions on the brain information map.

Decision prediction

Next we predicted the decision in the brain using the obtained brain information maps. We began by reflecting on the previously obtained maps the activity of 323 neurons (323-dimensional vectors) recorded under unknown test conditions (Fig. 2 (A)). We assumed that when a position indicated at this time was near any of the known positions corresponding to the six stimulus positions, this indicated brain activity when a stimulus was presented at that position. We calculated a "decision distance index" as the inverse number of the distance between this position and each of the stimulus positions (Fig. 2 (B)), and took the maximum value of this index as meaning the detected decision. This calculation was performed independently for the decision "Where is the stimulus?" and "Look or not look" and evaluated these answers in combination. As a result, we were able to predict correctly in 95 % of 600 trials.

Application to the neuromarketing field

The brain information maps created in this project have possible application to many different fields. One field that has become active recently is neuromarketing, which uses such tools as brainwave monitoring and functional MRI (fMRI)

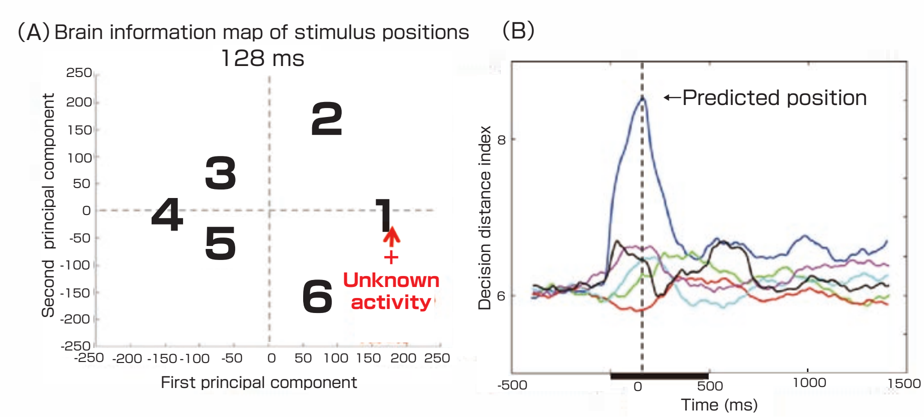

Fig. 2 (A) Neuron activity recorded under unknown test conditions (+ mark) and projected on the brain information map obtained as in Fig. 1
(B) Stimulus position predicted using decision distance index
Of the stimulus positions, the one in closest proximity (in this case, the one to the right of the position indicated by the blue line = position No. 1) on the brain information map during the time the stimulus was presented (the time indicated by the black horizontal line) was predicted to be the position of the presented stimulus (and the prediction turned out to be correct). The dotted line indicates the time of nearest proximity, corresponding to the time obtained in (A).

devices to investigate brain activity related to consumer behavior.[2] We are also planning to make use of the brain information maps for understanding and predicting the information processing in the brain when making subjective and unconscious decisions (buy/not buy decisions) based on brand, preferences and other factors.

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Interest and Preference Measured by Gamma-Band Electroencephalogram (EEG)

The need for affective evaluation technology by EEG

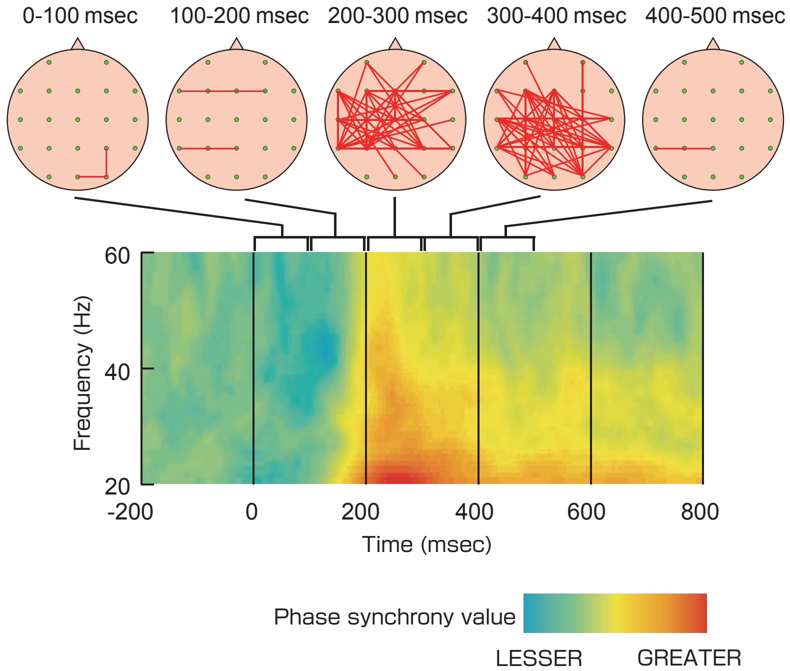
In our daily life, we regularly make affective judgments such as "like" or "dislike" regarding various events, and behave on that basis. For product developers, an important task is to investigate user interest and preference in order to design better products. Typically, such affective evaluation is surveyed by presenting users with questionnaires asking about their impressions of products. Problems pointed out with this approach include the lack of guaranteed objectivity and the difficulty of obtaining quantitative results. An answer to these problems would be to develop an affective evaluation method relying on objective indices such as EEG.

Gamma-band Phase synchronization of EEG

Functions like perception, memory, and judgment are located in specific parts of the brain, while affective evaluation is believed to be realized by an overall interaction among these functions. EEG involves various frequency bands; of these, researches in recent years has found that EEG in the gamma band (20 to 100 Hz) relate to higher-order cognitive activity. Recent researches have also revealed that by analyzing the phase synchronization of electrodes placed on the scalp, the functional connectivity among different brain regions can be visualized. In our research, we therefore developed a technique for evaluating user preferences by measuring phase synchronization of gamma-band EEG.

Phase synchronization in gamma-band during evaluation of photographic images

We performed experiments in which EEG were measured while participants made "like/dislike" judgments of photographic images displayed on a computer screen. We discovered that phase synchronization of gamma-band EEG was greater across large numbers of brain regions when viewing images that the participant liked, compared to the results for disliked images or images that were neither liked nor disliked (see Figure). This indicates that the feeling of "like" is accompanied by functional connection among many brain



Gamma-band phase synchrony when looking at a "liked" photographic image
Greater phase synchronization is observed starting 200 msec after the presentation of the images (the zero point on the time course indicates the presentation of an image). The red lines in the top panel of this figure represent channel pairs seen to have significantly greater phase synchronization than when viewing "disliked" images.

regions, and that affective evaluation can be measured by visualizing this synchrony. Moreover, since phase synchronization begins around 200 msec after the presentation of an image, more intuitive affective evaluation can be measured than in the case of a written questionnaire, where the consumer has time to consider responses. By further developing this technique, it should become possible to perform objective affective evaluation without having to ask for repeated subjective evaluations as on a "like/dislike" questionnaire.

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Functional MRI (fMRI) Provides a Look into the "Mind System"

A few years ago the author contributed a paper on "Research on Human Intelligence by fMRI "[1] to the Journal of the Institute of Electronics, Information and Communication Engineers (IEICE). The paper describes the possibility of gaining deep insight into everyday human intelligence through knowledge of the brain, which can be gained in a safe and noninvasive way by using magnetic resonance imaging (MRI) to measure whole-brain activity accompanying cognitive activity in healthy subjects. The predictions made in that article have turned out to be accurate, and MRI is now becoming a useful tool in BMI (Brain Machine Interfaces) introduced elsewhere in this series, in BCI (Brain Computer Interfaces), and in fields such as neuro-marketing and neuro-economics. In the case of neuro-marketing, we are starting to understand the brain functioning by which people make purchasing decisions, based more on preferences and intuition than on rational judgment.

Using MRI to glimpse the human "mind system"

Here we shall introduce the results of a "neuroscience and education" project, which is pursuing the strong relationship between the human hippocampus and

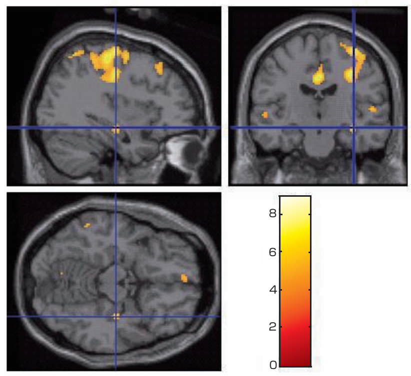

Fig. 1 World's first MRI image recording action in the brain (hippocampus) at the time of an "Aha!" moment of inspiration
Introduced in the White Paper on Science and Technology [3]

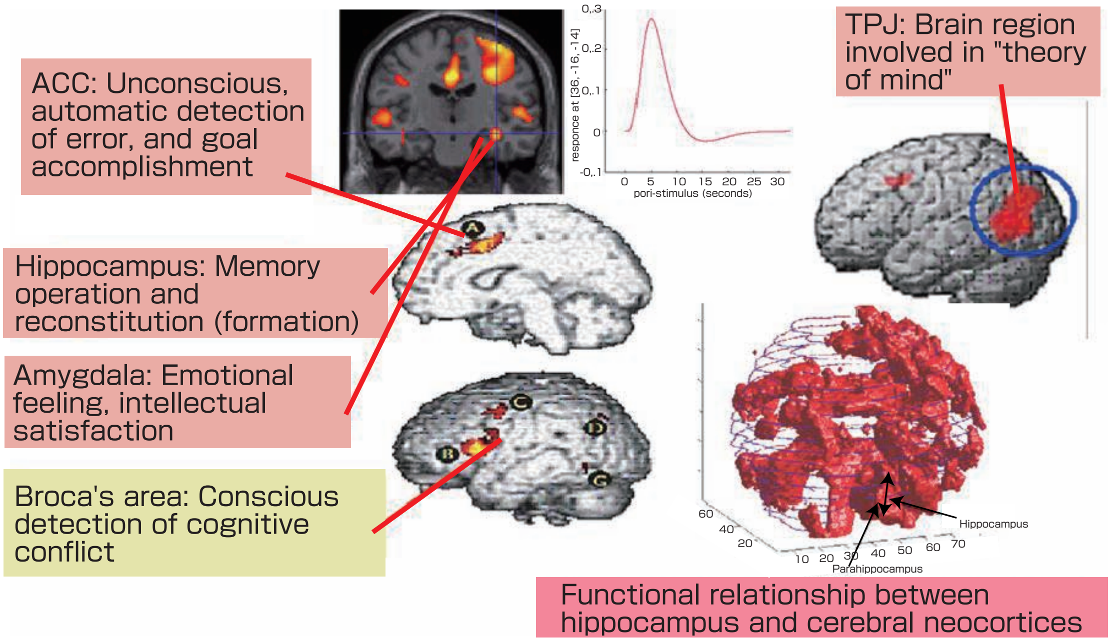

Fig. 2 Working of the "mind system" when knowledge and intelligence are formed through experience

higher-order cognition in order to demonstrate the wonders of being able to understand the "mind system" with MRI.

The hippocampus has its pivotal role in memory, however, the hippocampus is commonly misunderstood that it is responsible only for short-term memory. In fact, the human hippocampus is involved in the formation and use of "episode memory," which is the most advanced type of memory, and is therefore essential in forming and using the human's higher-order cognitive functions.[2] When human beings experience something, and especially in the case of purposeful cognitive activities, we form new knowledge and intelligence. The most extreme example is the insight phenomenon; at the short-lived "Aha!" moment, new knowledge/intelligence is formed and acquired (Fig. 1). Fig. 2 gives an overview of the brain areas active when knowledge and/or intelligence are reconstructed through experiences of this kind.

The figure shows that not only the hippocampus central to memory is active at this time but also a simultaneously acting brain system supporting it. The amygdala central to emotions such as intellectual satisfaction, the ACC (anterior cingulate cortex) functioning for the sake of error detection and goal accomplishment, and the TPJ (temporo-parietal junction) said to be the region involved in the "theory of mind" necessary for empathetic understanding, are all working at the same time. That the social brain (developed through adaptation to the social environment) and the affective areas of the brain are actively involved in formation and utilization of human intelligence is instructive for understanding the nature of human intelligence.

"How should education be designed?" "What is the best approach to lifelong learning?" "What does it mean to develop human resources?" "What is the source of human creativity?" "What are feelings and emotions?" "How does the brain work when a consumer decides to purchase?" The understanding necessary for answering these questions is sure to deepen by looking at the mind system by which human intelligence is formed and used.

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Research Hotline

UPDATE FROM THE CUTTING EDGE

Jan.-Mar. 2009

The abstracts of the recent research information appearing in Vol.9 No.1-3 of "AIST TODAY" are introduced here, classified by research area. For inquiry about the full article, please contact the author via e-mail.

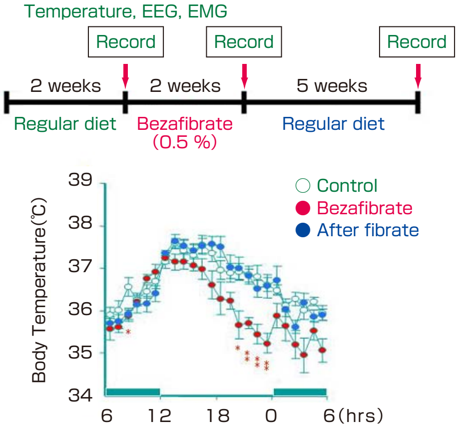
Life Science and Biotechnology

Daily circadian clock tells four seasons to seasonal clock

Hypolipidemic drug, bezafibrate changes seasonal physiological clock of mice

We found that bezafibrate, which is an well-known hypolipidemic drug for humans, influences animals' biological seasonal clocks, including torpor and non-REM sleep.

This study revealed that mice fed on a diet containing fibrate showed physiological patterns similar to those in the hibernating state. It is well known that fibrate is a ligand for Peroxisome Proliferator-Activated Reactor α PPARα, a nuclear receptor on liver cells. In 2007, we found that fibrate advanced the pace of the circadian clock forward and had a therapeutic effect on sleep rhythm disorders called delayed sleep phase syndrome. In this news, we showed that PPARα effects not only the circadian clock but also the biological seasonal clock.



Mice were housed on 12 hours day and 12 hours night cycles for the whole experimental period of 9 weeks, and were fed a fibrate diet for 2 weeks (red circle).

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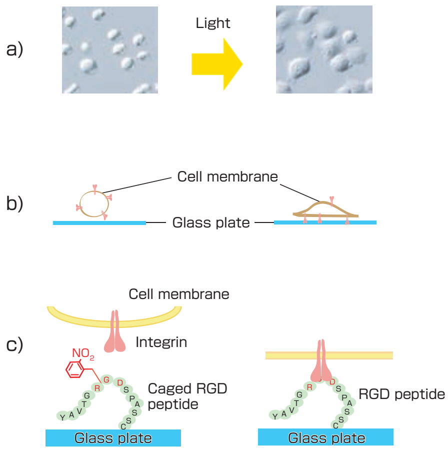
AIST TODAY Vol.9, No.1 p.9 (2009)

Photo-control of biomolecules and cells
Triggering of reaction using caged peptides

Caged peptides, whose activities are masked by the introduction of photocleavable groups, have recently been recognized as a useful tool to elucidate various biological phenomena with a high spatial and temporal resolution, even in living cells. AIST has developed techniques in design, synthesis and application of caged peptides. Here we would like to introduce the application of caged RGD (arginine-glycine- aspartic acid) peptide, by which the cell adhesion can be photocontrolled spatiotemporally.



Micrographs and proposed mechanism of photo-triggered cell adhesion. Upon light irradiation, the caged RGD peptide moiety immobilized on the glass-bottom dish is converted to the RGD peptide, and cells adhere.

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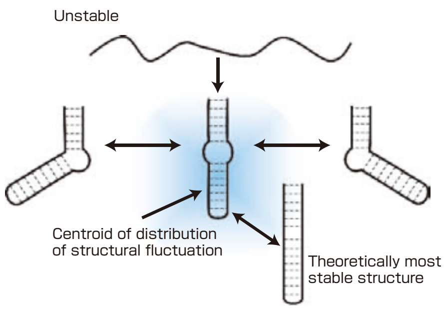
AIST TODAY Vol.9, No.1 p.10 (2009)

Life Science and Biotechnology

Development of RNA secondary structure prediction software
A major tool to help RNA medicine development and novel functional RNA discovery

We have developed a software tool to predict RNA secondary structures. Our tool achieved the world's best performance for RNA secondary structure benchmarks as of this date. The RNA secondary structure prediction is one of the widely used techniques in the field of biotechnology. The technique is indispensable for oligo-primer/probe design, siRNA design and micro RNA target prediction to name a few.

We are aiming to replace still widely used but outdated traditional prediction tools with our tool named CentroidFold. CentroidFold is backed by our original theory that maximizes the expected prediction accuracy. The theory promises the improvement of the prediction accuracy at mathematical precision. CentroidFold is provided in the form of a web application as well as a standalone software package. The web application can be accessed at **http://www.ncrna.org/centroidfold/**. The standalone software package can be downloaded from **http://www.ncrna.org/software/centroidfold/download/**.



An RNA structure fluctuates and folds into one structure of a hypothetical distribution of structures. Theoretically the most stable structure is included in the distribution but it can differ from the centroid of the distribution which is a better prediction in many cases. CentroidFold computes the centroid structure instead of theoretically the most stable structure.

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Development of a novel enzymatic method for measuring levels of mizoribine, an immunosuppressive drug, in serum

The method will be applied to high-throughput measurement of serum mizoribine

Mizoribine (MZR), an immunosuppressive drug, has been used for treatment in organ transplantation, lupus nephritis and rheumatoid arthritis. Orally administrated MZR is adsorbed, phosphorylated to MZR 5'-mono phosphate (MZR-P) and then inhibit inosine 5'-mono phosphate dehydrogenase. In this way, MZR-P blocks nucleic acid synthesis, which in turn inhibits proliferation of T and B cells. In order to refine optimum individual dosage of MZR, it is important to measure MZR levels in serum. Although only available method is high-performance liquid chromatography analysis, it is not suitable for high-throughput measurement of MZR levels in serum. Here, we identified a novel nucleoside kinase, which phosphorylates MZR, and developed an enzymatic method for measuring serum MZR levels. This enzymatic method can be applied to an automatic clinical analyzer for measuring a set of serum samples.

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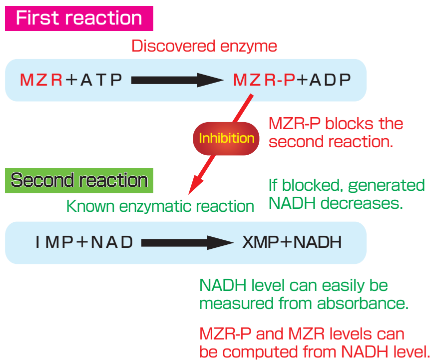
AIST TODAY Vol.9, No.3 p.17 (2009)



Enzymatic method for measurement of mizoribine

Development of a technique for mass production of metal-containing organic nanotubes

Expected to be used as catalysts, in DNA separation, and as templates of metallic nanomaterials

We have developed a technique for mass production of metal-complex-type organic nanotubes (ONTs). Just mixing an aqueous solution of metal salt and an alcohol suspension of peptide lipid gives the metal-complex-type ONTs. Exchange of proton of the lipids and metal cations occurs rapidly, and the original plate structures of the lipids convert into the nanotube structures within a few minutes. We can obtain more than 100 g dry nanotubes from 1 L solvent just by filtration. These metal-complex-type ONTs are expected to apply in various fields such as medical, health, nano-biotechnologies, and electronics. For example, metal cations on the surfaces can be connecting sites of various materials such as functional molecules and biological macromolecules. Metal cations both on the surfaces and in-between the layers can be also good templates for metal nanostructures.

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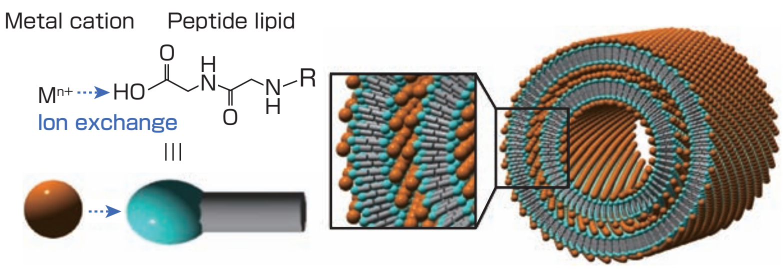

Proposed structure of metal-complex-type organic nanotube

Microminiature super-fine ink-jet system

Micrometer order manufacturing technology is miniaturized to palm size

We have developed super-fine ink-jet (SIJ) technology which can eject a super fine droplet of 1/1000 in volume, compared with conventional home use ink-jet printer. Recently, microminiaturization of system size to 1/600 in volume is achieved. Furthermore, the system requires only DC5V, and can be operated on battery. By using this ultra-small SIJ units, micrometer scale patterning or precise material deposition in femt litter order is feasible. Mask-less patterning, such as micrometer scale circuit pattern can be achieved without a photolithograph process. It is a so-called portable palm-sized micro manufacturing system (Pocket factory). By brushing up more miniaturization and reliability, the palm sized system will be launched from an AIST start up company.

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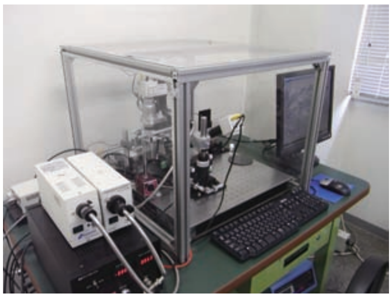

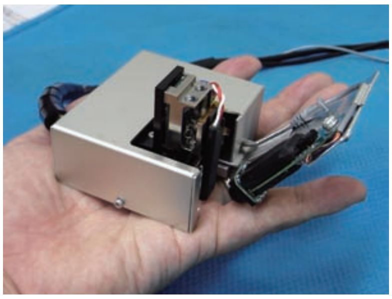

Left: Conventional super ink-jet system
Right: Newly developed palm-sized super ink-jet system

High sensitive sensor with good stability

Encapsulation of enzymes into nanoporous materials by controlling their pore sizes and conditions

We have developed encapsulation technologies of enzymes into nanoporous materials by controlling their pore sizes and conditions, and a novel detection method, based on the biosensors composed of an immobilized enzyme in the mesoporous silica materials, an electrochemical mediator (i.e., quinone) and an electrochemical cell, using the enzyme, i.e. formaldehyde dehydrogenase. These biosensors show rapid response and high sensitivity, which can detect 1.2 µM of formaldehyde in aqueous solution (corresponding to sub-ppb atmospheric concentration of formaldehyde). Furthermore, the sensors show high selectivity, reusability and remarkable storage stability (stable over 100 days), indicating formaldehyde dehydrogenase remains in highly ordered structure in these mesoporous silica materials. These results indicate that the mesoporous silica materials can provide favorable methods for enzyme immobilization on the electrode and then are useful for electrochemical biosensors with high performance.

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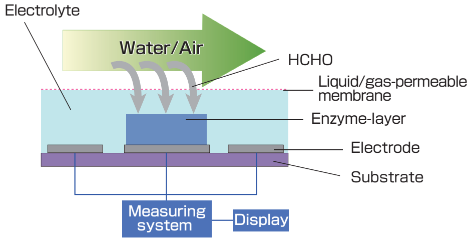
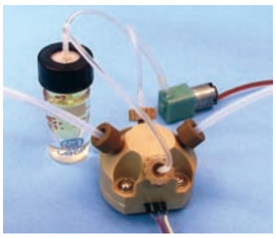
AIST TODAY Vol.9, No.2 p.18 (2009)

Sensor structure



External view



The sensor structure for the detection of formaldehyde

A geological record of old tsunamis in southern Thailand
An international collaboration revealed recurrent tsunami in Indian Ocean

Predecessors of the 2004 Indian Ocean tsunami left their own geological records in the last millennia, though no such written records exist in the last few centuries either on the devastated coast or within its source area. Here we found probable precedent for the 2004 tsunami from stratigraphy on an island 125 km north of Phuket. The western part of the island consists of former beach ridges that rise 1 m above intervenient swales. The 2004 tsunami inundated this beach ridge plain as much as 2 km inland with sandy deposit. Earlier sand sheets underlie the 2004 tsunami deposit in the swales. In a couple of swales 0.5 km from the modern beach, three sand sheets are interbedded with black peat of 2500-2800 years old and the youngest sand sheet was deposited postdating 550-700 years ago. Because the 1881 Car Nicobar earthquake of magnitude 7.9, which provided a tsunami less than a meter in India, lacks significant sand sheet in the swales, tsunami deposits below the 2004 deposit were originated from recurrent full-sized Sumatra-Andaman earthquakes.

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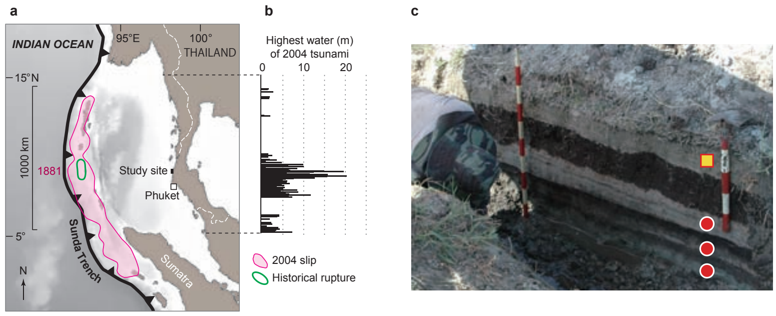
AIST TODAY Vol.9, No.2 p.19 (2009)



a: Northern Sunda Trench and vicinity. Red part shows a modeled fault slip during the 2004 Sumatra-Andaman earthquake. Green line shows a historical rupture in AD 1881.
b: Heights of the 2004 tsunami along western coast of Thai-Malay Peninsula.
c: Four tsunami deposits in Phra Thong Island, southern Thailand. A yellow square shows the 2004 tsunami deposit. Red circles show tsunami deposits before 2004 (Jankaew et al., 2008; © Nature).

Development of elimination technique of isobaric interference in ICP-MS
Mixed reaction gas technique has expanded application of high-sensitive ICP-MS

Inductively coupled plasma mass spectrometry (ICP-MS) has been widely used in various research fields because of its high-sensitivity, and has played an important role in the certification of fine ceramics reference materials developed in NMIJ, AIST. However ICP-MS often suffers from problems due to spectral interferences; especially the removal of isobaric interference is almost impossible even with high-resolution ICP mass spectrometer. In the precise quantitative analysis of V in fine ceramics using ICP-MS, the isobaric interference causes severe problems because the mass spectra for one of the two V isotopes overlaps with that for ^{50}Ti and ^{50}Cr. The author has developed a new method for determination of V in the presence of Ti and Cr using ICP-MS with a $CH_3F + NH_3$ mixed reaction gas to realize selective separation of V as the form of $[VF_2(NH_3)_4]^+$. This improved method enabled precise determination of V at the concentration level of mg kg^{-1} in fine ceramics. The elimination technique of isobaric interference will expand application of high-sensitive ICP-MS.

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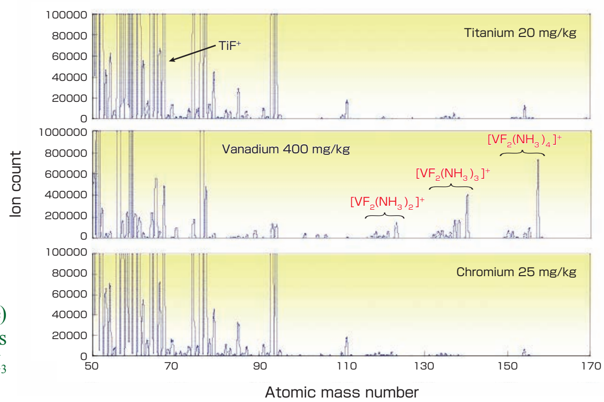
AIST TODAY Vol.9, No.1 p.11 (2009)



Mass spectra of Ti(upper), V(middle) and Cr(lower)obtained by ICP mass spectrometer equipped with CH_3F+NH_3 mixed reaction gas system

Development of quantum Hall array resistance standards

Toward the next generation quantum resistance standard

The quantized Hall resistance (QHR) device is widely used by national metrology institutes (NMIs) as DC resistance standards. The plateau at $i = 2$ is practically used for DC resistance calibration, and the nominal value of QHR at this plateau is 12 906.403 5 Ω. This non-decade value requires sophisticated technology to be used for actual resistance calibration, therefore several NMIs tried to make convenient quantum resistance standards which have nominally decade values: 100 Ω, 1 kΩ, 10 kΩ and so on by combining QHR elements in series and in parallel.

We are now trying to establish the next generation standards of DC resistance, and an experimental device of quantum Hall array resistance standard (QHARS) with a nominal value close to 10 kΩ has been developed. This QHARS device consists of 266 Hall bar elements. This device will play an important role in future calibration services due to the growing demand of 10 kΩ resistance calibration.

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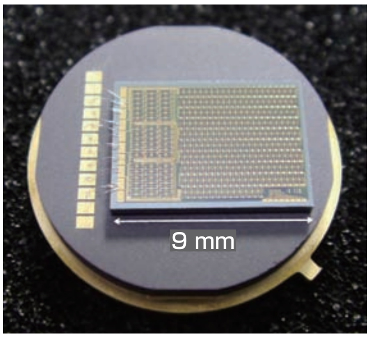

10 kΩ quantum hall array resistance standard (QHARS) device. 266 single Hall bar elements are integrated on this 9 mm × 7 mm chip.

Metrology and Measurement Science

First observation of natural circular dichroism in extreme ultraviolet region

A polarizing undulator exceeds the wavelength coverage of natural circular dichroism measurement

We have developed a polarizing undulator-based optical system for natural circular dichroism (CD) measurement and succeeded in the observation of natural circular dichroism in the extreme vacuum ultraviolet (EUV) region.

CD has been utilized to analyze the structure of chiral molecules and polymers. The extension of the CD-measurable region to the EUV region has made a significant increase in the number of the CD-applicable molecules such as sugars. However, in the EUV region, no continuous transparent-type optics is currently available. Therefore, the EUV-CD measurement system without transmission-type optics has been developed at the beam line BL-5B in the storage ring TERAS at AIST in Japan, which has adopted a polarizing undulator as a circularly polarized light source. The intensity of CD is generally weak, approximately 0.1-1 % of absorption intensity. Such a weak CD signal was successfully acquired by an appreciable improvement in our undulator-based CD system and calibration method.

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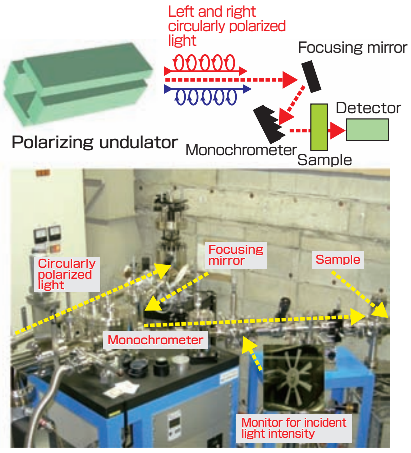


Schematic view and photograph of natural circular dichroism measurement system using the polarizing undulator

Second Workshop of AIST and DBT of India

The 2nd workshop, based on the comprehensive memorardum of understanding signed with the Department of Biotechnology (DBT) of the Ministry of Science and Technology of the Government of India, was held on November 25 and 26, 2008, in Hyderabad, India. Over 50 people participated in the symposium held on November 25. Researches of both countries were presented in the three fields of glycoengineering, cell engineering, and bioinformatics and there was much interaction amongst researchers.

After the 1st workshop held in January, 2008, DBT has been publicly seeking institutes which would cooperate in bioinformatics based on the collaborative research themes presented by AIST, and the selection progress was reported at the bilateral meeting held on November 26. In the future, after the final selection based on detailed recommendations, individual collaborative research will begin.

Concerning collaborative research in glycoengineering and cell engineering, there was much discussion, and it was agreed that collaborative project plans will be promptly presented by AIST to DBT, and collaborative research will be advanced. In the future, projects with specific research institutes of India will be recommended and collaborative research will be carried out.

Lecture by Dr. Kazuhiko Fukui, Leader of Molecular Function Team, Computational Biology Research Center, AIST

CNRS-AIST Symposium in Celebration of 150 Years of Japan-France Relations

Presently, along with the development of industry, various problems such as deterioration of global environment including global warming, and depletion of natural resources have arisen. Generation of innovation is necessary to solve these problems in order for human beings to maintain sustainable development. To promptly accelerate innovation, an active open innovation promotion based on international collaboration of industry-academia is essential, instead of efforts in closed environments. With this awareness, AIST and National Center for Scientific Research (CNRS) of France co-hosted a symposium titled “For Science-Industry Cooperation toward Sustainable Development” on December 1, 2008 at Yasuda Auditorium, the University of Tokyo, as part of events celebrating the 150 years of Japan-France relations. This symposium was based on a proposal of Dr. Catherine Bréchignac, President of CNRS, with which AIST has actively fostered international collaboration from the past.

Symposium hall

There were over 500 participants from businesses, public research institutes and universities. Speakers from the French side were: Mr. Carlos Ghosn, President of Renault Group and President and CEO of Nissan; Dr. Catherine Bréchignac, President of CNRS; Dr. François Guinot, President of Academy of Technology of France; Prof. Jean-Charles Pomerol, President of Pierre and Marie Curie University (Paris 6); and Prof. Benoît Legait, Director of MINES ParisTech. From the Japanese side were: Mr. Toshinori Kobayashi, Director of Industrial Science and Technology Policy Division, Industrial Science and Technology Policy and Environment Bureau (METI); Prof. Masuo Aizawa, Executive Member of the Council for Science and Technology Policy, Cabinet Office; Prof. Hiroshi Komiyama, then President of the University of Tokyo; Mr. Shoei Utsuda, Vice Chairman of Nippon Keidanren (Japan Business Federation); and Dr. Hiroyuki Yoshikawa, then President of AIST.

Presented here are the lecture summaries according to the order they were given.

Director Toshinori Kobayashi of METI said that, we need to build a robust society in this age of financial crisis and rapid change of economy, and there is a greater necessity to promote innovation. Moreover, an important issue is the scientific technology to countermeasure worldwide problems of global warming. Although collaborations have been strengthened among science and technology communities of both France and Japan, he expressed expectations for such representative public research institutes as AIST and CNRS to cooperate in building an international research network. He expressed hopes that in doing so, the two organizations will cooperate over a wide range of fields, contribute to the development of scientific technology of the entire world, and take initiative toward solving the problems of global scale and helping the dampened growth of the world economy.

As the next speaker, then AIST President Yoshikawa gave a lecture on "*Full Research* at AIST". He described, from the perspective of researchers on site, the concept and methods to bring basic research results into industry and to efficiently benefit society with the fruits of its research.

CNRS President Bréchignac talked on the topic of "Networking Research: the Role of CNRS". With the revisions of relevant laws concerning science and technology in France (establishment of the law related to Liberties and Responsibilities of Universities in 2007), CNRS needed to change its organization to do cooperative research on equal footing with universities in France. The previous CNRS system of 6 research departments plus 2 institutes was reorganized to a new system with institutes of 9 different fields. CNRS is now given a coordinating function as well as its original operating function. Concerning international networks especially with Asia, the networks with AIST and other universities including the University of Tokyo were presented.

The talk of Renault President Ghosn was given in a form of dialogue with CNRS President Bréchignac with a title, "Modify the Paysage: Zero Emission Vehicles". In the auto industry, fuel cell cars and electric cars will become mainstream as means of transportation in the future. In order to further popularize these types of vehicles, it is important not only to strengthen cooperation between universities and industry but also to take comprehensive measures for taxes (consumer preferential taxation) and finance. There was a question-and-answer session after the talk and there was active direct dialogue between President Ghosn and the participants concerning the company's approach to innovative vehicle development.

Then President Komiyama talked on the topic of "University as a Driving Engine for Innovation ~ toward Sustainable Society~" and said that energy with high efficiency such as from photovoltaic power generation should be sought as energy of the future. He mentioned, as an example, 80 % of energy use was successfully reduced at his home with photovoltaic generation, and that a project to reduce energy consumption was started at the University of Tokyo campuses. Positive activities of the University were presented, including the G8 University Summit before the G8 Hokkaido Toyako Summit last year and the proposal of "a network of networks (NNs)".

President Pomerol gave a talk on "CNRS-University Relationships". He gave an overview of the University of Paris 6 and explained autonomous university management based on the revision of laws in France.

Director Legait gave a talk on "The Relations of ParisTech, with CNRS and Japanese Universities" and gave an overview on MINES ParisTech. It is the central engineering institute of France and many of its graduates have become presidents of major companies, a fact which demonstrates that it educates human resources necessary for management of large enterprises. Concerning renewable

Toshinori Kobayashi
Director, Industrial Science and Technology Policy Division, Industrial Science and Technology Policy and Environment Bureau, METI

Hiroyuki Yoshikawa
Then President, AIST

Catherine Bréchignac
President, CNRS


President, Renault Group, and President and CEO, Nissan, Carlos Ghosn and CNRS President Bréchignac


Comments from a participant

energy, MINES ParisTech was presented as having partnership with New Energy and Technology Development Organization (NEDO).

Vice Chairman Utsuda gave a talk on "Meeting the Challenge of Sustainable Growth for Industry", especially on Japanese industry's approaches toward solving global warming and tasks related to innovation creation. As expectations toward AIST, he mentioned that AIST, being a possible bridge between the university-centered creation of science and the business-oriented technology development, needs to integrate its management resources and networks. In reference to this, he expressed expectations in *Full Research* which was propounded by then AIST President Yoshikawa.

President Guinot gave a speech titled "150th Anniversary of Japan-France Relations: Universal Lessons of a Bilateral History?" With the historical view that technological development does not necessarily lead to human happiness, he said that, if man is to aim for a sustainable society, overall happiness cannot be achieved without the philosophy of "co-existence" including relations with people of developing countries who do not bask in the achievements of technology development.

Council Member Aizawa talked on the theme of "S&T Policy for Realizing a Sustainable Society". He described the activities of the Council for Science and Technology Policy. He expressed the need for research and development for solving issues in order to realize a sustainable society, and stated the need to reform our values concerning these issues. He also said that he advocates activities to enhance synergy effects of diplomacy and policies on science and technology, by promoting S&T diplomacy.

During this symposium "for Science-Industry Cooperation toward Sustainable Development", many leaders of industry and academia of both Japan and France gave recommendations and proposals from many aspects based on deep analyses including expectations toward public research institutes. In all aspects, it was a very meaningful symposium.

Hiroshi Komiyama
Then President, University of Tokyo


Jean-Charles Pomerol
President, University of Paris 6


Benoît Legait
Director, MINES ParisTech

Shoei Utsuda
Vice Chairman, Nippon Keidanren

François Guinot
President, Academy of Technology of France


Masuo Aizawa
Executive Member, Council for Science and Technology Policy, Cabinet Office of Japan

Fifth Biomass-Asia Workshop

The 5th Biomass-Asia Workshop was held from December 4 to 6 at Guangzhou, China.

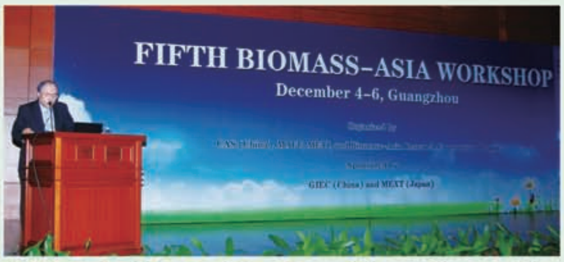
This workshop was a joint effort of China and Japan. Chinese Academy of Sciences (CAS) contributed to the workshop as the Chinese organizer, and the local secretariat was located at Guangzhou Institute of Energy Conversion, CAS. Japanese organizers were Ministry of Education, Culture, Sports, Science and Technology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Economy, Trade and Industry, and Biomass-Asia Research Consortium, and AIST functioned as secretariat.

Biomass-Asia Workshop, since its first event in Japan in 2005, has been organized annually in Thailand, Japan, Malaysia, and this time, in China.

The workshop welcomed over 250 participants (49 from Japan including 25 from AIST), and speakers from Australia, China, Indonesia, Japan, Malaysia, the Philippines, Thailand (expected but cancelled due to the closure of New Bangkok International Airport), and Vietnam.

After opening remarks by Dr. Akira Ono, Senior Vice-President of AIST, and Prof. Jinghai Li, Vice President of CAS (Mr. Huasheng Qiu, Deputy Director-General, Bureau of International Cooperation, CAS), keynote speeches and plenary lectures were delivered. During four technical sessions, based on the results of the past workshops, there were active discussions on regionally applicable models of sustainable biomass utilization technology in Asia. The topics included a hybrid agricultural waste utilization model possibly to be used in China and the "Palm Industry Complex Model" intensively discussed at the previous workshop, along with a possibility of evolving Biomass Town concept in East Asia. There were also vigorous discussions on standardization and sustainability assessment of biofuels, in the context of activities of Economic Research Institute for ASEAN and East Asia.

At the final session, it was agreed that efforts will be made to develop and disseminate the technologies for utilization models, and that the next workshop will be held in Japan. As a technical tour, the municipal solid waste comprehensive treatment demonstration plant in Huizhou City was visited. At the reception on the first evening, greeting speeches were delivered by Dr. Yong Chen, Director, Guangzhou Branch, CAS, and Mr. Masaharu Yoshida, Consul General of Japan in Guangzhou.



AIST Senior Vice-President Ono giving address at the opening

Sixth Japan-Thailand Collaboration Workshop

The 6th Japan-Thailand Collaboration Workshop was held on February 12 and 13, 2009 at AIST Tsukuba. From the Thai side, nearly 70 people participated including President Sakarindr Bhumiratana of National Science and Technology Development Agency (NSTDA), Acting Governor Surapol Vatanawong of Thailand Institute of Scientific and Technological Research (TISTR), many representatives of the two research organizations and of Siam Cement Group, and Thai doctoral students studying in Japan. From AIST, then President Hiroyuki Yoshikawa, Senior Vice-President Akira Ono, Mr. Masakazu Yamazaki, Vice-President in charge of International Affairs, Prof. Naomasa Nakajima, then Vice-President / Director of Evaluation Division, and many people related to the collaborative research participated.

There were active discussions on a wide range of research fields where collaborations exist from the past such as bioethanol, biodiesel fuel, biomaterial, life cycle assessment (LCA), photocatalysts, ceramics, information technology, biomedicinal information, and biosensors; and also fields of possible collaboration in the future.

Siam Cement Group participated for the first time, and possibilities for collaboration were sought. At the management session, opinions were exchanged regarding research management on topics as *Full Research*, the journal *Synthesiology*, Innovation School, and research evaluation.

It was agreed that the 7th Japan-Thailand Collaboration Workshop will be held in Bangkok, and that collaboration will be advanced further in each field in the future.

Heads of 3 institutes (center from left: NSTDA President Sakarindr, then AIST President Yoshikawa, TISTR Acting Governor Surapol) and workshop participants

Cover Photos
Above: Message from President (p. 2)
Below: CNRS-AIST Symposium (p. 25-27)

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