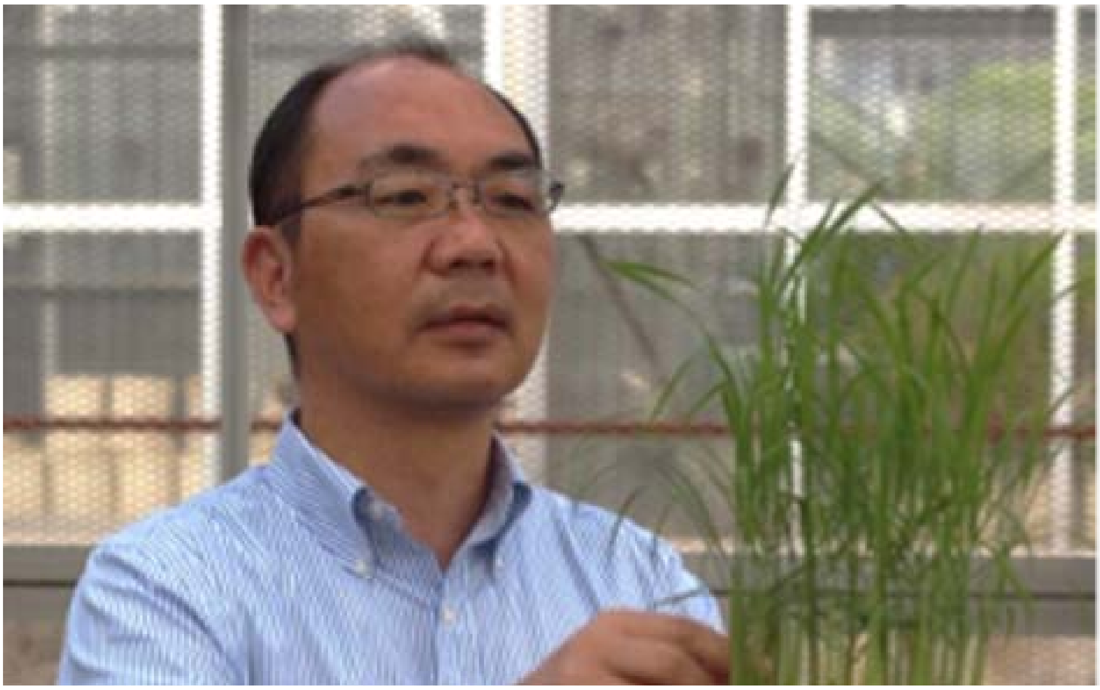
OKAYAMA UNIV. e-Bulletin



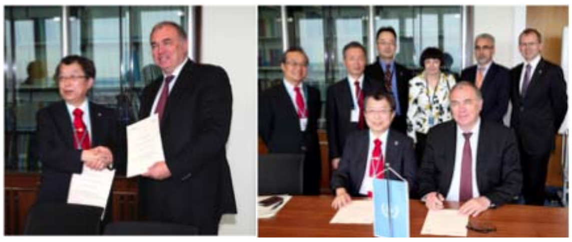
Vol. 12, September 2015

Contents

News

Okayama University and IAEA sign a new agreement related to radioactive waste management and environmental remediation

A new agreement signed in Vienna formalized the cooperation between Okayama University and the IAEA in the area of research and higher education in radioactive waste management and environmental remediation. Prof. Kiyoshi Morita, President of the University and Prof. Shinichi Yamamoto, Vice President and Executive Director of the University signed the Arrangements on behalf of Okayama University. Dr. Mikhail Chudakov, Deputy Director General and Head of the Department of Nuclear Energy, signed the Practical Arrangements on the 29th of June, 2015 on behalf of the IAEA.



The signing ceremony of the Practical Arrangements: Prof. S. Yamamoto, Vice President and Executive Director of Okayama University, Dr. M. Chudakov, Deputy Director General and Head of the Department of Nuclear Energy, IAEA, and the persons concerned.

"The IAEA is committed to assisting its Member States in safe and sustainable radioactive waste management. These are very complex issues and require cooperation with internationally recognized institutions, such as Okayama University." said Dr. Chudakov.

The discussion of BNCT technologies: Prof. H. Matsui, Okayama University, Dr. M. Venkatesh, Director of Division of Physics and Chemical Sciences, and Dr. A. Meghzifene, Head of Dosimetry and Medical Radiation Physics Section, IAEA.

"Our goal is to strengthen education and research programmes at our University through this formal agreement," said Prof. Morita. "At the same time, we hope to contribute to capacity building and human resource development around the world." Prof. Shinichi Yamamoto added that the agreement would help disseminate scientific information concerning radioactive waste, which currently has a negative image in the world and especially in Japan, after the Fukushima Daiichi disaster. "However," he said, "looking at the uses and benefits of nuclear technology, we can see its important role also in medicine, engineering and agriculture. Hence, we must solve the difficult problem of safe, economical and effective disposal of radioactive wastes."

The headquarter of IAEA

The Practical Arrangements build on already established cooperation between Okayama University and the IAEA over several years. In fact both institutes have organized two symposia: "Nuclear Energy and Radioactive Waste Management" in 2012 and "The Current and a Future of Radiation" in 2015. Okayama University and the IAEA foresee cooperation in research activities, establishment and implementation of educational programmes and courses as well as exchange of experiences and good practices in radioactive waste management and remediation activities. The University will start an international education programme using the e-Learning system developed by the IAEA. Prof. Yasuaki Ichikawa and Prof. Satoshi Nishiyama, Graduate School of Environmental and Life Science, Okayama University, are responsible for the activities of radioactive waste management together with Dr. Irena Mele and Mr. Akira Izumo, Waste Technology Section of the Nuclear Energy Department, the IAEA.

Recently, BNCT is receiving increasing attention as an effective cancer therapy. In this treatment, cancer cells are first dosed with a medical agent that includes a boron isotope (B-10) and then irradiated with neutron radiation, leading to the death of cancer cells by fission (i.e. α-ray and Li-nucleus ray). To the IAEA's experts in charge, Dr. Meera Venkatesh, Director of Division of Physics and Chemical Sciences, Department of Nuclear Sciences and Applications, and Dr. Ahmed Meghzifene, Head of Dosimetry and Medical Radiation Physics Section, Prof. Hideki Matsui, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, showed a new agent of B-10, which works very effectively because it is delivered through tumor cell membranes and further into nuclei. Both organizations agreed to continue to exchange information on BNCT technologies. Dr. Meghzifene requested Prof. Matsui to join an international conference on BNCT to be held in 2017.

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News

Developing new insights into iron-controlled biology

Iron is the most common metal on Earth and an essential element for all living creatures. Thus, iron control is a potential candidate for therapeutic applications. There are many researchers studying iron at Okayama University. Multi-disciplinary workshops have been held from time to time to connect the various research fields including medicine, engineering and science (Picture 1).

<Picture 1>
An oral presentation at a multidisciplinary fusion study symposium in 2014

As well as healthy cells, cancer cells also need iron to proliferate and metastasize. Dr. Toshiaki Ohara (M.D., Ph.D.) and colleagues are developing a new therapy to decrease the iron content in cancer tumors (Literature 1& Fig.1). A clinical study for hepatocellular carcinoma patients is ongoing in Okayama University Hospital supported by the Princess Takamatsu Cancer Research Fund.

<Picture 2>
An oral presentation at the multidisciplinary fusion study symposium for inflectional disease using iron control technique 2015

Researchers are also considering whether an iron-control technique is applicable for dealing with infection (Literature 2). On 18 March 2015, a multidisciplinary fusion study symposium for inflectional disease using an iron-control technique was held (Picture 2). The participants discussed the iron dependency of pathogenic bacteria. The symposium enabled attendees to share their knowledge and connect the various research fields.

We are now gathering more colleagues to study iron control in the different research disciplines.

Literature 1 :
A novel synergistic effect of iron depletion on antiangiogenic cancer therapy :
http://onlinelibrary.wiley.com/doi/10.1002/ijc.27943/abstract

Literature 2 :

Iron controlled therapy for cancer and inflectional disease (Japanese / English) :
http://www.okayama-u.net/renkei/document/pdf/oogata_tenjikai/4_lifescienceworld/2015/3_ohara.pdf

For reference :

Princess Takamatsu Cancer Research Fund :
http://www.ptcrf.or.jp/english/index.html
Okayama university hospital :
http://www.hsc.okayama-u.ac.jp/hos/en/index.html

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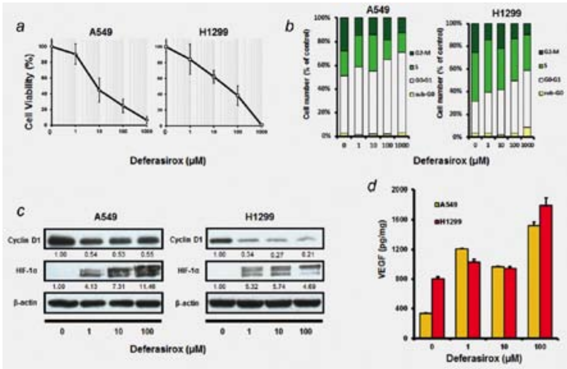
http://www.okayama-u.ac.jp/user/byouri/pathology-1/TOP.html



<Fig.1>
Iron-depletion inhibited cell proliferation via cell-cycle arrest and induced VEGF secretion *in vitro*. (a) Cultured A549 cells and H1299 cells were treated with the indicated concentrations of deferasirox for 24 h and the cell viability was measured by the WST-1 method. (b) The cells were treated with different concentrations of deferasirox for 24 h and the cell-cycle distribution was analyzed by flow cytometry. Each histogram consists of the following four cell cycle populations; sub-G0 (black), G0-G1 (white), S (light gray) and G2-M (dark gray). (c) Whole-cell lysates and the nuclear protein of these cells treated with the indicated concentrations of deferasirox were used for Western blot analysis to determine its inhibitory effects on cell cycle and upregulation effects on HIF-1a. The expression level of each protein was calculated relative to its expression in mock-treated cells, whose expression level was designated as 1. (d) Supernatant treated with the indicated concentrations of deferasirox was harvested and VEGF secretion examined by ELISA.

News

Combatting Infectious Diseases with Research Networks

The Collaborative Research Center of Okayama University for Infectious Diseases in India (CRCOUI) started up in 2007 at the National Institute of Cholera and Enteric Diseases (NICED) in Kolkata, India. CRCOUI is one of the research centers of the “Japan Initiative for a Global Research Network on Infectious Diseases: J-GRID”, which has been governed by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. It was transferred to the control of the newly established “Japan Agency for Medical Research and Development: AMED” in April 2015.

The major causes of death in developed countries including Japan are so-called lifestyle-related disease or non-communicable diseases (NCDs), such as malignant tumor (cancer), heart disease and cerebral apoplexy. However, infectious diseases are still responsible for a high number of mortalities in developing countries, especially among children under the age of five. World Health Statistics published by the World Health Organization report a high percentage of mortality from infectious diseases such as HIV/AIDS, diarrhea, measles, malaria and pneumonia in children of South and Southeast Asian and African countries, which prompted the establishment of J-GRID.

One example of how infectious disease continues to claim lives is diarrhea, which accounted for 15% and 10% of total deaths among children under the age of five in India in the years 2000 and 2013, respectively.As a result, the main project of the CRCOUI is concentrated on diarrheal disease

Figure 1.
The National Institute of Cholera and Enteric Diseases (NICED) building in which the Collaborative Research Center of Okayama University was established.

Figure 2.
Staff of the Collaborative Research Center of Okayama University.

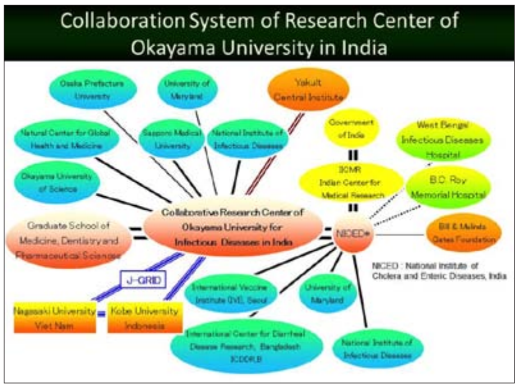


Figure 3.
Links with the Collaborative Research Center of Okayama University.

research. Three Okayama University researchers and one office secretary reside in the center and carry out the following research themes in collaboration with NICED staff.

1. Active surveillance of diarrheal patients
2. Development of dysentery vaccines
3. Viable but nonculturable (VBNC) *Vibrio cholerae*
4. Pathogenic mechanisms of various diarrheagenic microorganisms
5. Genome analysis of diarrheagenic microorganisms and molecular epidemiology
6. Development of therapeutic and diagnostic drugs for diarrheal diseases

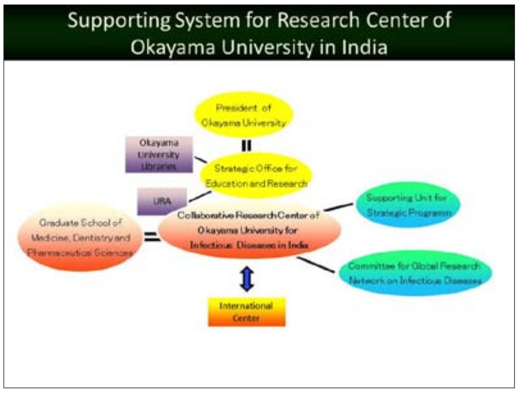


Figure 4.
Supporting system for the Collaborative Research Center of Okayama University.

The recent main research publications are as follows :

1. Shinoda S, Imamura D, Mizuno T, Miyoshi S. Activity of Collaborative Research Center of Okayama University for Infectious Disease in India. *J Disast Res*. 9:774-783 (2014).
https://www.fujipress.jp/finder/xslt.php?mode=present&inputfile=DSSTR000900050002.xml
2. Barman S, Koley H, Nag D, Shinoda S, Nair GB, Takeda Y. Passive immunity with multi-serotype heat-killed *Shigellae* in neonatal mice. Microbiol *Immunol*. 58:463-466 (2014).
http://www.ncbi.nlm.nih.gov/pubmed/24909404
3. Mizuno T, Nanko A, Maehara Y, Shinoda S, Miyoshi S. A novel extracellular protease of *Vibrio mimicus* that mediates maturation of an endogenous hemolysin. *Microbiol Immunol*. 58:503-512 (2014).
http://www.ncbi.nlm.nih.gov/pubmed/25040152
4. Ramamurthy T, Ghosh A, Pazhani GP, Shinoda S. Current perspectives on viable but non-culturable (VBNC) pathogenic bacteria. *Frontier Publ Health*. 5:1-8 (2014).
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4116801/
5. Miyoshi S, Ikehara H, Kumagai M, Mizuno T, Kawase T, Maehara Y. Defensive effects of human intestinal antimicrobial peptides against infectious diseases caused by *Vibrio mimicus* and *V. vulnificus. Biocontrol Sci.* 19:199 (2014).
https://www.jstage.jst.go.jp/article/bio/19/4/19_199/_article
6. Imamura, D., Mizuno, T., Miyoshi, S., Shinoda, S. Stepwise changes in viable but nonculturable *Vibrio cholerae* cells. *Microbiol Immunol* 59: 305-310 (2015).
http://onlinelibrary.wiley.com/doi/10.1111/1348-0421.12246/abstract

7. Shinoda S, Imamura D, Mizuno T, Miyoshi, S, Ramamurthy T. International collaborative research for infectious diseases of Japanese universities and institutes in Asia and Africa, special emphasis on J-GRID. *Biocontrol Sci*, 20: 77-89 (2015).
https://www.jstage.jst.go.jp/article/bio/20/2/20_77/_article

Okayama UNIV. e-Bulletin (Vol.7, June 2014) :

International research: Collaborative Research Center of Okayama University for Infectious Diseases in India
http://www.okayama-u.ac.jp/user/kouhou/ebulletin/topics/vol7/travelogue.html

For reference :

National Institute of Cholera and Enteric Diseases : http://www.niced.org.in/
Japan Agency for Medical Research and Development : http://www.amed.go.jp/en/

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News

World's first hybrid lung transplant: Simultaneous lung transplants from both brain-dead and living donors

On 4 April 2015, the simultaneous transplant of the left lung from a brain-dead donor and right lung (inferior lobe) from a living donor to a patient suffering from idiopathic interstitial pneumonitis was successfully undertaken at Okayama University Hospital. This was the first so-called hybrid transplant in the world with a simultaneous transplant from a brain-dead and a living donor.

The operation was conducted by a team led by the Lung Transplant Chief Takahiro Oto of the Department of Respiratory Medicine, Okayama University Hospital. During the operation, which took about ten hours, a lung provided by a brain-dead donor and part of a lung provided by a living donor were transplanted.

At the post-surgery press conference, Professor Oto said, "it was a great achievement to save a life using a fully functioning lung from a living donor, in addition to the usage of a lung from a brain-dead donor. It is extremely significant that we were able to transplant a lung that was not considered usable for medical reasons. I would like to reduce, even if it is only a small amount, the number of lungs that go unused."

Hybrid lung transplant (simultaneous transplant from brain-dead and living donor) conducted at Okayama University Hospital.

Lung Transplant Team, including Professor OTO (second from left), at the post-surgery press conference (April 4)

News

Life Science World 2015 : Okayama University presents its latest research achievements at Asia's largest bio event

Okayama University participated in the Life Science World 2015—Asia's largest bio event—the 12th Academic Forum, Tokyo Big Sight, 14-16 May 2014.

Okayama University booth with many visitors.

In this exhibition, seven researchers from Okayama University presented their latest research achievements in fields including pharmaceutical seeds, cancer, research tools, immunology, drug discovery tools, and imaging.

Professor Heiichiro Udono of the Graduate school of Medicine, Dentistry and Pharmaceutical Sciences showed that Metformin, an anti-type 2 diabetes drug, effectively reverts exhausted T-cells to functional states within tumor tissue, giving rise to an anti-cancer effect.

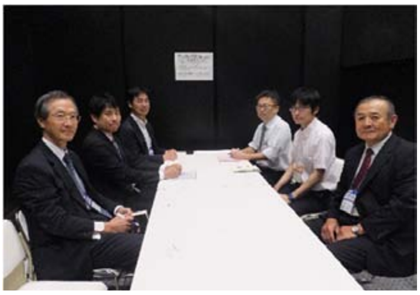
Professor Udono giving his talk.

Professor Mitsunobu Kano from the same graduate school, explained that in the treatment of that cancer, the cause of intractability of pancreatic cancer is not only due to the target cells themselves, but also can be due to the characteristics of its tumor vasculature, that is drug delivery routes.

Professor Mitsunobu Kano making a presentation.

Also, the researchers exchanged views about joint research with visitors from pharmaceutical companies and organizations at the meeting room for the business partnering.

Okayama University's Organization for Research Promotion & Collaboration will continue to actively support the participation of its members in exhibitions in order to increase the visibility of research achievements of Okayama University, and transfer technology.



Business partnering meeting.

Feature

Plants feel stress!

Frontiers in plant mineral stress tolerance and how nutrients and toxins are absorbed by rice and other plants

Professor Jian Feng Ma
Head of the Plant Stress Physiology Group, Institute of Plant Science and Resources, Okayama University, Japan.

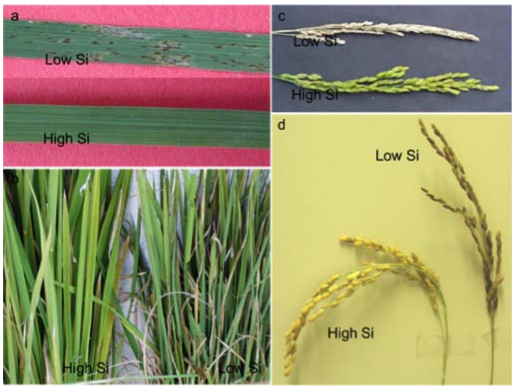
Professor Jian Feng Ma describes his research on the identification of critical transport mechanisms governing the absorption and distribution of mineral nutrients and toxins by rice and other plants. These findings are important for the efficient and safe production of food crops for sustaining human life on Earth.

Plants feel stress! But not the type that inflicts the lives of humans in the hustle and bustle of modern life. "Plants require 14 mineral elements to grow and survive," says Professor Jian Feng Ma, head of the Group of Plant Stress Physiology of the Institute of Plant Science and Resources, Okayama University. "Plant stress is induced by a deficiency of any of these minerals, absorption of poisonous elements such as arsenic and cadmium, and adverse weather conditions. My research is focused on determining the mechanisms that govern the absorption of minerals by plants. I work mainly on barley and rice." Ma adds that plants also absorb toxic elements, such as cadmium and arsenic as well, so the results of his research are important for monitoring the safety of agricultural products.

Okayama University Institute of Plant Science and Resources (IPSR)

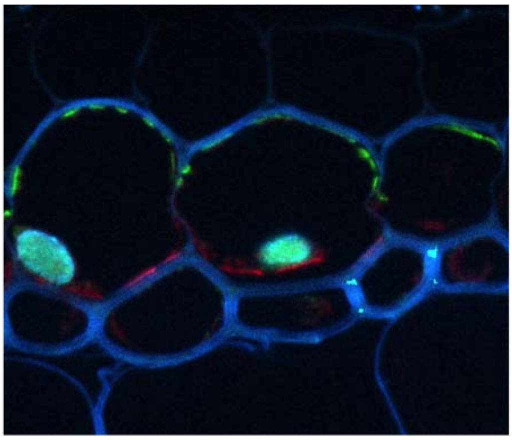
Phytotron for genetically modified (GM) plants

Japan has an excellent international reputation for research on plant stress physiology and the Institute of Plant Science and Resources, Okayama University is renowned for the high quality of its research with recent reports by independent assessment agencies showing the institute to be ranked 6th in Japan in this field of research. "We are a relatively small institute, with only 35 or so research staff," says Ma. "So we are pleased to be ranked so close to huge Japanese research organizations such as RIKEN. This high assessment reflects the excellent research conducted by our predecessors at this institute. Also we insist on whole plant physiology at the molecular level, and whole plant genome analysis. We grow proper plants."



Beneficial effect of silicon on plant. Silicon is able to protect the plants from various stresses such as pathogen, insect damage and water loss.

Professor Ma's research is focused on the determination of the nature of 'transporters' that are responsible for the absorption of minerals by plants. Specific examples of include determination of transporters for the absorption and distribution of silicon, iron, manganese, cadmium, and arsenic. "Our findings for silicon showed the importance of this mineral element for the growth of a healthy plant," explains Ma. "The presence of silicon in plants prevents disease and also makes plants resilient towards adverse weather such as strong winds. There are still many challenging mysteries in the world of plant stress."



Silicon transporters for uptake in rice. Silicon uptake is mediated by Lsi1 (green) and Lsi2 (red), localized at the distal and proximal side of both root exodermis and endodermis.

Research highlights

Silicon transporters

The accumulation of silicon in plants is beneficial for their growth by enabling them to overcome biotic and abiotic stress. In 2006 and 2007 Ma and colleagues identified two different transporters for silicon in rice plants.

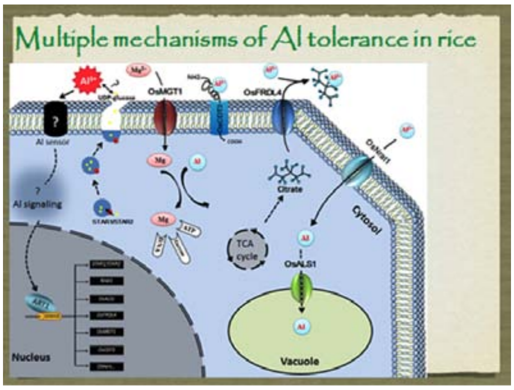
J.F. Ma et al, A silicon transporter in rice, *Nature* 440, 688-691 (2006).

J.F. Ma et al, An efflux transporter of silicon in rice, Nature 448: 209-211 (2007)

Aluminum toxicity stress

Aluminum is toxic to plants and affects the production of crops in acidic soils. Ma and his colleagues have identified the genes involved in aluminum tolerance and the regulation mechanism in plants.

N. Yamaji et al, A Zn-finger transcription factor ART1 regulates multiple genes implicated in aluminum tolerance in rice, *Plant Cell*, **21**, 3339-3349, (2009).

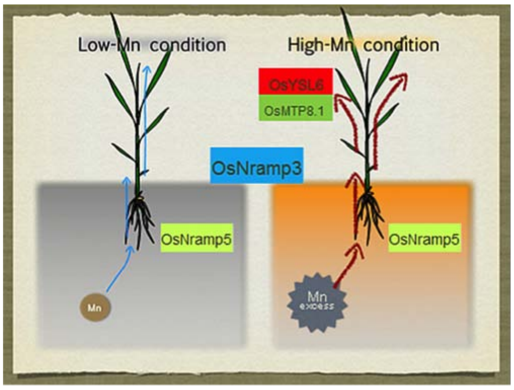


Multiple mechanisms of Al tolerance in rice. High Al tolerance in rice is achieved by a transcription factor, ART1, which regulates at least 30 genes implicated in Al tolerance.

Molecular mechanisms of environmental responses and manganese absorption

Rice is a robust plant able to adjust to its environment. For example, manganese is a nutrient for plants but when present in excess it exhibits phytotoxicity, which is harmful for plant growth. But rice is able to grow in a wide range of Mn concentration by regulating the uptake, distribution, and detoxification. Ma and colleagues have identified genes that govern this control and detoxification of Mn in rice plants.

N. Yamaji et al, A node-based switch for preferential distribution of manganese in rice, *Nature Communications* **4**, 2442, (2013).



Strategy of rice to overcome manganese changes in the environment.

Transporters of arsenic and cadmium in rice

Excess cadmium in plants poses dangers for food safety. Ma and colleagues have clarified the molecular mechanisms of transporters governing Cd accumulation in rice and barley.

Arsenic is poisonous with an estimated 40 million people suffering from toxicity worldwide. Notably, rice is a major source of arsenic poisoning in the food chain. Ma and colleagues have defined transporters responsible for absorption and distribution of As by rice in paddy fields.

J. F. Ma et al, Transporters of arsenite in rice and their role in arsenic accumulation in rice grain. *Proceedings of the National Academy of Sciences (PNAS)*, **105**, 9931-9935, (2008).

D. Ueno et al, Gene limiting cadmium accumulation in rice, *Proceedings of the National Academy of Sciences (PNAS)*, **107**, 16500-16505, (2010).

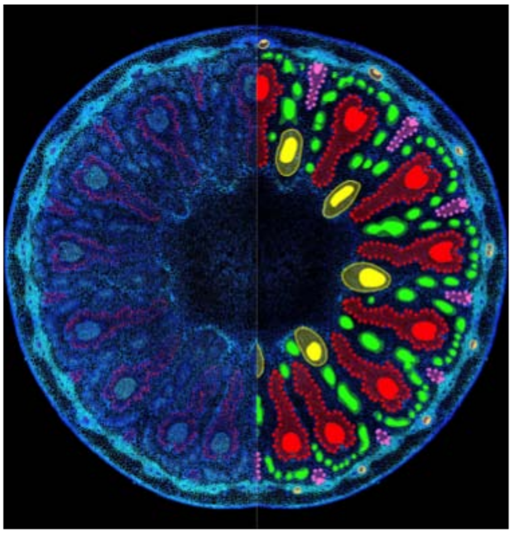
Recent publications

1. N. Yamaji et al, Orchestration of three transporters and distinct vascular structures in node for inter-vascular transfer of silicon in rice. Proc Natl Acad Sci USA doi/10.1073/pnas.1508987112 (2015)
2. W. Y. Song et al, A rice ABC transporter, OsABCC1, reduces arsenic accumulation in the grain. Proc Natl Acad Sci USA 111: 15699-15704 (2014)
3. J. F. Ma and N. Yamaji, A cooperative system of silicon transport in plants. Trends Plant Sci. doi.org/10.1016/j.tplants.2015.04.007 (2015)
4. M. Ashikari and J. F. Ma, Exploring the power of plants to overcome environmental stresses. *Rice*, 8, 10, (2015). DOI 10.1186/s12284-014-0037-y

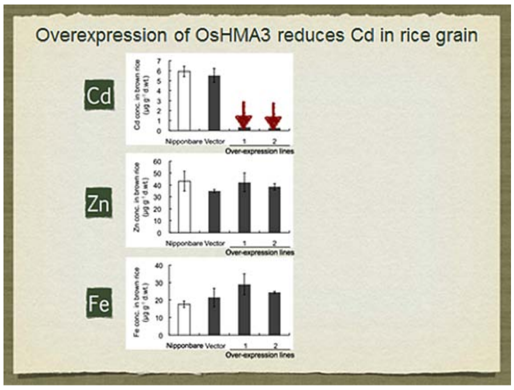
Further information

1. Institute of Plant Science and Resources, Okayama University, website:
   http://www.rib.okayama-u.ac.jp/plant.stress/index.html

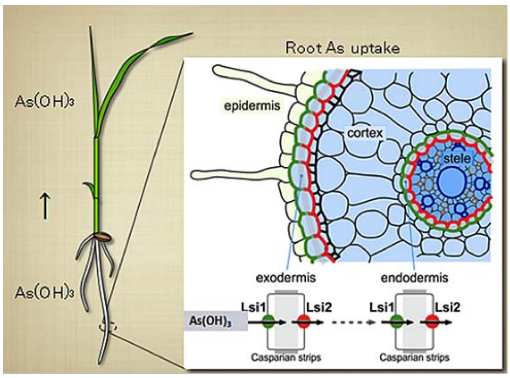
2. YouTube videos about research at the Institute of Plant Science and Resources, Okayama University, Japan.
   https://www.youtube.com/watch?v=-yNuldmwyul
   https://www.youtube.com/watch?v=tlFm-UIHzeY



Cross section of rice node, a hub for distribution of mineral element.



Effect of over-expression of OsHMA3 gene on Cd accumulation in rice grain.



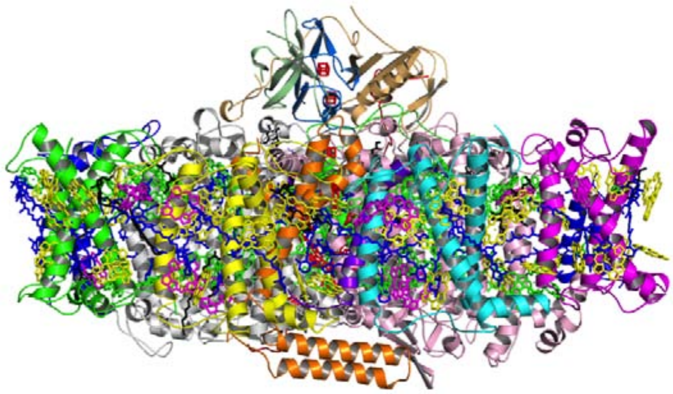
Pathway of arsenite in rice. Arsenite uptake is mediated by two silicon transporters; Lsi1 and Lsi2.

3. *University of Okayama e-Bulletin Research Vol.4 Okayama Travelogue:* "Okayama University Institute of Plant Science and Resources in Kurashiki: The oldest agricultural research institute in Japan" http://www.okayama-u.ac.jp/user/kouhou/ebulletin/topics/vol4/travelogue.html

Research Highlights

Exploring the structural basis for high-efficiency energy transfer in photosynthetic organisms

Photosystem I (PSI) is one of the two photosystems found in the thylakoid membrane of oxygenic photosynthetic organisms. Its function is to harvest light energy that is utilized to drive a chain of electron transfer reactions, which leads to the production of the reduction power required for converting CO_2 into sugars. In higher plants, the core of PSI is surrounded by a large light-harvesting complex I (LHCI), which forms a PSI-LHCI supercomplex with a total molecular mass of 600 kDa. The light energy captured by LHCI is transferred to the PSI core with an extremely high efficiency.



Crystal structure of plant PSI-LHCI supercomplex

The crystal structure of plant PSI-LHCI supercomplex has been reported previously. However, the crystal structures reported so far lacked sufficient resolution to reveal the detailed organization of the PSI-LHCI supercomplex with atomic precision, especially with respect to the positions and number of cofactors associated with LHCI.

Now, Michi Suga, Jian-Ren Shen at Okayama University in collaboration with Tingyun Kuang and Xiaochun Qin at the Chinese Academy of Sciences have solved the crystal structure of plant PSI-LHCI supercomplex to a resolution of 2.8 Å.

The research group purified and crystallized the PSI-LHCI supercomplex from the leaves of a pea plant and succeeded in improving the quality of the crystals dramatically. With these improved crystals the group was able to collect the X-ray diffraction data using the intense X-ray at the synchrotron facility SPring-8 in Japan. They then analysed the data using crystallographic approaches to determine the structure.

The improved structure revealed the detailed organization of protein subunits and cofactors. This enabled the mechanisms of energy transfer, regulation, and photoprotection within the PSI-LHCI supercomplex to be examined on a more robust structural basis.

This work provides structural insights into the energy absorption and transfer mechanisms in photosynthesis. In addition it may provide a blueprint for the design of light-harvesting setups with extremely high efficiencies that can be utilized in artificial photosynthetic systems.

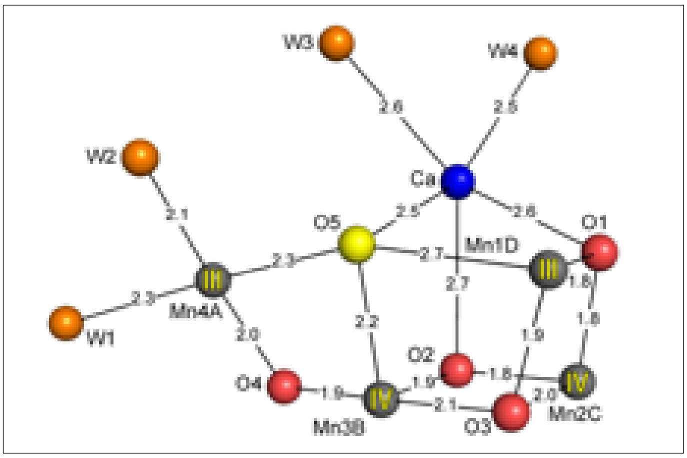
Reference:

- Authors: Xiaochun Qin[1,2], Michihiro Suga[1], Tingyun Kuang[2] and Jian-Ren Shen[1,2]
- Title of original paper: Structural basis for energy transfer pathways in the plant PSI-LHCI supercomplex.
- Journal, volume, pages and year: *Science* **348**, 989 (2015).
- Digital Object Identifier (DOI): 10.1126/science.aab0214
- Journal website: http://www.sciencemag.org/content/348/6238/989.full
- Affiliations: [1]Photosynthesis Research Center, Graduate School of Natural Science and Technology, Okayama University; [2]Institute of Botany, Chinese Academy of Sciences
- Department website: http://www.gnst.okayama-u.ac.jp/index_e.html

Research Highlights

Damage-free structure of photosystem II and the synthesis of model compounds for water-oxidation

Photosystem II (PSII) performs light-induced electron transfer reactions in photosynthesis, leading to the splitting of water into electrons, hydrogen ions, and oxygen, with which light energy from the sun is converted into chemical energy and molecular oxygen is produced to sustain all aerobic life on the earth. PSII is an extremely large membrane protein complex consisting of 20 subunits with a total molecular mass of 700 kDa for a dimer. The catalytic center for water-splitting is a Mn_4CaO_5-cluster organized as an asymmetric, distorted chair form embedded within the protein matrix of PSII.



Damage-free structure of the water-splitting catalyst Mn_4CaO_5-cluster in photosystem II

The crystal structure of cyanobacterial PSII has previously been reported at a resolution of 1.9 Å using synchrotron radiation (SR) X-rays. However, due to the intense and continuous SR X-rays, the Mn_4CaO_5-cluster has been suggested to suffer from radiation damage, leading to slight changes in the inter-atomic distances within the cluster.

Now, a joint team led by Jian-Ren Shen at Okayama University, and Masaki Yamamoto and Hedeo Ago at the RIKEN SPring-8 Center, has solved the damage-free crystal structure of PSII at 1.95 Å resolution using the femtosecond X-ray free electron laser (XFEL) provided by SACLA, an XFEL facility located within the same campus of SPring-8.

The research group prepared a large number of highly isomorphous, high quality, large sized PSII crystals, and used the femtosecond XFEL pulses to collect diffraction data from a fresh volume of the crystals after illumination by each pulse. In this way, completely damage-free diffraction data was collected, allowing the analysis of the structure by the "diffraction before destruction" approach.

The structure obtained revealed the precise inter-atomic distances within the Mn_4CaO_5-cluster, enabling the mechanism of water-splitting to be examined in more detail. Based on the structure of the native Mn_4CaO_5-cluster, a research team consisting of scientists from the Chinese Academy of Sciences, Free University Berlin (Germany), and Okayama University (Jian-Ren Shen) has succeeded in synthesizing an artificial compound resembling to a large extent the structure of the native Mn_4CaO_5-cluster and exhibiting some distinctive characteristics of the native cluster.

These studies not only greatly advance our understanding of the mechanism of photosynthetic water-oxidation, but also are a large step forward towards the development of artificial photosynthesis that will ultimately provide us with a source of clean and renewable energy.

Reference1:

- Authors: Michihiro Suga[1], Fusamichi Akita[1], Kunio Hirata[2,3], Go Ueno[2], Hironori Murakami[2], Yoshiki Nakajima[1], Tetsuya Shimizu[1], Keitaro Yamashita[2], Masaki Yamamoto[2], Hideo Ago[2], Jian-Ren Shen[1]
- Title of original paper: Native structure of photosystem II at 1.95Å resolution viewed by femtosecond X-ray pulses
- Journal, volume, pages and year: *Nature* **517**, 99 (2015).
- Digital Object Identifier (DOI): 10.1038/nature13991
- Journal website: http://www.nature.com/nature/journal/v517/n7532/full/nature13991.html
- Department website: http://www.gnst.okayama-u.ac.jp/index_e.html
- Affiliations: [1]Photosynthesis Research Center, Graduate School of Natural Science and Technology, Okayama University; [2]RIKEN SPring-8 Center, [3]Core Research for Evolutional Science and Technology (CREST), Science and Technology Agency (JST), Japan.

Reference2:

- Authors: Chunxi Zhang[1], Changhui Chen[2], Hongxing Dong[2], Jian-Ren Shen[3], Holger Dau[4], Jingquan Zhao[1]
- Title of original paper: A synthetic Mn4Ca-cluster mimicking the oxygen-evolving center of photosynthesis
- Journal, volume, pages and year: *Science* **348**, 690 (2015).
- Digital Object Identifier (DOI): 10.1126/science.aaa6550
- Journal website: http://www.sciencemag.org/content/348/6235/690.full
- Department website: http://www.gnst.okayama-u.ac.jp/index_e.html
- Affiliations: [1]Laboratory of Photochemistry, Institute of Chemistry, Chinese Academy of Sciences, China; [2]College of Materials Science and Chemical Engineering, Harbin Engineering University, China; [3]Photosynthesis Research Center, Graduate School of Natural Science and Technology, Okayama University, Japan; [4]Department of Physics, Free University Berlin, Germany.

Research Highlights

Key genes in epidermal cell differentiation are essential for survival of plants

The bodies of plants consist of only three tissue systems: the outermost epidermal tissue, the inner tissue, and the vascular tissue. The epidermis plays an important role in protecting the body of a plant from external stresses, preventing organ fusions, and determining final organ shapes.

An Arabidopsis embryo of the wild type (left) and that of the complete loss-of-function mutant of ATML1 and PDF2, which shows embryonic arrest (right).

In a model plant, Arabidopsis, a pair of genes, ATML1 and PDF2, has been identified to serve as a key factor involved in the formation of the epidermis. However, the functional importance of these two genes reamins to be fully understood.

Now, Taku Takahashi and his colleagues at Okayama University in collaboration with a group at the University of Tokyo have provided compeling evidence that ATML1 and PDF2 are essential for the growth of embryos in Arabidopsis.

They generated the double loss-of-function mutant of ATML1 and PDF2 and found that the complete loss of these two genes resulted in the embryonic arrest before seed germination.

They confirmed that the inhibition of the expression of ATML1 and PDF2 caused a severe defect in epidermis formation and organ fusions in leaves, stems and flowers.

The results provide significant clues to the understanding of how the identity of epidermal cells is established in the plant embryo and to further studies on how plant bodies are formed.

Reference:

- Authors: Eriko Ogawa, Yusuke Yamada, Noriko Sezaki, Sho Kosaka, Hitoshi Kondo, Naoko Kamata, Mitsutomo Abe, Yoshibumi Komeda, and Taku Takahashi.
- Title of original paper: ATML1 and PDF2 Play a Redundant and Essential Role in Arabidopsis Embryo Development.
- Journal, volume, pages and year: *Plant and Cell Physiology* **56**, 1183-1192 (2015).
- Digital Object Identifier (DOI): 10.1093/pcp/pcv045
- Journal website: http://pcp.oxfordjournals.org/content/56/6/1183.long
- Affiliations: Division of Bioscience, Graduate School of Natural Science and Technology, Okayama University.
- Department website: http://www.biol.okayama-u.ac.jp/news/news_id4716.html

Research Highlights

Evidence for solid-liquid critical points of water in carbon nanotubes

Many physicists do not accept the idea that a solid-liquid phase boundary can terminate at a critical point — a unique state where two phases lose their separate identities. Why do they not? The authoritative textbook by Landau and Lifshitz says that “we can say only that a particular symmetry property exits or does not exist; ... The critical point therefore cannot exist for such phases.” But since 2001, the possibility of the solid-liquid critical point has been reported in computer-simulation studies of water in nanopores [1,2]. In fact, there is no rigorous proof for the nonexistence of the solid-liquid critical point.

Kenji Mochizuki and Kenichiro Koga at Okayama University provided unambiguous evidence to support the solid-liquid critical point for a class of water in nanotubes by performing extensive molecular dynamics simulations: macroscopic solid-liquid phase separation below a critical temperature T_c, diverging heat capacity and isothermal compressibility at around T_c, and the loci of response function maxima (the Widom lines) above T_c.

Figure 1 shows the hydrogen bond structures of six crystals of ice formed in carbon nanotubes with diameters of 1.11 nm and 1.25 nm. The researchers found that all of the first-order phase boundaries between the ice and liquid eventually ceased to exist at the critical points, as shown in Figure 2. The T-P phase diagram is very different from that of bulk water, where ice regions are completely surrounded by the first-order phase boundaries (solid black lines).

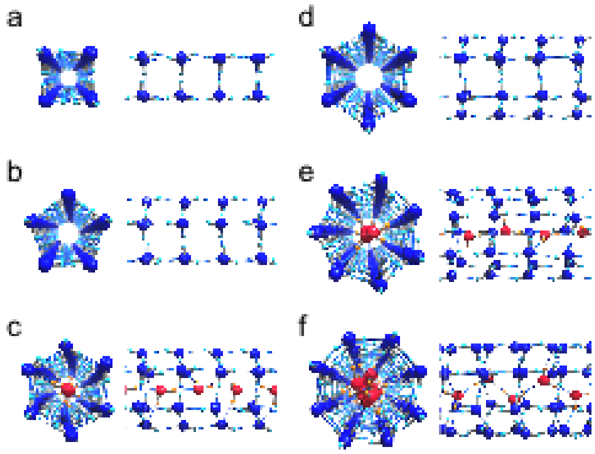


Figure1: Hydrogen bond structures of six ices formed in the nanotubes: (a) (4,0)ice, (b) (5,0) ice and (c) filled (6,0) ice at a diameter of 1.11nm, (d) (6,0) ice, (e) filled (7,0) ice and (f) filled (8,0) ice at a diameter of 1.25nm. Top views and the corresponding side view are drawn abreast. Central water molecules forming a chain in the filled ices are colored red to distinguish them from the exterior rings.

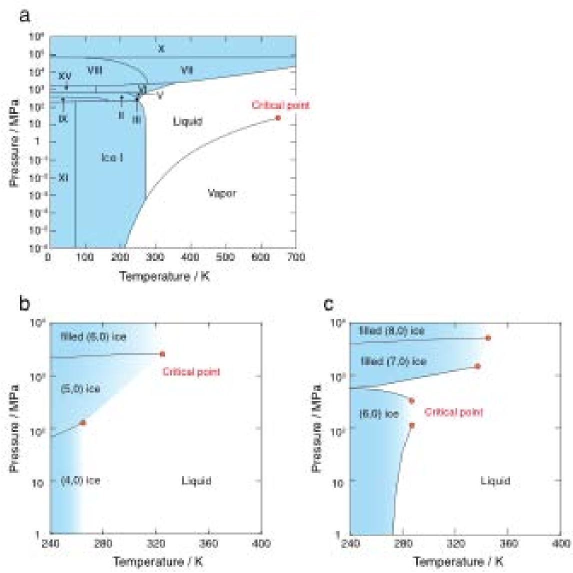


Figure 2: Phase diagrams of (a) bulk water, (b) water confined in the nanotube of a diameter of 1.11 nm, and (c) 1.25 nm. The phase diagrams of (b) and (c) are firstly revealed in this study. Solid regions are colored in blue and critical points are indicated by red circles.

The researchers also gave a microscopic explanation to a simple, yet unanswered, question: how can liquid water continuously freeze to crystalline ice? They found dynamic fluctuations of microscopic domains of water and ice near the critical point–a microscopic picture of water in the course of gradual freezing or melting.

The critical points in confined water are ubiquitous and can be found at ambient conditions by tuning the pore diameter, and therefore one of the potential applications is to use the tunable critical fluctuations in order to facilitate chemical reactions, structural changes in biological molecules, and formation of biomolecules assembly in water.

[1] K. Koga, G.T. Gao , H. Tanaka and X.C. Zeng, Nature, 412, 802-805 (2001)
[2] S. Han, M. Choi, P. Kumar and H. Stanley, *Nature Physics*, **6**, 685-689 (2010)

Reference:

- Authors: Kenji Mochizuki and Kenichiro Koga
- Title of original paper: Solid-liquid critical behavior of water in nanopores
- Journal, volume, pages and year: *Proc. Natl. Acad. Sci. USA* (2015)
- Digital Object Identifier (DOI): 10.1073/pnas.1422829112
- Journal website: http://www.pnas.org/content/early/2015/06/19/1422829112
- Affiliations: Department of Chemistry, Faculty of Science, Okayama University
- Department website: http://chem.okayama-u.ac.jp/index.html

Intellectual Property and Enterprise

Quick and low-cost fabrication of metallic nano-surfaces for surface-enhanced Raman spectroscopy

Not only sensitivity and accuracy but also rapidity and low cost are demanded for analytical methods used in medical diagnosis, food hygiene inspection and other such applications. The ultimate goal of such analytical methods the is real-time detection and identification of specific target molecules in samples.

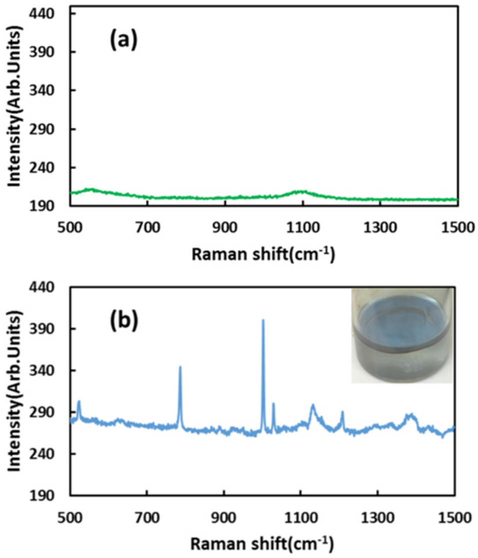


Fig. 1. Raman spectrum of a 5.1 mM toluene solution (a) without and (b) with SERS substrate. The inset in (b) is self-assembled AuNPs film at oil/water interface.

Of the wide range of methods available for such applications, Surface-Enhanced Raman Scattering/ Spectroscopy (SERS) is a highly effective candidate to achieve these goals. SERS is an ultra-sensitive analytical method based on Raman spectroscopy that even enables the , detection and identification of a single molecule without any pre-treatment and destruction of samples. Such high sensitivity is achieved by significant enhancement of an electro-magnetic field through formation of surface plasmons at the surface with metallic nano-structures. It is necessary to prepare nano-surfaces (more than ~cm^2) with noble metals whose plasmon resonance is tuned to match the wavelength of the excitation laser. For commercial applications, the main issues to resolve are mass-production of SERS substrates with high reproducibility and low cost.

At Okayama University, we have used an oil-in-water (O/W) type emulsion to develop a simple and low cost fabrication method for mass production of SERS substrates. Metallic nano-particles are trapped at the surface of the oil droplets when the O/W emulsion and nano-particles are mixed. The oil droplets containing nano-particles aggregate and coalesce, as a result, a two-dimensional nano-particle film of noble metals is spontaneously formed at the oil/water interface (Fig. 1b inset). The plasmon resonance of the film is readily controllable by changing the type of metal, the size of nano-particles, and the type of surfactant (alkylamine) for emulsion.

We fabricated SERS substrates using 20 nm Ag nano-particles and lauryl amine ($C_{12}H_{23}NH_2$) for measurement with a 532 nm wavelength excitation laser.

We measured the SERS spectrum of a 5.1 mM toluene in a water solution to evaluate the SERS substrate that we had fabricated. Raman peaks of toluene were enhanced by a factor of ~10^3 (~10^6 is possible) compared with conventional Raman measurements, as shown in Fig. 1. The enhancement of the Raman signals was observed everywhere in the film with high reproducibility.

[Enquires]

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Topics : Letters from alumni

Johannes Effenberger

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Faculty of Environmental Sciences
Technische Universitaet Dresden (TUD)

I have had the good fortune to have been an exchange student at the Geo-Environmental Evaluation Lab under the supervision of Professor Makoto Nishigaki from September 2009 to September 2010. My stay was kindly funded by the German Academic Exchange Service through a mutual exchange program which was co-established by Professor Peter-Wolfgang Graeber (TUD) and Professor Nishigaki. Having finished three of five years of my diploma course on water management at the time of my arrival at Okayama University, I was eager to experience student life in Japan as well as Japanese culture, and of course, food.

The most amazing part of student life at Okayama University for me was how close students of different ages, as well as lab associates worked and studied together. Of course this includes mutual support in their research assignments, maintenance tasks, and organization of get-togethers and celebrations.

Regular meetings and presentations about research assignments were a great asset for me in understanding the various approaches to different scientific problems. For students, this is an ideal opportunity to understand scientific methods and exchange experiences and knowledge in order to avoid mistakes and misinterpretation of collected data. When comparing student life in Okayama to the student life in Germany, I have to admit that the Japanese way actually resembles my work life as a researcher rather than my life as a student in Germany.

When I returned to Germany to finish my studies, I had two more years before graduation. This gave me the opportunity to welcome two exchange students from Okayama University through the mutual exchange program and return some of the favors I was given during my stay in Okayama. These included visits to the immigration office, finding an apartment, and opening a bank account. Of course, we also spent our spare time together and shared many happy moments. After graduation, I was offered a position by my graduation supervisor at university. Needless to say I accepted and have been working as a scientific associate at TUD ever since. In my time working at TUD, I have contributed to and given lectures, worked on several research projects, and supervised the graduation of students. The time at the University of Okayama has contributed greatly to my communication and team skills and it made me understand the scientific process.

Unfortunately, with the retirement of Professor Nishigaki and of Professor Graber, the mutual exchange program between Okayama University and TUD is about to end. As a member of the German branch of the Okayama University International Alumni Association and as an alumni of TU Dresden, I would like to see the exchange between the two universities continue. This will require one professor of each university in comparable research fields to agree on another exchange program. As an alumni branch, we see one of our responsibilities in facilitating the academic exchange between German universities and Okayama University by supporting Japanese and German exchange students or aiding in the organization of exchange programs.

Topics : Okayama Travelogue

The lure of Bizen Yaki

Japan's Bizen pottery or 'Bizen yaki' has a distinctive rugged texture and reddish hue. The clay is extracted from kilns following the characteristic long, pine wood fueled firing that last around two weeks or so. Intriguingly, Bizen ware is produced without glazing with ceramic paints that are widely used for many other kinds of pottery.

Bizen ware: flask for serving sake (left) and vase for flowers (right)

The clay for Bizen pottery is dug from rice fields and has high iron content and the final look and feel of Bizen ware depends on the choice materials that master potters use to wrap around the clay objects during firing.

Bizen ware has its roots in Okayama Prefecture, and specifically in the village of Imbe more than a thousand years ago during the Heian era. The other famous kilns (cities) in Japan renowned for producing ceramics are Echizen, Seto, Shigaraki, Tokoname, and Tanba.

The four main types of Bizen are known as Goma, Hidasuki, Sangiri, and Yohen. The colors and appearance of each of these types depends on the wrapping used during firing, where for example, Hidasuki have distinctive red marks of the strands of straw used for wrapping.

Bizen City is a popular destination for tourists with many sights and sounds, including the kilns that date back a millennium.

Miss Bizen Yaki holding an example of actual Bizen pottery

Bizen City, Okayama website:
http://www.city.bizen.okayama.jp/english/bizen/miryoku.html

Okayama Prefecture Museum of Art:
http://www.pref.okayama.jp/seikatsu/kenbi/index-e.html

Topics : Club Activities

The art and culture of Japanese flower arrangement: Okayama University Ikebana Club

Miki Suzuki is a 2nd year economics student and the leader of the Okayama University ‘flower arrangement club’-known as ‘Kado’ or Ikebana in Japanese. “The Okayama University flower arrangement club was formally established in 2000,” says Miki. “Our members do not require any special skills apart from the ability to concentrate and be decisive. Both of these skills can be nurtured by continuing to practice flower arrangement. ”

“All of our 24 members are female. Most are undergraduates, with 6 or 7 of us having experience of flower arrangement prior to university. ” Students join the club because they like flowers and they want to know more about this form of Japanese culture. Most members have a quite nature and value cooperation in running the club. “We also enjoy talking, so club meetings can be noisy sometimes,” says Miki.

The Okayama University flower arrangement club follows the Misho Style of Ikebana—the oldest style in Japan dating back to the 18 century and especially well known in Western Japan.

“The long history of Misho Style makes it perfect for learning Ikebana,” says Miki. “Our resident teacher ensures that complete beginners can learn with confidence. A few times a year, we also learn flower arrangement, which gives us the chance to handle many kinds of flowers. ”

One of our members is an international graduate student studying mathematics, who is a good Japanese speaker and enjoys participating in the club. Several other international students have been members in past.

The club meets twice a month in the Japanese style room located on the 2nd floor of the University Kaikan. "During the monthly meetings we arrange flowers and ask the teachers for evaluation," says Miki. "Members of the club also give each other advice. We use actual flowers during these sessions, which last about three hours. We also take part in the annual Ikebana exhibition and competition. "

Further information

Okayama University Ikebana website and blog:
http://okadaikadoubublog.blog.fc2.com/

Photographs taken during the 2014 Okayama University Annual Festival