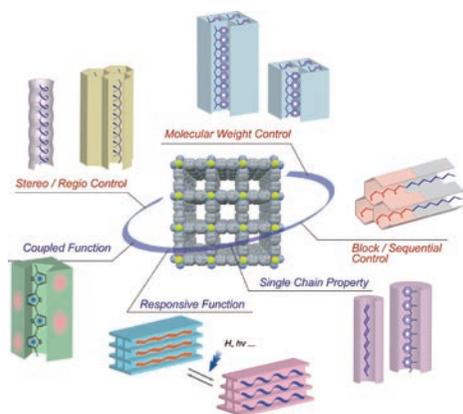


# Cutting-Edge Research in a Broad Range of Research Fields

Kyoto University is known for the quality and diversity of its research. Each issue of Research Activities can only highlight a small selection of those endeavors, but we hope to convey an impression of the university's rich academic milieu. Please refer to previous — and forthcoming — issues for more glimpses into our cutting-edge research.

## CHEM Super Plastics Made in Nanosized Factory

*Nanoscope can provide polymers with regulated structures and unusual assemblies.*



Recently, Metal-Organic Frameworks (MOFs) composed of metal ions and organic ligands have been studied extensively. The characteristic features of MOFs are highly regular channel structures, controllable channel sizes, and designable surface functionality. Dr. Uemura and his colleagues used their regulated and tunable channels for a field of polymerization, which allowed precision controls of the resulting polymers. In addition, construction of nanocomposites between MOFs and polymers provided unprecedented material platforms to accomplish many nanoscale functions. The promising approaches to multiple controls of polymer structures using MOFs developed by Dr. Uemura's group are expected to significantly contribute to research in the areas of inorganic, materials, and polymer chemistry.

**Dr. Takashi Uemura**

*Associate Professor, Graduate School of Engineering*

[www.sbchem.kyoto-u.ac.jp/kitagawa-lab/Member/Uemura-CV.html](http://www.sbchem.kyoto-u.ac.jp/kitagawa-lab/Member/Uemura-CV.html)

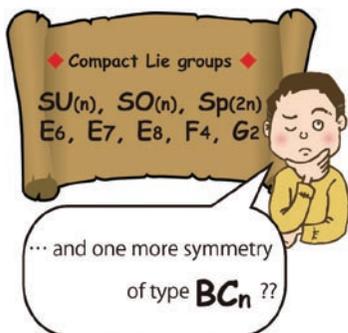


## MATH A New Compact Lie Group?!

*Exotic nilpotent cone is an avatar of a non-existing compact Lie group of type  $BC_n$ .*

In mathematics, realizations of a given symmetry through (possibly infinite-size) matrices are called representations. Each symmetry has many (essentially) different representations, and representation theory aims to organize and understand them. As a symmetry has many disguises, it connects many different areas of mathematics.

Dr. Kato is studying the representation theory of affine Hecke algebras (of classical types), which is connected to the Macdonald symmetric functions, the Lieb-McGuire hamiltonians, representation theory of semi-simple groups, and so on....

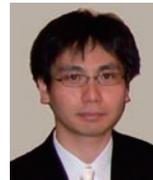


Dr. Kato discovered an object called “the exotic nilpotent cone” which organizes its representations better than the classical pictures (the exotic Deligne-Langlands correspondence). The exotic nilpotent cone is an avatar of the type  $BC$  compact Lie group, which is missing in the classical Cartan-Dynkin-Killing classification. It has multiple applications, and is anticipated to become a standard tool in representation theory.

**Dr. Syu Kato**

*Associate Professor, Graduate School of Science*

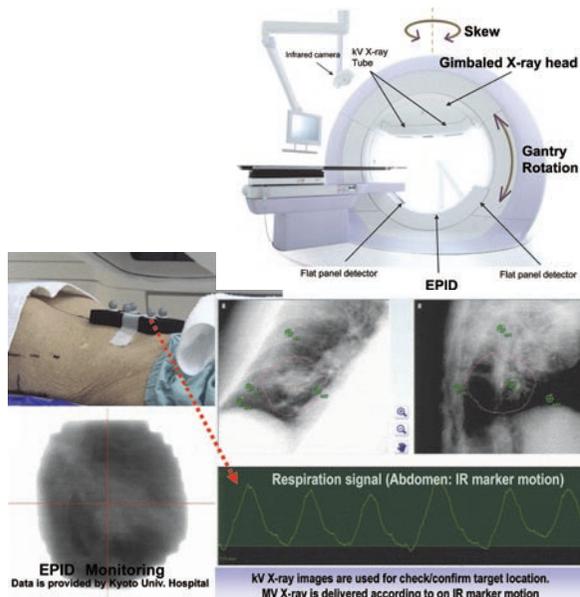
[www.math.kyoto-u.ac.jp/~syuchan/](http://www.math.kyoto-u.ac.jp/~syuchan/)





## MED Catching Moving Cancers

*Development of dynamic tracking radiotherapy system for moving cancers.*



The effectiveness of radiotherapy depends on the ability to precisely localize the damage by irradiation in cancer while sparing the adjacent normal tissues. One of the most important issues to be solved is to realize a precise radiation therapy for moving cancers, such as those in the lungs, liver, and pancreas.

Dr. Hiraoka and his team have been developing a new radiotherapy system since 2002 to realize a dynamic tracking radiotherapy which enables the above-mentioned treatment with real-time monitoring. The system is equipped with four types of imaging devices for tumor detection and monitoring, and a gimballed X-ray head for beam positioning. The system was approved as a medical device by the U.S. Food and Drug Administration (FDA) in 2006, by the Japan's Pharmaceuticals and Medical Devices Agency (PMDA) in 2007, and by the European CE mark in 2010. The dynamic tumor tracking system was implemented in the stereotactic body radiation therapy of lung cancers for the first time in the world in September 2011 at Kyoto University Hospital. In the twelve patients

treated, a reduction of 33.2% in planned tumor volume, and 22.3% in lung V20 was demonstrated. Dr. Hiraoka's team has also started applying this treatment for liver cancers.

The current development seeks to utilize dynamic tracking combined with the most advanced treatment technique: intensity-modulated radiation therapy. It is scheduled to be applied to the first human patients in Autumn 2013.

### Dr. Masahiro Hiraoka

*Professor/Chair, Graduate School of Medicine*  
 radiotherapy.kuhp.kyoto-u.ac.jp/  
 rtptb.med.hokudai.ac.jp/

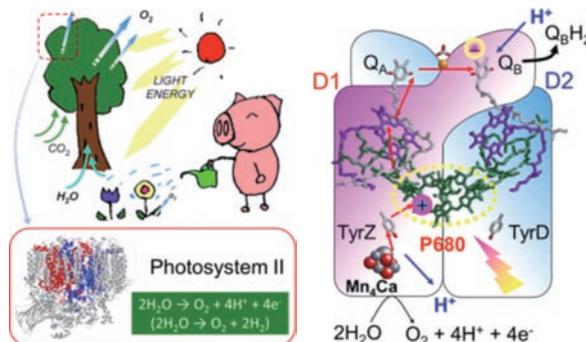


## BIO-PHYS How Do Green Plants Produce O<sub>2</sub> from Water?

*Exploring protein functions based on protein molecular structures.*

Chemical compound structures help determine the characteristics of compounds. Similarly, the shape of a protein molecule, namely the protein crystal structure, can determine the function of the protein molecule in a biological system. By using protein crystal structures and theoretical approaches such as quantum chemistry, Dr. Ishikita and his colleagues clarified protein functions that were thus far unknown. Their particular focus is in understanding the reaction mechanism behind the water-splitting/O<sub>2</sub>-evolving process in Photosystem II, the membrane protein-pigment complex involved in photosynthesis in green plants. It is

anticipated that in the future, this work will contribute to the design of a catalyst for artificial photosynthesis, whereby H<sub>2</sub> is produced solely from water by sunlight irradiation.



### Dr. Hiroshi Ishikita

*Assistant Professor, Career-Path Promotion Unit for Young Life Scientists/  
 Professor, Graduate School of Science, Osaka University (July 2013-)*

## MED Conserving Valuable Animal Strains

*Successful long-term preservation of sperm by freeze-drying.*

Freeze-drying sperm is an excellent preservation method for genetic resources. Using this method, sperm can be stored at 4°C and transported at room temperature, and liquid nitrogen is no longer necessary. Dr. Kaneko and his colleagues demonstrated that sperm freeze-dried in a Tris-EDTA buffer and stored at 4°C maintain their fertility for five years. This is the first successful report of long-term preservation of freeze-dried sperm. Furthermore, freeze-dried samples can be temporarily stored at room temperature, such as in the event of a power failure, interruption to the liquid nitrogen supply, or other emergencies caused by disasters such as earthquakes and typhoons. Freeze-drying provides a safe and economical method of preserving valuable animal strains. For more information: [WEB www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0035043](http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0035043)

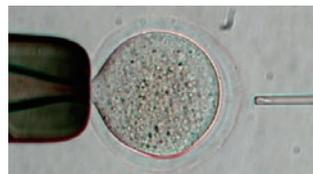


### Dr. Takehito Kaneko

Associate Professor, Graduate School of Medicine  
[www.anim.med.kyoto-u.ac.jp/reproduction/home.aspx](http://www.anim.med.kyoto-u.ac.jp/reproduction/home.aspx)



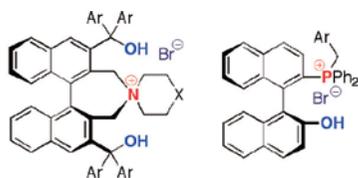
Freeze-dried sperm ampoules and a rat derived from oocytes fertilized with freeze-dried sperm stored at 4°C for five years



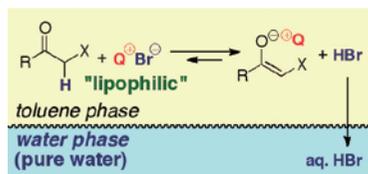
Oocytes are fertilized by intracytoplasmic injection (ICSI) of freeze-dried sperm

## CHEM Towards the Next Stage in Organic Chemistry

*Development of environmentally benign neutral phase-transfer reaction system.*



Although quaternary ammonium salts are generally believed to require base additives to act as catalysts in phase-transfer reactions, Dr. Shirakawa and his colleagues discovered that even without any base additives enantioselective phase-transfer reactions proceeded smoothly with high stereoselectivity in the presence of a lipophilic chiral bifunctional ammonium bromide under neutral conditions in a water-rich solvent. The utility of this environmentally benign neutral reaction system was demonstrated in practical asymmetric reactions and catalyst development. The reaction system will be further applied to various practical organic reactions in the near future.



### Dr. Seiji Shirakawa

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[kuchem.kyoto-u.ac.jp/yugo/orgcat/index.html](http://kuchem.kyoto-u.ac.jp/yugo/orgcat/index.html)



## GEOPHYS Large Earthquakes Remotely Induce Earthquakes

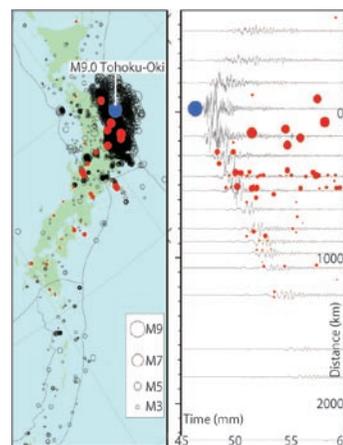
*Understanding the mechanisms that cause earthquake occurrences.*

Dr. Miyazawa studies the triggering of small earthquakes caused by the passage of seismic waves from distant large earthquakes. Such induced seismicity is often seen across Japan by nationwide dense seismic observation networks. The M9.0 2011 Tohoku-Oki Earthquake triggered other earthquakes extending to a distance of over 1,000 km that were associated with the strong seismic waves from the source (see the figure). Other recent large earthquakes, for example the 2004 Sumatra-Andaman Earthquake and 2008 Wenchuan Earthquake, remotely triggered tectonic tremor in southwest Japan. These studies provide a better understanding of the mechanisms that cause earthquake occurrences.



### Dr. Masatoshi Miyazawa

Associate Professor, Disaster Prevention Research Institute  
[www.rcep.dpri.kyoto-u.ac.jp/~miyazawa/](http://www.rcep.dpri.kyoto-u.ac.jp/~miyazawa/)



## BIO-ENG Controlling Cell Fate

*By constructing functional RNA switches.*

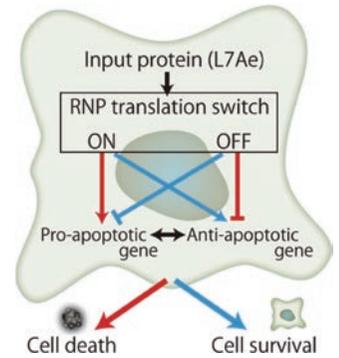
Dr. Saito and his colleagues recently developed new technologies to construct molecular systems out of functional RNA molecules that fulfill a wide range of functions in living organisms. These systems can be used to engineer safe and precise gene manipulation technology systems in mammalian cells. They have used molecular design techniques to create so-called “RNA translational switches,” which can turn the target gene expression “ON” and “OFF” in response to the detection of a range of intracellular target factors. They succeeded in controlling cell fate



by modulating cell signal pathways depending on the cellular environment. These new synthetic biology approaches have the potential to cure cellular defects by bypassing or rewiring intrinsic cellular signal networks.

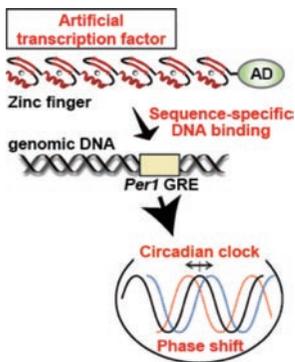
### Dr. Hirohide Saito

Associate Professor, The Hakubi Center for Advanced Research & Center for iPS Cell Research and Application (CiRA)  
[www.cira.kyoto-u.ac.jp/e/research/hsaito\\_summary.html](http://www.cira.kyoto-u.ac.jp/e/research/hsaito_summary.html)



## CHEM-BIO Touching the Circadian Time of Nature

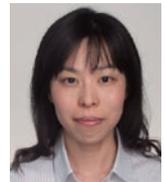
*Creation of artificial DNA binding proteins toward regulation of cellular events.*



Designing DNA binding proteins that bind desired DNA sequences at the right time is important for the regulation and evaluation of biological events. A C2H2 zinc finger motif is known as the most ubiquitous DNA binding motif. By changing the zinc ligands of the motif, a zinc ion-responsive transcription factor was created. In addition, an artificial zinc finger transcription factor targeting a core clock gene successfully changed the circadian time. A simple system to manipulate gene expression patterns to be circadian was also constructed using a zinc finger motif. These artificial proteins are expected to be useful for elucidating cellular events.

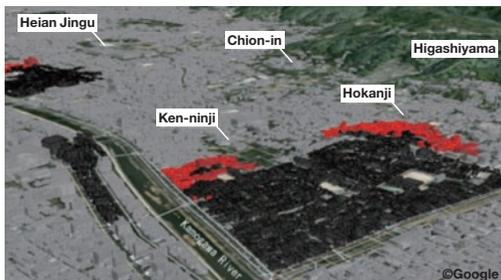
### Dr. Miki Imanishi

Assistant Professor, Institute for Chemical Research  
[www.scl.kyoto-u.ac.jp/~bfdc/index.html](http://www.scl.kyoto-u.ac.jp/~bfdc/index.html)



## ARCHIT To Measure Fire Risks Following Earthquakes

*Development of a physics-based urban fire spread model and its application to risk assessment.*



measures in several urban areas at risk of fires following an earthquake, including historic areas in Kyoto City.

Conflagrations are one of the common hazards which follow earthquakes in Japan. To date, a number of empirical models have been developed for predicting the behavior of such conflagrations in urban areas. However, because the mechanism of fire spread is black-boxed, there has always been difficulty in designing fire safety measures using empirical models. Dr. Himoto's research has developed a physics-based model by utilizing advanced engineering knowledge in the field of fire safety engineering. The model has been applied in designing fire safety

### Dr. Keisuke Himoto

Assistant Professor, Disaster Prevention Research Institute  
[kyouindb.iimc.kyoto-u.ac.jp/e/gE9eR](http://kyouindb.iimc.kyoto-u.ac.jp/e/gE9eR)



## COG-SCI Constructive Developmental Science

*Revealing the principles of human development from the fetal period.*

Compared to other animals, humans are born in a premature state. However, newborn humans are known to possess an elaborate capacity to process information about the external world, as well as about their own bodies. The research team led by Dr. Myowa-Yamakoshi has shown that there is a clear continuity in human sensorimotor development from prenatal to postnatal life. For example in one study, the team investigated cerebral responses in full-term neonates and preterm infants at a term-equivalent age and found that preterm infants from a very early developmental stage follow different developmental trajectories from those born at full term. In 2012, Dr. Myowa-Yamakoshi started to lead a research group of the five-year Constructive Developmental Science research project, which is supported by the Grant-in-Aid for Scientific Research on Innovative Areas from the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT). This interdisciplinary research project integrating robotics, medicine, psychology, neuroscience, and Tohjisha-kenkyu (person-centered, peer-supported research) aims at evolving a new understanding of human development and its disorders, comprehensive diagnostic methodologies, and truly appropriate assistive technologies.



**Dr. Masako Myowa-Yamakoshi**

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[www.educ.kyoto-u.ac.jp/myowa/en/index.html](http://www.educ.kyoto-u.ac.jp/myowa/en/index.html)  
[devsci.isi.imi.i.u-tokyo.ac.jp/about?lang=en](http://devsci.isi.imi.i.u-tokyo.ac.jp/about?lang=en)

## PRIMATOL Understanding Chimpanzee Social Intelligence

*A quest for the evolutionary origins of the human mind.*

Chimpanzees are the evolutionarily closest primates to humans, and thus research on chimpanzees helps us to understand the origins of human nature. Homo sapiens, the scientific name for human beings, means “wise man” in Latin. How, then, did we become “wise?” The social intelligence hypothesis claims that the evolution of intelligence is driven by the needs of living in a complex social world where an individual is faced with various social problems, such as competition, cooperation, and conflict resolution. Dr. Hirata is exploring social intelligence in chimpanzees from a comparative cognitive perspective, in a quest for the evolutionary origins of the human mind.



**Dr. Satoshi Hirata**

Program-Specific Associate Professor, Primate Research Institute  
[www.wrc.kyoto-u.ac.jp/kumasan/](http://www.wrc.kyoto-u.ac.jp/kumasan/)



## The Tachibana Award

*Outstanding Female Researchers at Kyoto University.*

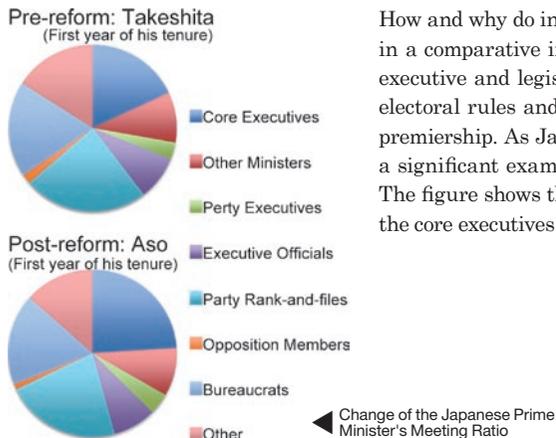
The Tachibana Award was established in 2008 to acknowledge the achievements of outstanding young female students and researchers in the humanities, social sciences, and natural sciences fields at Kyoto University. In 2012, six students and six researchers were nominated for the award. The winners were as follows.

Division	Name	Current Affiliation/Position	Research Topic
Student	Dr. Mami Iima	M.D./Ph.D. Candidate, Graduate School of Medicine	Development of a New Non-Invasive Diagnostic Tool for Investigating Breast Cancer Using Diffusion Weighted MRI
Researcher	Dr. Kaoru Satou-Imai	Research Fellow of the Japan Society for the Promotion of Science	Cis-Acting Transcriptional Repression Establishes a Sharp Boundary in Chordate Embryos



## POL-SCI Transformation of the Japanese Premiership

*A comparative institutional analysis of the power relationship between the executive and legislative branches.*



How and why do institutions matter in politics? Professor Machidori is engaged in a comparative institutional analysis of the power relationship between the executive and legislative branches, particularly the ways in which changes of electoral rules and changes in the prime minister's office affect the Japanese premiership. As Japanese politics has undergone major reforms it can serve as a significant example in understanding the operation of political institutions. The figure shows that the prime minister has become meeting more often with the core executives of his government as a result of reforms in the 1990s.

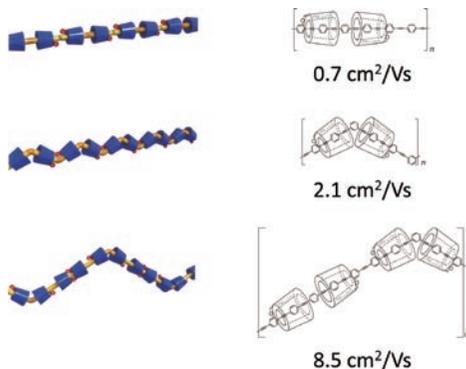
**Satoshi Machidori, Ph.D.**

Professor, School of Government  
kyodai.jp/shokai/staff/ma-machidori.html  
(Japanese only)



## CHEM For the Next-Generation of Electronic Materials

*A new design principle for increasing the intramolecular charge mobility of  $\pi$ -conjugated polymers.*



$\pi$ -Conjugated polymers are expected to be the next-generation of electronic materials because of their flexibility and light-weight properties. However, the charge mobility of  $\pi$ -conjugated polymers is not comparable to that of silicon-based semiconductor materials. To address that problem, Dr. Terao and his colleagues proposed a new strategy for increasing the charge mobility of  $\pi$ -conjugated polymers by insulating the  $\pi$ -conjugated chain with macrocycles and regularly localizing  $\pi$ -molecular orbitals in order to realize an ideal orbital alignment for charge hopping. Rewardingly, the zigzag insulated molecular wire exhibited a higher intramolecular charge mobility compared with that of the corresponding linear wire.

**Dr. Jun Terao**

Associate Professor, Graduate School of Engineering  
www.ehcc.kyoto-u.ac.jp/terao/index.html



### Origins of the Name

The tachibana tree, which produces small blossoms in summer and inedible citrus fruits in winter, is very well known in Japan. In the country's oldest historical record, the Kojiki (『古事記』), the tree is called tokijikunomi (非時香果), which means "ever-fragrant fruit," and it was respected as a symbol of vitality. Likewise, it is featured in sixty-six verses of the Manyōshū (『万葉集』), Japan's oldest poetry anthology, making it one of the collection's most frequently referred-to plants. In those verses its evergreen quality is used as a metaphor for eternal life and prosperity. In the Heian period, the tachibana tree was used, together with the cherry tree as an auspicious symbol, and the two trees were planted outside important buildings such as the Kyoto Imperial Palace. The tachibana blossom was also used as the basis for the five-leafed design of the Japanese Order of Culture medal. Originally, a design based on the cherry blossom was proposed for the medal, but the Emperor Showa requested that the tachibana be used instead. The Emperor explained that "falling cherry blossoms have meaning, but culture should be everlasting," and so the flower of the perpetually green tachibana tree was adopted to symbolize the permanence of culture. In that tradition, Kyoto University chose to name its award for outstanding young female researchers after the tachibana tree, to express the hope that the work of the awardees will continue to flourish. (See also the next pages.)



(Author: The Center for Women Researchers)

## MUSICAL How Music Comes into the World

*The birth and development of public concerts.*

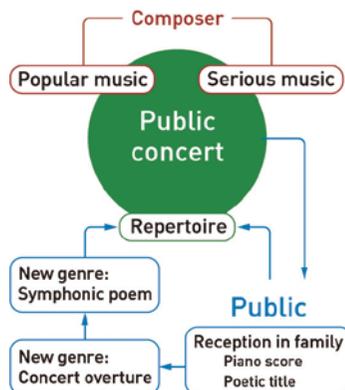
The public cannot listen to music from its score. Only when performers play a piece of music does it come into the world. A concert, therefore, is a meeting place between composers, their work, and the public. Until now, musicological discussion has generally focused on classical music composers or their works. In musicology, classical music is categorized through certain criteria into “serious music” (also referred to as “art” or “legitimate music”) or “popular music,” and it is only the former which has been a subject for research. Such categorizations are transgressed, however, at concerts, which feature performances of both serious and popular pieces, or when “serious” orchestral scores are arranged and sold as “popular” piano pieces to be played by non-professional members of the public. Through an examination of concerts, where both types of music are performed, Dr. Koishi seeks to write a new form of music history.



**Dr. Katsura Koishi**

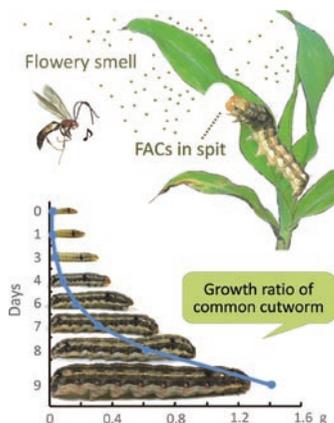
Assistant Professor, The Hakubi Center for Advanced Research  
[www.hakubi.kyoto-u.ac.jp/eng/02\\_mem/h24/koishi.html](http://www.hakubi.kyoto-u.ac.jp/eng/02_mem/h24/koishi.html)

Concert as a meeting place between composer, works and public



## AGRI Why Don't Fast-Growing Caterpillars Bother about Defense?

*Analytical chemistry unravels the mystery of ecological phenomenon.*



Although generally assumed to be helpless against caterpillars, many plants protect themselves by releasing a flowery smell that recruits parasitoids. Fatty acid amino acid conjugates (FACs), originally identified in lepidopteran larval spit as elicitors of such volatiles (and which consequently function negatively for the caterpillars), turned out to enhance nitrogen assimilation. Therefore, species which have FACs grow fast and eat more, usually have no defense strategy, and, incidentally, many of them are known as serious pests in the agricultural industry. Since grown-up caterpillars are subject to less parasitoid attacks, “no defense but to grow up” can be an effective strategy — especially in a farm densely populated by caterpillars.

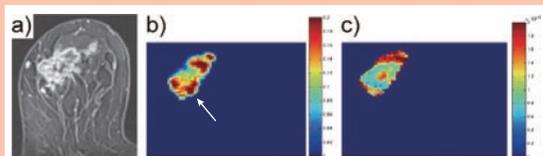
**Dr. Naoko Yoshinaga**

Assistant Professor, Graduate School of Agriculture  
[www.chemeco.kais.kyoto-u.ac.jp/](http://www.chemeco.kais.kyoto-u.ac.jp/)



## TACHIBANA MED Development of a New Non-Invasive Diagnostic Tool for Investigating Breast Cancer Using Diffusion Weighted MRI

Breast cancer is the most prevalent cancer among women worldwide. However, current imaging approaches (such as mammography) often do not provide enough information for proper lesion management, which sometimes results in unnecessary invasive treatments. Dr. Iima and her colleagues, under the supervision of Prof. Denis Le Bihan who has introduced the concept of diffusion MRI, have succeeded in identifying patients presenting low-risk lesions (ductal carcinoma *in situ*) with very high specificity, precluding the necessity for invasive treatments. Diffusion MRI is a new, noninvasive diagnostic approach to evaluating tumor types and their perfusion, and a step toward “tailor made” oncology treatment.



Conventional postcontrast MRI image (a), Perfusion map (b), Diffusion map (c)  
 The malignant nature of the lesion is established based on the high perfusion fraction area (b, white arrow) associated with low water diffusion (c).

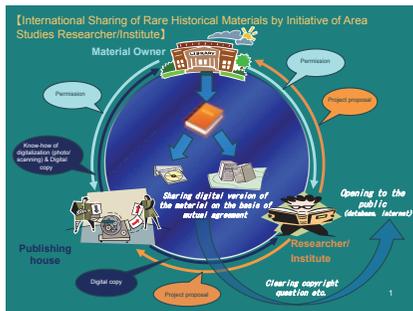
**AWARD WINNER** Dr. Mami Iima

M.D./Ph.D. Candidate, Graduate School of Medicine  
[www.kuhp.kyoto-u.ac.jp/~diag\\_rad/](http://www.kuhp.kyoto-u.ac.jp/~diag_rad/)



## BIBLIOG Database-Building for Turkestanskii Sbornik

*Exploring Imperial Russia's colonial knowledge of Central Asia.*



to construct a progressive bibliography-based database. By developing a more advanced system to explore TS by using chains and links of keywords and categories, Associate Prof. Obiya hopes to delve into Imperial Russia's colonial knowledge on Central Asia.

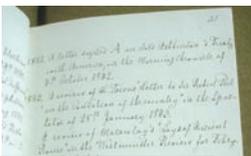
**Associate Prof. Chika Obiya**

Associate Professor, Center for Integrated Area Studies (CIAS)  
www.cias.kyoto-u.ac.jp/en/database/ (CIAS Database)



## HIST “The Physiology of the Social Body”

*The political thought of John Stuart Mill.*



▲ ‘A Leap in the Dark,’ Punch, 3<sup>rd</sup> Aug. 1867,  
Used for Jacket illustration of Dr. Kawana's Book.

Dr. Kawana's major study of utilitarian philosopher and reformer, John Stuart Mill, “The Physiology of the Social Body (Shakaitai no Seirigaku)” was published by Kyoto University Press in 2012. Drawing on an extensive range of works by Mill and his contemporaries, the book investigates Mill's projected sciences of society which dealt with the nature and prospects of civilized society, and included the sciences of history and of the formation of character (which Mill termed ‘ethology’), as well as political economy.

The book was awarded the Mizuta Prize for 2012, a prize which is presented to a young intellectual historian who has made significant contributions to the field of intellectual history.

◀ Sample of Mill's handwriting  
©LSE

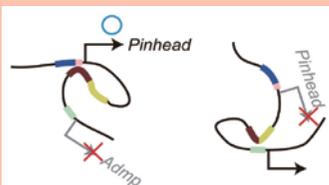
**Dr. Yuichiro Kawana**

Assistant Professor, The Hakubi Center for Advanced Research  
www.hakubi.kyoto-u.ac.jp/eng/



## TACHIBANA BIO Cis-Acting Transcriptional Repression Establishes a Sharp Boundary in Chordate Embryos

The function of the bone morphogenetic protein (BMP) signaling system in dorso-ventral (DV) patterning of animal embryos is widely conserved among Bilateria. In vertebrates, the BMP ligand Admp is expressed dorsally and moves to the opposite side to specify the ventral fate. Dr. Satou-Imai and Associate Professor Yutaka Satou showed that Pinhead is an antagonist specific for Admp with an essential role in establishing the sharp boundary of the ascidian epidermis along the DV-axis. Pinhead and Admp exist in tandem in the genomes of a wide range of animals. This genomic configuration is important for mutually exclusive expression of these two functionally opposed genes through cis-acting transcriptional repression. Their data suggests that this dual negative regulatory mechanism is widely conserved in a wide range of animals.



Models of chromosome conformations Pinhead and ADMP genomic region when Pinhead transcription is active (left) and inactive (right)

**AWARD WINNER** Dr. Kaoru Satou-Imai

Research Fellow of the Japan Society for the Promotion of Science (RPD)  
ghost.zool.kyoto-u.ac.jp/

