## Research Topics



## **WPI**: Institute for Integrated Cell-Material Sciences (iCeMS)

The World Premier International Research Center (WPI) **Initiative**, a MEXT\* program, seeks to 1) advance leading edge research, 2) create new inter-disciplinary domains, 3) establish truly international research environments, and 4) reform existing research organizations. The iCeMS was selected as one of five WPI centers and established at Kyoto University in 2007. Its founding director is Prof Norio Nakatsuji, Japan's pioneer in the establishment and distribution of human ES cell lines, and a leader in ES/iPS cell-based drug discovery.

#### The iCeMS aims to create new cross-disciplinary fields through the integration of cell and material sciences,

pioneering the development of stem cell technologies and mesoscopic sciences. These are anticipated to lead to innovations in medicine, pharmaceuticals, the environment, and industry.

Stem cell technologies include:

- Reprogramming with chemical compounds for iPS cell derivation
- Chemical probes for stem cell research
- Control of ES/iPS cell growth and differentiation with . chemicals and materials
- Creation and applications of stem cell-derived model cells in medicine and drug discovery

#### Mesoscopic sciences include:

- Imaging and probing mesoscopic complexes in living cells .
- Production of functional mesoscopic materials
- Integration of mesoscopic materials and living cells
- Modeling, simulation, and physics theories of mesoscopic . events in materials and living cells







From left: Deputy Director Susumu Kitagawa, Director Norio Nakatsuji, CiRA Director and iCeMS Professor Shinya Yamanaka

Innovations in medicine, pharmaceuticals, the environment, and industry



- Chromatin architecture/function and meso-control Gene expression control with bio-functional chemicals/ materials
- Cell membrane architecture/function and meso-control Ion channel transporter/receptor with bio-functional chemicals/materials
- Intracellular delivery of bio-functional materials
- Control by external signals
- Cellular environment architecture/function and meso-control Nano/meso/micro-engineered materials with bio-functional molecules

\* Japanese Government Ministry of Education, Culture, Sports, Science and Technology. Also known as Monkasho.





## iCeMS Center for Meso-Bio Single-Molecule Imaging (CeMI)

The CeMI was established in 2009 as the iCeMS' imaging innovation center for cellular meso-science. Its key missions are: 1) develop new, powerful technologies for imaging the *restless* nano- to meso-scale universe of biomolecular complexes in living cells, at the spatiotemporal resolutions of functioning single molecules, and 2) make these technologies available quickly to the scientific community worldwide for the further advancement of cellular meso-science.



The center places special emphasis on **single-molecule imaging** and **tracking**, and on **terahertz spectroscopy and microscopy**. The CeMI's aim is to become a world hub, where scientists from across the globe can gather to engage in meso-bio, single-molecule imaging, and to develop the meso-science of cells. The founding director of the center is Prof Akihiro Kusumi.

www.cemi.icems.kyoto-u.ac.jp/e\_index.php

## Kyoto University Center for iPS Cell Research and Application (CiRA)

Following Prof **Shinya Yamanaka**'s successful generation of induced pluripotent stem (iPS) cells from human fibroblasts in 2007, the Center for iPS Cell Research and Application (CiRA) was established in 2008 under the auspices of Kyoto University Institute for Integrated Cell-Material Sciences (iCeMS) in order to further advance iPS cell research. Institute Director **Norio Nakatsuji** appointed iCeMS Prof Yamanaka as director of the CiRA.



In 2010 Kyoto University reestablished the CiRA as an independent institute under its jurisdiction. Prof Yamanaka serves both as director of the new center while continuing in his iCeMS professorship. The two sister institutes continue to be closely tied in their cooperative investigations involving basic research related to iPS cells. www.cira.kyoto-u.ac.jp/e





## Global COE Programs:13 Centers of Excellence

The Global COE (Centers of Excellence) is a program with an aim to support quality research and education centers of the world's highest order. 13 projects have been selected from the wide range of scientific fields at Kyoto University, and are supported by the MEXT. These are the projects that have been chosen from among hundreds that were established by the previous 21st Century COE program, and continue to contribute to the world's knowledge bank.

www.kyoto-u.ac.jp/en/research/capital/global\_coe/global.htm

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HOTO UNIVERSITY LACOR THEWE DATERIALS SCIENCE	Category : Chemistry, material sciences (Since 2007)         Title       : International Center for Integrated Research and         Advanced Education in Materials Science         Leader       : Professor Mitsuo Sawamoto,         Graduate School of Engineering         URL       : www.mtl.kyoto-u.ac.jp/gcoe/E
	Category : Information sciences, electrical and electronic sciences (Since 2007)         Title       : Informatics Education and Research Center for         Knowledge-Circulating Society         Leader       : Professor Katsumi Tanaka,         Graduate School of Informatics         URL       : www.i.kyoto-u.ac.jp/gcoe
PESEC Deserver and and a	Category : Information sciences, electrical and electronic sciences (Since 2007)         Title       : Center of Excellence for Education and Research on         Photonics and Electronics Science and Engineering         Leader       : Professor Susumu Noda,         Graduate School of Engineering         URL       : www.kuee.kyoto-u.ac.jp/gcoe/eng
	Category : Humanities (Since 2007)         Title       : Revitalizing Education for Dynamic Hearts and Minds         Leader       : Professor Masuo Koyasu, Graduate School of Education         URL       : www.educ.kyoto-u.ac.jp/gcoe/en
HUMANOSPHERE	Category : Interdisciplinary and combined fields (Since 2007)         Title       : In Search of Sustainable Humanosphere in Asia and Africa         Leader       : Professor Kaoru Sugihara, Center for Southeast Asian Studies         URL       : www.humanosphere.cseas.kyoto-u.ac.jp/en



FRONTIER MEDICINE G-COE KYOTO	Category: Title Leader	Medical sciences (Since 2008) <b>Center for Frontier Medicine</b> Professor Syu Narumiya, Graduate School of Medicine <u>www.med.kyoto-u.ac.jp/GCOE/E</u>
AND THERESTER AND THE OWNERS OF THE OWNERS O	Category: Title Leader URL	Mathematics, physics, earth sciences (Since 2008) <b>Fostering top leaders in mathematics - broadening the</b> <b>core and exploring new ground</b> Professor Kenji Fukaya, Graduate School of Science <u>gcoe.math.kyoto-u.ac.jp/english</u>
hs Net Constant of Portion of Portio of Portion of Portion of Portion of Portion of Port	Category Title Leader	Mathematics, physics, earth sciences (Since 2008) <b>The Next Generation of Physics,</b> <b>Spun from Universality and Emergence</b> Professor Hikaru Kawai, Graduate School of Science <u>www.scphys.kyoto-u.ac.jp/gcoe/index_e.html</u>
HSF	Category Title Leader	<ul> <li>Mechanical, civil engineering, architectural and other fields of engineering (Since 2008)</li> <li>Global Center for Education and Research on Human Security Engineering for Asia Megacities</li> <li>Professor Yusuru Matsuoka, Graduate School of Engineering</li> <li>hse.gcoe.kyoto-u.ac.jp</li> </ul>
Public Kyoto University	Category Title Leader	<ul> <li>Social sciences (Since 2008)</li> <li>Global Center of Excellence for Reconstruction of the Intimate and Public Spheres in 21st Century Asia</li> <li>Professor Emiko Ochiai, Graduate School of Letters</li> <li>www.gcoe-intimacy.jp</li> </ul>
COLUMNON COLUMNON	Category Title	<ul> <li>Interdisciplinary, combined fields (Since 2008)</li> <li>Energy Science in the Age of Global Warming</li> <li>-Toward CO<sub>2</sub> Zero-emission Energy System</li> <li>Professor Takeshi Yao,</li> <li>Graduate School of Energy Science</li> <li>www.energy.kyoto-u.ac.jp/gcoe/en</li> </ul>
ARS CONTRACTOR	Category Title Leader URL	<ul> <li>Interdisciplinary, combined fields (Since 2009)</li> <li>Sustainability/Survivability Science for a Resilient Society Adaptable to Extreme Weather Conditions</li> <li>Professor Kaoru Takara, Disaster Prevention Research Institute</li> <li>ars.gcoe.kyoto-u.ac.jp/index.php?id=3</li> </ul>



## The most advanced institute for BNCT

**Boron Neutron Capture Therapy (BNCT)** is a binary treatment for cancers. The <sup>10</sup>B nucleus absorbs thermal neutrons at much higher probabilities than other elements in the body, and instantly splits into two high linear energy transfer particles, an -particle and a Li atomic nucleus, with a total range of 13 m, which corresponds to general cell diameter. Therefore, with the combination of pre-injecting <sup>10</sup>B-compound to selectively accumulate in cancer lesions, and thermal neutron irradiation, we are able to selectively destroy cancers. A huge amount of neutrons are necessary for BNCT and the research reactor is used as a neutron source.



Professor Koji Ono



At the Kyoto University Research Reactor Institute (KURRI), more than 330 patients with no other viable treatment options, have received BNCT to the present. This is the largest number of BNCT treatments in the world. The kind of cancers that has been treated by BNCT include malignant brain tumors, malignant melanoma, recurrent H & N cancers, multiple liver cancers and lung cancers, especially malignant pleural mesothelioma. The effectiveness of BNCT has been clearly demonstrated on the first 3 cancers. KURRI was the first in the world to begin BNCT for malignant melanoma, H & N cancer and mesothelioma.

In order for BNCT to be recognized as an approved medical treatment, Prof Koji Ono, who is the leading figure of BNCT research in Japan, began a new project in August 2004, to develop an accelerator based neutron source. In the past twenty years, many researchers tried, but failed to succeed due to weaknesses in current and neutron production targets. Ono's group successfully developed the cyclotron neutron system with sufficient current and beryllium targets with an optimized neutron production method, on March 2009. Today, preparations are being made to begin clinical testing.







Accelerator based neutron source

www.rri.kyoto-u.ac.jp/en/RD/LSMS/lsms04\_pro.html



## Low-Carbon Research Network JAPAN (LC-net)

#### Nano/Micro device fabrication Infrastructural Platform for a Low Carbon Society

The **Low-Carbon research network** that was proposed in 2010 is under development by the MEXT as the new research infrastructure network in Japan, according to the scope of the "Challenge toward Environment and Energy Technology" initiative, which is a part of the greater "Groundwork for Growth" strategy. Its total budget is 13 billion JPY. The research accomplishments and Nanotechnology discoveries will be integrated into the environmental technologies and systems in practical use to accelerate new developments and applications.

Achieving innovative research thorough the fusion of related research fields, the LC-net is composed of three HUB centers – one of which is Kyoto university – and 15 other satellite research centers. All of the centers will be equipped with advanced systems and apparatus. The three HUB centers work toward the development of new materials, the fabrication of micro and nano devices and carry out their testing.



Kyoto university is equipped with more than 70 fabrication and testing facilities supported by the senior professional engineers responding to not only support and advise its users, but to develop new technologies to build mico/nano devices, and also educate the students. The coordinators lead the users to collaborate with each other in open innovation and also provide a seamlessly interconnected environment between each user's labs and the HUBs.

## Clinical Research Center for Medical Equipment Development (CRCMeD)

The **Clinical Research Center for Medical Equipment Development** (**CRCMeD**) was established in 2011 in order to accelerate product development in innovative medical equipment and devices to support all stages throughout early diagnosis and treatment. Clinical research is a critical part of the medical product development process. The key function of the CRCMeD is to promote academiaindustry collaboration in this clinical research field.



CRCMeD Director Michiaki Mishima





## The **RISING Project**

The **R&D** Initiative for Scientific Innovation of New Generation Batteries (**RISING**) project is an endeavor to develop innovative rechargeable batteries for a green revolution within Japan at this time of tough competition. Cooperation between Kyoto University and NEDO (New Energy and Industrial Development Organization) has been ongoing to support this framework since 2009, and currently 12 industries and 12 academic institutions participate from across the nation.



Professor Zempachi Ogumi

#### **Objectives:**

- 1. To strengthen the battery industry within Japan at this time of tough global competition.
- 2. To develop a new generation of batteries with high performances of greater than 500Wh/kg.
- 3. To act as a central hub for the battery community.

**Project Duration:** Planned for 7 years: 2009 through 2016

#### Budget:

3 billion JPY per year

Three important targets for the RISING Project are; 1) establish advanced analytical methods based on close collaboration between industrial society and academia, to understand the phenomena in LIBs and to improve the performance 2) develop novel technology to realize innovative batteries with its performance as high as 500Wh/kg 3) form an interdisciplinary community for developing new generation batteries.





Towards this goal, what is most important is to realize that the battery reaction proceeds in a variety of space and time scales; from the sub-nanometer range where the charge transfer reaction takes place, to the centimeter range which corresponds to the size of the whole battery. This structural size hierarchy gives non-uniform distribution in the battery reaction sites so that we often fail to understand the details of the phenomena, kinetics and stability. Accordingly it is necessary to elucidate these phenomena in broad space and time ranges. We believe that to understand the limitations of LIBs with advanced analytical methods is the most effective way to lead to new concepts for innovative batteries.

www.rising.saci.kyoto-u.ac.jp (Japanese only)



## The Hakubi Project : Fostering Young Researchers

In this age of globalization, it is increasingly important for researchers to possess creativity, broad perspectives and a flexible mindset, all of which are essential for pioneering new academic frontiers. With this in mind, Kyoto University launched what is called the Hakubi Project. Under this project, Kyoto University annually selects and employs up to twenty researchers as associate and assistant professors for terms of up to five years. The Young Researcher Development Center (also known as the Hakubi Center) is responsible for the logistics of this program, acting as liaison between the selected individuals and Kyoto University's research institutions.

The Hakubi Project is open to applicants of all nationalities, from anywhere in the world, and welcomes young researchers holding doctoral degrees (or equivalent research skills) in any range of basic and applied studies, in all academic fields.

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• What does *Hakubi* mean?

The term *hakubi* literally means "white eyebrows" in Japanese. The project is named after a legend from *Shu* (蜀), one of the states of the Three Kingdoms era in ancient China. According to the legend, in the Kingdom lived five brothers with extraordinary talents. Since the fourth brother who was particularly outstanding, had white hairs in his eyebrows, the term *hakubi* has come to refer to the most prominent individuals.

#### Number of Applicants

	Total No. of Applicants	Successful Applicants	Competition Rate
FY 2009	588	18	32.7 times
FY 2010	517	19	27.2 times
Ratio of Tota	al Applicant	FY 2009	FY 2010
Male : Female	e (%)	77.9 : 22.1	81.4 : 18.6
Humanity & S Natural Scien	Social Sciences : lices (%)	33.3 : 66.7	27.3 : 72.7
Kyoto U. Affili	ate : Others (%)	38.4 : 61.6	35.4 : 64.6
Address in Ja Countries (%)	apan : Other	81.0 : 19.0	79.5 : 20.5



Applications are complete with the receipt of both the registration form and e-mailed proposal. The first group of Hakubi researchers took up their positions as program-specific associate and assistant professors in April of 2010, and the second group in April 2011. The third call for applications was closed on May 26, 2011.

■ For further information: www.hakubi.kyoto-u.ac.jp/eng

#### ■ How do I apply?

Stay tuned for the call next spring!