



## RIKEN NATIONAL SCIENCE INSTITUTE

# Crossing disciplines, borders and scales

**F**ounded almost a century ago in 1917, today RIKEN is Japan's largest research institution in the natural sciences. It has a prestigious history of conducting research in a wide range of specialized scientific areas. Throughout its history, RIKEN has also strived to integrate research across disciplines to deepen our knowledge of the comprehensive nature of our physical and biological environment. This vision has resulted in a better understanding of how phenomena on different scales — from the atomic level to the ecosystem and beyond — shape the world we experience.

Here, we take a closer look at two RIKEN centres at the forefront of integrated research: the Nishina Center for Accelerator-Based Science and the Center for Life Science Technologies.

### Integrated nuclear physics research

On the last day of 2015, RIKEN gave a press conference (bottom photograph on the next page) to announce that just that morning, Kosuke Morita from the Nishina Centre for Accelerator-Based Science had received news from the International Union of Pure and Applied Chemistry that his group had been recognized as the discoverers of a new chemical element, element 113. It was a historic milestone — the first time an element had been discovered in Asia.

This discovery was made possible by one of the most powerful and versatile heavy ion accelerators in the world. The Nishina Centre's RI Beam Factory, where the research was conducted, is a tremendous instrument made from a linear accelerator, a series of cyclotrons,

including the world's first superconducting ring cyclotron and a superconducting radioactive-isotope beam separator. The RIBF is a leading facility for accelerator-based research into the nature and origin of the nucleus and its elementary particles.

At the Nishina Center, investigators combine experimental research on particles, atomic nuclei and solid-state materials using protons, mesons, muons and other particles with theoretical methods for exploring the most fundamental laws of physics. This combined approach, together with a clear mandate to apply new elementary findings to medicine, agriculture and other natural sciences, sets the Nishina Center apart from other nuclear physics institutes.

According to Hideto En'yo, director of the centre, "The Nishina Center is also an exponent of the global reach RIKEN has gained with its research initiatives. The centre operates two facilities abroad. In the UK, we have a muon facility at the Rutherford Appleton Laboratory that provides access to an intense pulsed muon beam; with this muon beam, researchers can study the electromagnetic properties of insulating, metallic, magnetic and superconducting materials. In the USA, we have established a combined theoretical, experimental and computing group at Brookhaven National Laboratory's Relativistic Heavy Ion Collider to train young scientists in the physics of strong interactions, including spin physics, lattice quantum chromodynamics and the physics of relativistic heavy-ion collisions. Our facilities are used by scientists around the world both for basic

research and applications.”

The discovery of element 113 was a first step in the centre’s long-term goal of attaining one of the holy grails of nuclear physics — reaching the so-called island of stability. The island of stability theory predicts that, for elements heavier than uranium, a set of heavy isotopes will be found exhibiting a magic combination of protons and neutrons that results in increasing rather than decreasing stability.

According to En’yo, “We have already begun our search for elements 119 and 120, our next goals in the search for super-heavy elements. Other milestones on this quest include the discovery of 300 new isotopes. So far, we have detected 150.”

Ultimately, the Nishina Center is on a quest to unravel the origin of the Universe by better understanding the inner workings of the atomic nucleus and thus reveal the processes by which heavy elements came to be. “The RIBF is producing a variety of data on unstable nuclei, nuclear reactions, nuclear structures, shapes, sizes, as well as many new and interesting features of exotic nuclei,” notes En’yo.

### Comprehensive living systems science

RIKEN’s Center for Life Science Technologies (CLST) is another champion of RIKEN’s focus on integrated research facilities. It was established to advance the understanding of how living systems work by integrating mechanistic insights from the atomic scale through molecular function and cellular organization to the whole-body level. This goal is achieved by approaching research from a dynamic and system-wide perspective, rather than a traditional static and reductionist angle.

“Integration in life science means orchestration of a variety of molecules in some architectonic features — CLST is mostly aiming to develop novel methodologies and techniques to follow this orchestration,” explains CLST’s director, Yasuyoshi Watanabe. “These technologies enable the analysis of big molecular complexes, exploration

of their regulatory mechanisms and imaging the dynamics of their molecular interactions.”

The centre’s mission is driven by the close interactions among its three divisions: structural and synthetic biology, genomic technologies, and bio-function dynamics imaging. Integration of technologies and research outcomes from these three divisions allows CLST to chart a clear course towards drug discovery, new therapies and healthcare innovation.

One of the areas CLST focuses on is the characterization of disease through the integrated and multimodal analysis of structural, topological and functional data that reveal the pathophysiology and molecular phenomena underlying pre-disease and disease states. “We have achieved much in this field, not only in experimental animals, but also in humans by using a multiangle approach — total omics analyses, interaction studies of neuroimmunendocrine systems, positron emission tomography studies, functional magnetic resonance imaging studies and magneto-encephalography studies,” says Watanabe. “The ultimate goal is to find ways to prevent disease by diagnosing it and initiating treatment before its onset.”

Translating new scientific and medical insights gathered at CLST into applications and therapies follows multiple paths including strong partnerships with industry, medical and academic institutions. And internally, CLST provides support for several RIKEN translational initiatives such as the RIKEN Program for Drug Discovery and Medical Technology Platforms and the RIKEN Preventive Medicine & Diagnosis Innovation Program. These



collaborations also seek to improve health outcomes on a more long-term time scale. “A perfect example of this is a recently approved project spearheaded by CLST and comprising local governmental offices and more than 40 healthcare, industrial and academic collaborators,” explains Watanabe. “This project aims to optimize personalized medicine approaches under the umbrella of the Compass for Healthy Life Research Complex project.”

## Contact

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Tel: +81 48 462 1225

E-mail: [pr@riken.jp](mailto:pr@riken.jp)

