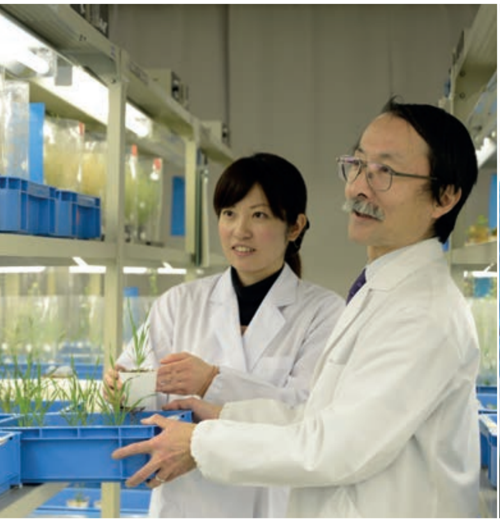

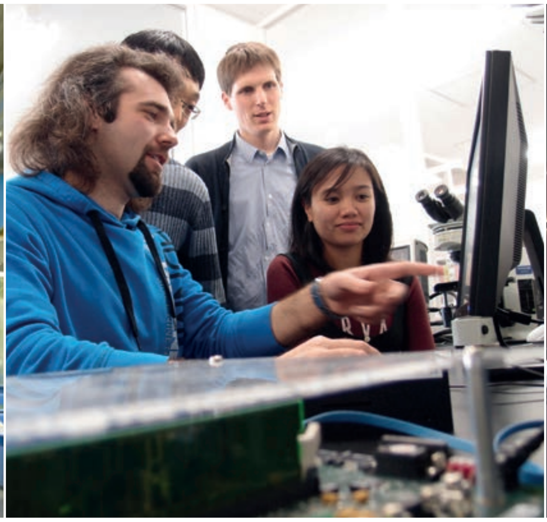

RIKEN

Science for survival

RIKEN's new president is asking its scientists to think about changing the world and they are rising to the challenge

Yoshinori Tokura has a passion for skyrmions, which sounds a bit fantastical. A skyrmion is only about 20 nanometres in diameter, but it consists of thousands of spins that form a vortex in a material — "like a typhoon," as Tokura puts it. "Once created, a skyrmion cannot be easily destroyed," he says. "It can flow freely, acting as a high-energy particle."

For Tokura, who directs the RIKEN Center for Emergent Matter Science (CEMS), skyrmions are a perfect example of an emergent entity, forming a topologically defined, independent object whose characteristics altogether surpass those of its component parts. They are a discovery of fundamental research and yet promise to lead to real-world applications — more efficient memory devices. They also represent the ideal that RIKEN is pursuing with success: the marriage of curiosity-driven basic research with potentially game-changing applications in areas of critical importance for our global future. CEMS and the RIKEN Center for Sustainable Resource Science (CSRS), both established in 2013, have been tasked with finding radical solutions to some of the world's most pressing problems, including energy supply and environmental protection. That bar has been set even higher since April, when RIKEN entered a new era under the leadership of President Hiroshi Matsumoto.

'Shaking things up'

According to Matsumoto, 'sustainability' is a bit of a misnomer for his vision of RIKEN's mission. As a concept, sustainability leaves people complacent, he says, offering the example of water, which people know is in short supply but do little to conserve. "The globe is almost broken," he says. "We need to make people realize it's a matter of survival. Only then will people realize the significance of science."

Matsumoto combines a deeply philosophical management style with an appreciation of social and economic realities and, above all, a respect for what science can achieve. "It's the only way we will survive, with the constantly increasing population in the developing world coming to expect a better quality of life," he says. "RIKEN should offer something. We need to shake things up."

He is shaking things up with a five-point plan that calls for RIKEN to become a global hub for innovation, where its researchers can form collaborations with those from universities and industry around the world.

RIKEN President Hiroshi Matsumoto.

He is encouraging more joint RIKEN appointments for university researchers and pressing researchers to find interdisciplinary opportunities to expand their research. "RIKEN will be the place where exchanges take place," he says. His plan also calls for more foreign researchers — from the current 19 per cent to 30 per cent — and the creation of a fully bilingual RIKEN.

Perhaps most importantly for researchers, Matsumoto wants to ensure firm support for RIKEN scientists. He plans to increase the number of permanent staff and implement a tenure track system. He is seeking to increase researcher contracts from five to seven years; a period he says is required for many projects to bear fruit. He also plans to launch a similar programme to one he introduced while president of Kyoto University in which a few select scientists will be given generous funding and set free to do research anywhere in the world.

With the benefits come expectations. "Excellency in science is not enough. Before being a scientist, you must be a human," he says. He tells his scientists to always consider how they can contribute to society: "RIKEN is a place where you can help change the world."

CEMS and CSRS are good examples of how this mission is being carried out.

Carbon, nitrogen and metals

CSRS, which is directed by Kazuo Shinozaki, has researchers from various fields ranging from microbiology to catalytic chemistry, from plant science to chemical biology. Research at CSRS is focused on three targets, all of which require interdisciplinary collaboration and aim to create a society based on renewable resources and energy. Researchers engaged in the carbon initiative are enhancing photosynthesis in order to use carbon dioxide, which would otherwise contribute to global warming, to create useful materials. Research projects focused on nitrogen aim to find less fossil-fuel-intensive methods of creating ammonium and to create crops that produce high yields even with low nitrogen fertilizers. The metallic elements initiative aims to create cheap and readily available catalysts for chemical synthesis. It is also targeting a means to recover metals using moss or microorganisms. In addition, CSRS has a biomass engineering project geared towards translational research in collaboration with industry. To become more international, the centre has adopted English as its official language.

Experimental results are already capturing global attention. Zhaomin Hou's discovery that a novel titanium polyhydride complex can break the strong bond between two atoms of nitrogen (N_2) will open a way to break the N_2 bond at room temperature, a crucial step towards a long-sought method for producing ammonia more cheaply. That work followed closely on Hou's discovery that the titanium polyhydride complex can be used to break carbon–carbon bonds in benzene, opening up the possibility of previously unimaginable applications for the whole range of aromatic molecules.

CSRS scientists are also making breakthroughs relating to food safety and security. Last year, Kazuki Saito reported the ability to silence a potato gene involved in the production of a toxin. Ryoung Shin is building on the discovery of a chemical that binds to caesium to make plants that will not accumulate the radioactive substance, which will contribute to Fukushima remediation efforts. Shinozaki dreams of understanding complex gene networks well enough to produce drought-resistant plants. "This will be very important for the future of food security," he says.

As director, Shinozaki strikes a balance by encouraging CSRS researchers to think broadly about the scope of their science and its applications. "We give them freedom to pursue research in a particularly interdisciplinary way," he says. "We especially encourage young researchers to take on this challenge."

Ubiquitous skyrmions

At CEMS, Tokura is already eyeing applications for skyrmions. Skyrmions were once just a theoretical hypothesis and were then thought to occur only under special circumstances, but Tokura used cutting-edge Lorentz electron microscopy to show that skyrmions are ubiquitous in conventional magnets. This discovery opened the door to using skyrmions as information carriers in next-generation magnetic memory devices.

"People are excited; they're jumping into the field, especially engineers in spintronics," says Tokura. The skyrmion research moved ahead only because of close collaboration with other groups at the centre, bringing together theoreticians and those who could design the structures of new materials, those who could make the materials, and those who could observe skyrmion properties. "There are no barriers between laboratories within the centre," he says.

Another representative example of interdisciplinary emergent matter research at CEMS is the development of aqua materials, or 'watery plastics', made from 95 per cent water. By linking water molecules together with tiny amounts of clays and organic macromolecules, CEMS researchers have created aqua materials that are environmentally benign and moldable with special biological and optical functions.

With close to 30 per cent foreign staff and a host of international and industrial collaborations, CEMS is already starting to make headway on its formal mission of contributing to a sustainable society through big innovation.

Aside from his own goals with skyrmions, Tokura has laid out "Big Four" goals that require massive innovation: tripling the efficiencies of superconductors, solar cells, batteries and thermoelectric materials used in refrigeration. These goals are ambitious — "a bit crazy," says Tokura — but they could radically rewrite the economics of energy. "We always have to keep these kinds of issues in mind," says Tokura. "Then, as long as we are allowed to do very basic research, we have a chance to make a big leap."

Fast facts:

- **RIKEN, a national R&D institution founded in 1917, is Japan's largest and most comprehensive research organization for basic and applied science.**
- **RIKEN conducts world-leading research in developmental biology, neuroscience, drug development, plant science, nuclear physics, solid-state physics, photonics, chemistry, materials science and supercomputing.**

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