LAYING THE GROUNDWORK FOR A MORE RESILIENT PLANET

Using cutting-edge education and research, TOHOKU UNIVERSITY aims to help resolve environmental and social issues through its GREEN GOALS INITIATIVE.

Tohoku University, an institution with a 115-year history of trailblazing achievements, is building on this record of innovation by strongly investing in world-class facilities. It is slated to host Japan's next-generation synchrotron radiation facility in 2023 and is establishing a science park where in-development tests and experiments can be performed, and where industry partners co-create production-grade materials. These facilities will see the university introduce emerging technologies to address societal problems and enhance resilience.

Located in the city of Sendai, the university has about 18,000 students spread across 10 faculties, 15 graduate schools and six research institutes. It was one of the three inaugural designated national universities selected by the Japanese government in 2017, and has ranked number one on Times Higher Education's list of top Japanese universities for the last two years.

As part of its multi-pronged response to the COVID-19 pandemic, the university activated its international network towards addressing rapidly emerging global problems such as stressed supply chains, high energy costs, and the need for rapid disease testing. This effort towards recovery with an eye to future resilience is the cornerstone of the university's new Green Goals Initiative, which was launched in July 2021. Developed in line with the United Nations' Sustainable Development Goals, the project aims to utilize green technology to create inclusive and sustainable societies better equipped to respond to natural disasters.

"WITH SPINTRONICS, WE CAN COMPLETELY TURN OFF THE POWER AND STILL RETAIN THE DATA."

PUTTING A NEW SPIN ON ELECTRONICS

One area that Tohoku University researchers are exploring is the emerging field of spintronics. Remarkable advances in artificial intelligence and wireless-network technology are primed to impact fields ranging from wearable health sensors to advanced earthquake detection, but such technologies rely on conventional computers and their voracious appetite for electric power.

Using concepts developed in the 1990s by the university's current president, Hideo Ohno, researchers at Tohoku University have been working on spintronic systems that perform high-speed computations using electron spin instead of charge. Because magnetic systems can store electron spin information without power, this technology promises to achieve substantial energy savings.

"Conventional semiconductor memory devices need electrical power to store information even when they're not being used," says Shunsuke Fukami, a professor at Tohoku University's Research Institute of Electrical Communication. "But with spintronics, we can completely turn off the power and still retain the data."

Fukami specializes in fabricating magnetic thin films and devices uniquely suited to meet the demands of spintronics. One example is his role in developing technology known as probabilistic bits, or p-bits, that tap into the random thermal motions of electron spins to mimic the operations of a quantum computer. By optimizing the device's nanoscale structure, his team accelerated p-bit operations by 100-fold over previous approaches, making it possible to solve complex optimizations with minimal energy demands.

Other achievements by Fukami include the creation of magnetic data-storage devices that use shapes similar to tiny bar magnets to scale down to record-small sizes, and spintronic-based artificial-intelligence applications. "The human brain can do complex computations such as facial recognition with limited power," says Fukami. "That inspired me to investigate the potential of spintronics towards a new era of computing."

UNCOVERING A KEY CANCER-DRIVING MECHANISM

Tohoku University also excels in the life sciences. Through detailed studies of biochemistry and mouse genetics, Hozumi Motohashi, deputy director of Tohoku University's Institute of Development, Aging and Cancer, has elucidated the surprising role of a protein known as NRF2 in cellular processes.

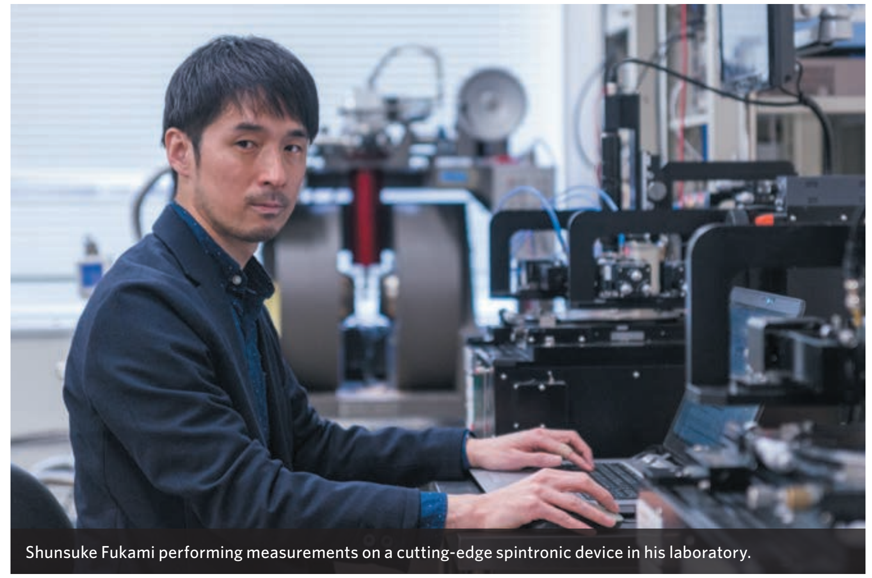
NRF2, a transcription factor that binds to DNA sequences to control the expression of genes, normally protects cells against oxidative stress. But in cancer cells, it can enhance tumorigenesis by driving metabolic reprogramming. In searching for the mechanism that helps cancers exploit NRF2, Motohashi uncovered distinct signaling pathways based on sulfur-containing small molecules known as supersulfides.

"Supersulfides play a key role in mitochondrial energy metabolism," explains Motohashi. "When supersulfide production is defective, reactive oxygen species in mitochondria increase remarkably. Supersulfides have a physiological role as a part of the electron-transport chain, which hadn't been recognized before."

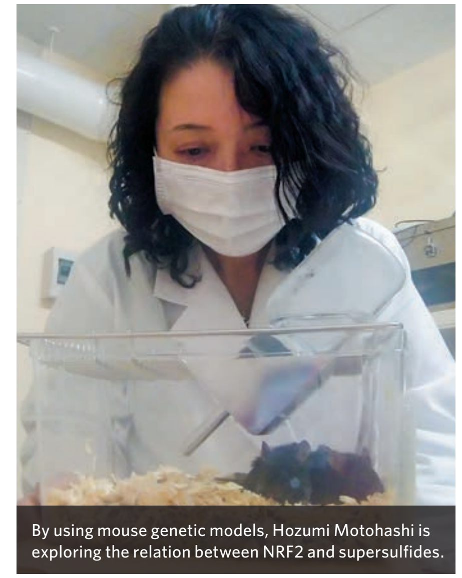
In collaboration with Takaaki Akaike at the Graduate School of Medicine, Motohashi pioneered efforts to study supersulfides using a non-invasive procedure that collects the exhaled breath condensate from humans and mice.

Motohashi was recently tasked by the Japanese government to extend this research towards an urgent purpose — the rapid detection of the COVID-19 virus. "Peptides derived from SARS-CoV2 viral proteins, as well as other metabolites related to viral infection, can be detected in the exhaled breath condensate," says Motohashi. "Unlike conventional tests, this doesn't require direct interactions between patients and medical staff."

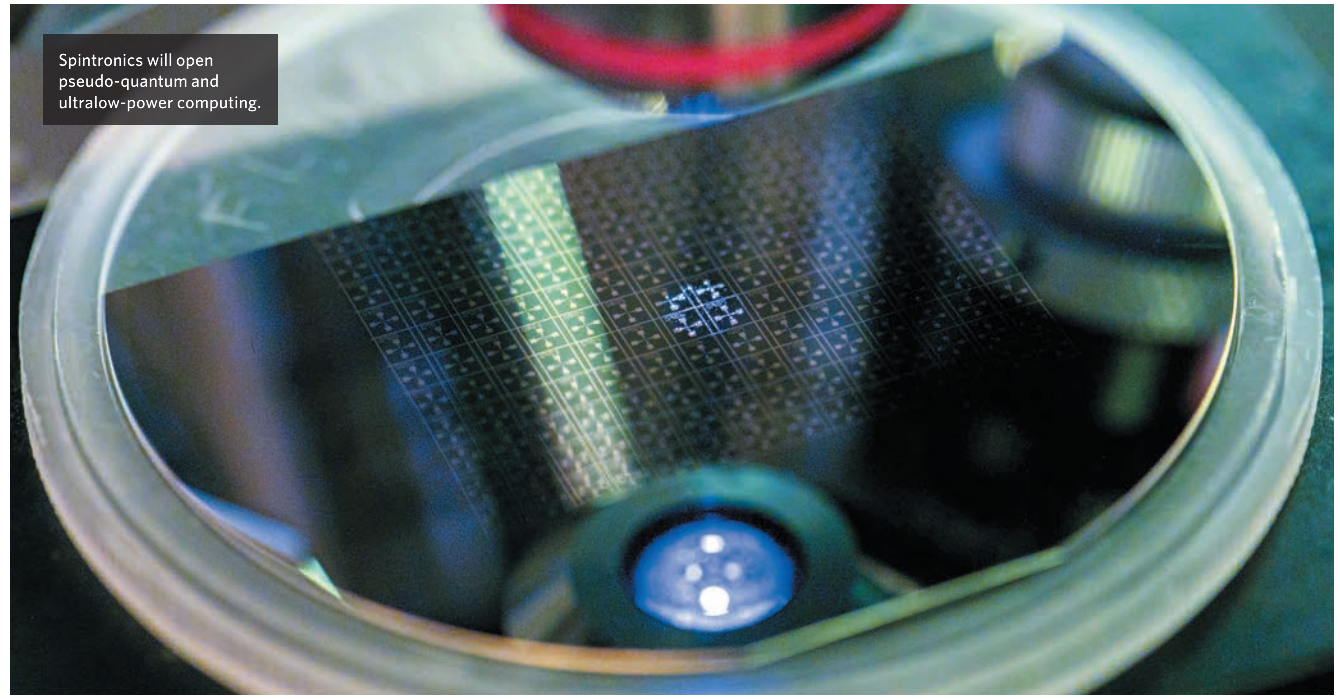
Motohashi is one of many researchers who are thriving because of the university's strong culture of diversity and inclusivity. Since 1913 — when it was the first university in Japan to accept female students — Tohoku University has continued to achieve research excellence through the promotion of gender equality. Tohoku University offers female researchers various forms of support, including financial assistance, to build on the expertise needed to make a difference to the future of the planet. ■



Shunsuke Fukami performing measurements on a cutting-edge spintronic device in his laboratory.



By using mouse genetic models, Hozumi Motohashi is exploring the relation between NRF2 and supersulfides.



Spintronics will open pseudo-quantum and ultralow-power computing.

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