

## Scientific and Technological Achievements that Contribute to Daily Life

In this segment, we describe R&D achievements and topics that are already having an impact on our daily lives or that are expected to in the near future.

- ① Jerseys that Provide a Competitive Edge in World Championships
- ② Optical Mouse: a Technology that Eliminated the Need for Maintenance
- ③ Quantum Computers May Potentially Become Capable of Decrypting Prime Number Encryption
- ④ Geochemical Map of Sea and Land of Japan: Comprehensive Reference for Environmental Risk Assessment
- ⑤ Life-Saving Irrigation Reservoir Flood Alert System
- ⑥ Increasing Cancer Screening Rates Using “Nudges”

## Jerseys that Provide a Competitive Edge in World Championships



2019 Japan national rugby team uniforms  
Uniforms for the front row (left), second / back row (middle) and backs (right) players  
Photo provided by Canterbury of New Zealand Japan Inc.

### (Outline)

- A year before the 1964 Tokyo Olympics, Tsuzawa Knit Fabric Manufacturer in Toyama Prefecture changed its name to GOLDWIN Inc. with the hope of helping Olympians win gold medals by providing them with high-quality athletic wear. In the 1964 Olympics, Japanese athletes wearing GOLDWIN products won 12 gold medals.
- In 2019, Canterbury of New Zealand Japan—part of the GOLDWIN Group—developed jerseys for the Japanese national rugby team designed to help the team perform to the best of its potential in the 2019 Rugby World Cup. The jerseys were an optimal balance of durability and light weight and offered wearers outstanding mobility and comfort. These jerseys were a product of a collaborative Japanese technological effort intended to harmoniously combine Japan's traditional artisanal craftsmanship with cutting-edge technology.
- Canterbury worked on the development of tricot knit<sup>1</sup> fabrics with a manufacturer in Fukui Prefecture for forward player uniforms while simultaneously working on weft knit<sup>2</sup> fabric uniforms for backs players with a manufacturer in Wakayama Prefecture.
- Canterbury also developed Smart Seam technology<sup>3</sup>, a combined use of special tapes, ultrasonic welding<sup>4</sup> and sewing. The use of this technology made the jerseys much more comfortable while also greatly enhancing their ability to withstand impact and intense movement.
- The Japan national rugby team made history in these newly developed jerseys by advancing to the final eight in the Rugby World Cup for the first time.

### (Commentary)

1. Tricot knitting: This technique is used to make the surfaces of knitted fabrics uneven, thereby increasing the thickness of materials without adding weight. This fabric construction is suitable for forward player jerseys that need to be durable and protect players from rough contact.
2. Weft knitting: This technique is used to create stretchable, light fabrics suitable for backs player jerseys, which have to be designed to not limit players' mobility and running performance.
3. Smart Seam technology: This technique is used to join two fabrics together. Ultrasonic welding is first used to bind two fabrics. The joined parts are then reinforced by sewing and adding adhesive tape.
4. Ultrasonic welding: A processing technique used to instantaneously join two fabrics together by heating thermoplastic resin, causing it to melt and fuse to the fabrics. This device applies fine ultrasonic vibration and a small amount of pressure to the resin, generating frictional



Scientific and Technological Achievements that Contribute to Daily Life ②

## Optical Mouse: a Technology that Eliminated the Need for Maintenance

Contributor: Tokyo Institute of Technology

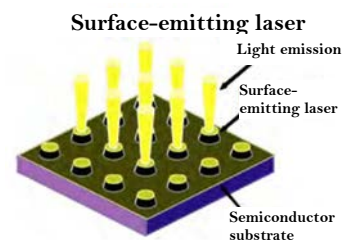


(Outline)

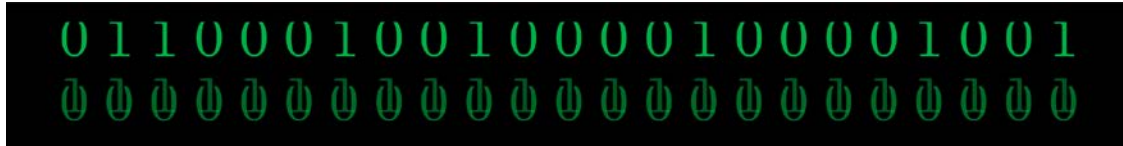
- A mouse is a very common computer hardware device. Most mice used today are optical mice, which can track their movement by emitting light from their bottom surfaces and sensing the reflected light. Their movements are then translated into the movement of the cursor on the computer monitor.
- The most common type of mouse used in the earliest days of mouse history was a ball mouse equipped with a downwardly protruding rollable ball. It was able to track its movement by sensing the rotational movement of the ball.
- Ball mice have inevitable mechanical/structural drawbacks: poor mouse performance caused by slippage of the trackball and the need for regular maintenance (i.e., opening the mouse and removing dust collected inside by the ball).
- In 1977 IGA Kenichi, then Tokyo Institute of Technology Associate Professor (currently Professor Emeritus), devised the concept of a surface-emitting laser<sup>1</sup>. This concept was put into practice in 2001 in the form of the optical mouse capable of detecting its movement using a laser light emitter and an optical sensor on its bottom surface. This new mouse technology resolved the issues associated with ball mice (i.e., slippage of the ball and the need for regular maintenance).

(Commentary)

1. Surface-emitting laser: This technology was conceptualized by IGA Kenichi (Professor Emeritus at the Tokyo Institute of Technology) in 1977 and was put into practice when a surface-emitting laser operable at room temperature was developed in 1988. Unlike other laser diodes, the surface-emitting laser is uniquely designed to amplify the light it emits in the direction perpendicular to the substrate plane, rather than in the parallel direction. In addition, production of surface-emitting lasers does not require performing the cleavage process (splitting crystalline materials along crystallographic structural planes)—a necessary process in producing other types of laser diodes—and they can be arranged in a side-by-side array, making them suitable for mass production at low cost. A total of 1.1 billion surface-emitting lasers have been produced since 2000, including ones used in computer mice.



## Quantum Computers May Potentially Become Capable of Decrypting Prime Number Encryption



Conventional computers use binary digits (1s and 0s) to process information (top row) while quantum computers use quantum bits to achieve this (depicted symbolically in the bottom row).

### (Outline)

- Sensitive information that needs to be transmitted online is normally protected using prime number encryption. A prime number is a natural number greater than 1 that is not a product of two smaller natural numbers. The sequence of prime numbers (i.e., 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, and so on) lacks periodic patterns and is infinite. These characteristics make prime number encryption a very reliable security tool.
- The product of two large prime numbers  $p$  and  $q$  has been used as a public key—a piece of numerical information generated and released to the public by the receiver of a sensitive message and which is used by the sender of the message to encrypt it. The receiver then uses a private key derived from a mathematical formula containing  $p$  and  $q$  to decode the encrypted message. Only the receiver knows the values of  $p$  and  $q$ . The encrypted message is therefore decodable only by the receiver, the sole owner of the private key. However, if a hacker succeeds in correctly prime factoring the public key (i.e., the product  $pq$ ), thereby identifying the values of  $p$  and  $q$ , this person can also determine the value of the private key.
- Determining the two prime numbers,  $p$  and  $q$ , by prime factoring the product  $pq$  is not simple. Their numerical values are huge, ranging from numbers of 300 digits to those of 1,000 digits in length. In addition, the fact that the sequence of prime numbers lacks periodic patterns forces hackers to examine each and every prime number as a potential factor. As such, identifying the values of  $p$  and  $q$  using a conventional computer would be impossibly time-consuming. For example, assuming that prime factors  $p$  and  $q$  are both numbers of 300 digits in length, a conventional computer needs to repeat computation  $10^{306}$  times, making it impossible to find solutions within a realistic timeframe.
- By contrast, quantum computers that use multiple quantum bits<sup>1</sup> are in theory capable of simultaneously processing a vast number of numerals, potentially enabling quick determination of correct prime factors. Quantum computer research has been carried out in many countries. A major challenge is to have multiple quantum bits arranged in a two-dimensional grid that can perform even more complex calculations.

### (Commentary)

1. Quantum bit: Conventional computers process data using binary digits (1s and 0s) or simply bits. A group of eight bits, for example, can represent  $256$  ( $2^8$ ) different values ranging from 00000000 to 11111111. Quantum bits used in quantum computing are in a superposition of both 0 and 1 at the same time until they are measured, at which point their states become definite: either 0 or 1. In other words, quantum computers can process both 0 and 1 at the same time until a quantum bit is measured. Using eight quantum bits, a quantum computer can simultaneously process 256 different values, enabling it to compute much more quickly than conventional computers.

Scientific and Technological Achievements that Contribute to Daily Life ④

Geochemical Map of Sea and Land of Japan:  
Comprehensive Reference for Environmental Risk  
Assessment

Contributor: National Institute of Advanced  
Industrial Science and Technology (AIST)

The website for the Geochemical Map of Sea and Land of Japan has geochemical maps of land and nearshore underwater areas in Japan at the national and local scales. It also displays three-dimensional geochemical maps focusing on four chemical elements: copper, lead, mercury and chromium<sup>1</sup>.

(Outline)

- Contamination of river and nearshore seafloor sediments with heavy metals is a serious concern, especially when they are excavated to build civil infrastructure and other structures. An increasing number of municipalities and private companies are therefore required to conduct preliminary environmental risk assessments to ensure the safety of construction sites.
- To facilitate the assessment of environmental contamination by toxic chemical elements, the AIST Geological Survey of Japan (GSJ) surveyed concentrations of 53 naturally occurring chemical elements—including toxic ones—in river and seafloor sediments across Japan and organized their distributions in the form of visually explicit geochemical maps<sup>1</sup>.
- AIST-GSJ collected about 3,000 river sediment samples and about 5,000 nearshore seafloor sediment samples across Japan, chemically analyzed them and organized the analytical results into geochemical maps. These maps can be used as basic data for a variety of geochemical studies, including analysis of the distribution and movement of chemical elements across land and nearshore seafloor areas, element dispersion processes, environmental contamination and geochemical resource exploration and assessment<sup>1</sup>.
- We are currently creating regional maps containing major cities with a spatial resolution 10 times higher than that of the national maps. High-resolution Kanto region maps have already been released online and high-resolution Chubu region maps were published in January 2020.

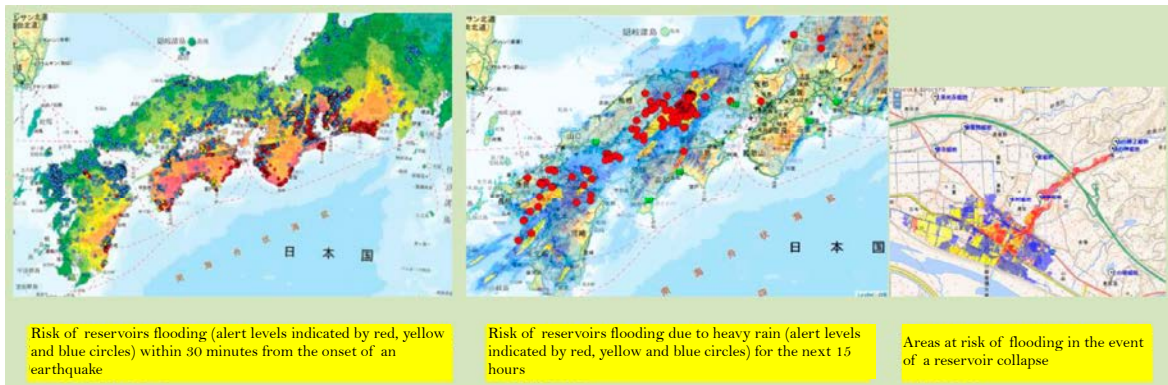
<Reference> AIST-GSJ's Geochemical Map of Sea and Land of Japan website (<https://gbank.gsj.jp/geochemmap/>)

(Commentary)

1. Geochemical Map of Sea and Land of Japan: This website, managed by the AIST-GSJ, exhibits concentration distribution maps of 53 chemical elements and naturally occurring radiation calculated from the potassium, uranium and thorium content of sediment. Sampling in terrestrial areas focused on river sediment while sampling in nearshore waters targeted seafloor sediment at numerous locations across Japan. Sediment samples were then chemically analyzed and the results were organized into geochemical maps.

## Life-Saving Irrigation Reservoir Flood Alert System

Contributors: National Agriculture and Food Research Organization (NARO)  
National Research Institute for Earth Science and Disaster Resilience (NIED)



(Left) Map showing risk of reservoirs collapsing in the event of an earthquake  
(Middle) Map showing risk of reservoirs collapsing in the event of heavy rain  
(Right) Map depicting areas at risk of flooding in the event of a reservoir collapse

### (Outline)

- Japan's approximately 170,000 irrigation reservoirs are important agricultural water sources. However, they occasionally collapse due to massive earthquakes or torrential rainfall, causing severe flooding.
- The Ministry of Agriculture, Forestry and Fisheries (MAFF) operates an irrigation reservoir flood alert system to forecast the risk of reservoirs flooding in the event of an earthquake or heavy rain and provides information on actual local damage, facilitating quick responses by the relevant parties<sup>1</sup>.
- The system classifies the risk of reservoirs flooding into three levels (safe, warning and dangerous) within 30 minutes from the onset of an earthquake and the risk due to heavy rain for the next 15 hours<sup>2, 3</sup>. The system also displays areas at risk of flooding from reservoir collapse<sup>4</sup> on the map.
- These forecasts enable local governments to respond quickly by releasing water from reservoirs and instructing residents to evacuate. In addition, the system allows different levels of government to share information on actual flood damage in real time using smartphones and other communication devices, enabling national and prefectural governments to promptly provide support to local authorities in affected areas<sup>5</sup>.

<Reference> NARO press release entitled "Irrigation reservoir flood alert system"  
([http://www.naro.affrc.go.jp/publicity\\_report/press/laboratory/nire/082685.html](http://www.naro.affrc.go.jp/publicity_report/press/laboratory/nire/082685.html))

### (Commentary)

1. The irrigation reservoir flood alert system was jointly developed in 2018 by NARO, NIED and Core Corporation, among others. MAFF began operating this system in 2020. The national government, municipalities across Japan and irrigation reservoir managers are expected to benefit from this service.
2. NARO and Integrated Geotechnology Institute Limited are jointly developing a system capable of forecasting the risk of irrigation reservoirs collapsing in real time in the event of an earthquake. The system can also perform preliminary assessments of reservoirs' resistance to large-scale earthquakes in preparation for disastrous events.
3. NARO and Osasi Technos Inc. are jointly developing a system capable of forecasting the risk of irrigation reservoirs collapsing in real time in the event of heavy rain. The system can also calculate the maximum water levels at which reservoirs can operate safely even when exposed to heavy rain.
4. NARO and Nita Consultant Co., Ltd. are jointly developing a system capable of predicting areas at risk of flooding from reservoir collapse.
5. NARO is developing smartphone software that can be used to monitor irrigation reservoirs not only during times of emergency but also for daily management.

Scientific and Technological Achievements that Contribute to Daily Life ⑥

**Increasing Cancer Screening Rates Using “Nudges”**

Contributors: Ministry of Health, Labour and Welfare (MHLW)  
National Cancer Center Japan (NCC)



Left: Leaflet encouraging adults to be screened for five major types of cancer

The title highlights the benefits of early cancer detection while the main text helps readers identify the screening tests most relevant to them, inspiring them to read further.

Right: Flier encouraging local residents to be screened for lung, stomach and large intestinal cancer together

It's designed to alert readers to the benefits of applying for a combination of three screening tests together instead of applying for individual tests separately.

(Outline)

- Half of the Japanese population develops cancer and one third dies from it. Cancer mortality can be reduced by encouraging more people to be screened for cancer. The MHLW has therefore been working to increase Japan's cancer screening rate to more than 50%. One approach the Ministry is taking is the use of “nudges.”
- Nudging is a technique used to non-forcibly guide people to behave in a certain desirable way by taking their habitual, conditioned decision-making behavior into account<sup>1</sup>.
- NCC has been conducting the Rainbow of *Kibou* (hope) Project in collaboration with the MHLW's Cancer Screening Study Group. The project members are researching ways in which behavioral science, nudges and social marketing can be applied to promote cancer screening and education. According to questionnaire surveys conducted among cancer patients, about 50% of them answered yes to the question, “will you have surgery to treat cancer?” after being informed that postoperative mortality is 10%. By comparison, about 80% answered yes to the same question after being informed that the postoperative survival rate is 90%. This example illustrates that more positive phrasing (a nudge) tends to be more successful in encouraging people to take action than more negative phrasing. The leaflet encouraging adults to be screened for five major types of cancer (photo on the left) is entitled, “More than 90% of cancer cases are curable if detected early”—an example of a nudge, or positive reinforcement. We develop various materials (e.g., leaflets, postcards and envelopes) using nudges and other techniques in the hope of effectively promoting 15 types of cancer screening tests. These materials are available for free as downloadable electronic files at the URL below.

<References> Research on ways in which behavioral science, nudges and social marketing can be applied to promote cancer screening and education

<http://rokproject.jp/kenshin/>

[https://www.ncc.go.jp/jp/cpub/division/public\\_health\\_policy/project/project\\_05/project\\_05.pdf](https://www.ncc.go.jp/jp/cpub/division/public_health_policy/project/project_05/project_05.pdf)

(Commentary)

1. Nudge theory: The word nudge generally means to try to get someone's attention by touching their elbow. In behavioral economics and behavioral science, it means using positive reinforcement and indirect suggestion to influence the behavior and decision making of individuals. The nudge theory originated from behavioral economics—the study of human behavior from psychological and economic perspectives—under the assumption that human behavior is conditioned and biased by various factors. Nudges are widely used. For example, footstep markings are pasted on the floors of convenience stores to guide customers to wait in line before being served by a cashier and a note is posted in the bathroom that reads “Thank you for keeping the toilet clean,” to encourage good manners. Nudges are indirect suggestions used to guide targeted individuals to behave in a certain way. The nudge concept was popularized by University of Chicago Professor and behavioral economist Richard Thaler—a winner of the 2017 Nobel Memorial Prize in Economic Sciences—among others. This recent recognition has brought renewed attention to the nudge technique.