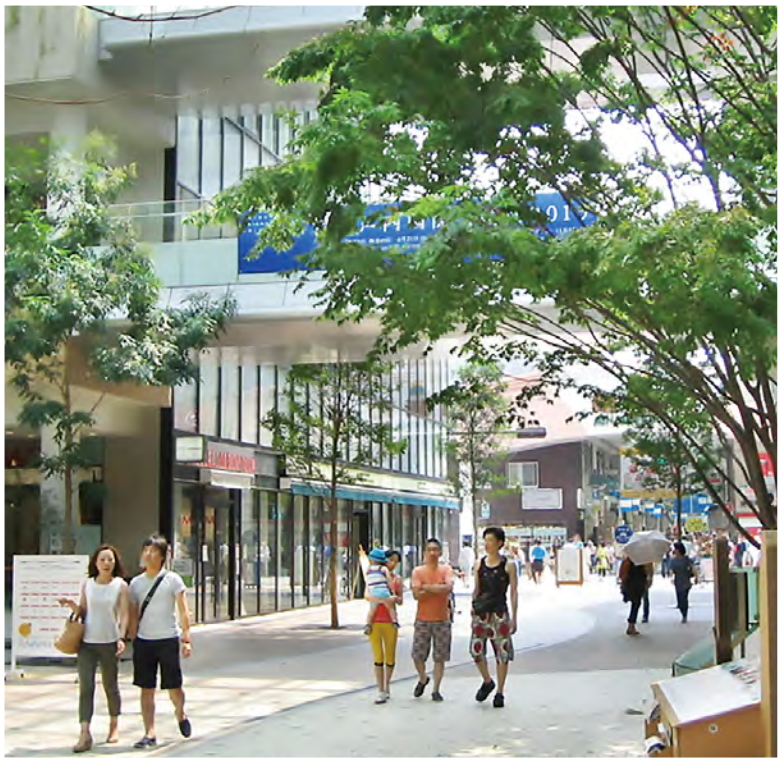
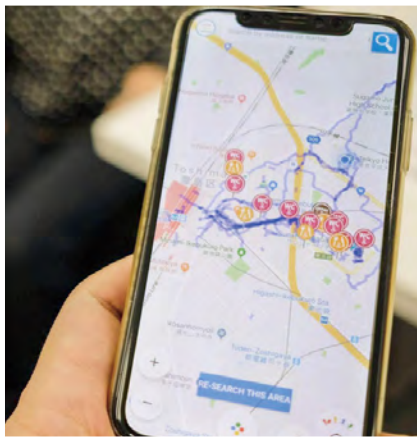
SDGs Special Issue | 2021

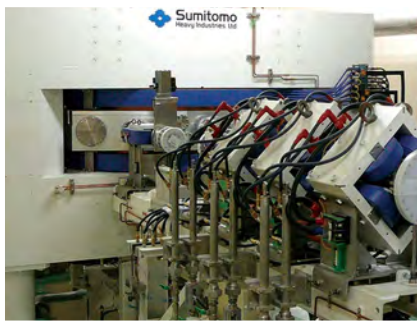
# Science Window

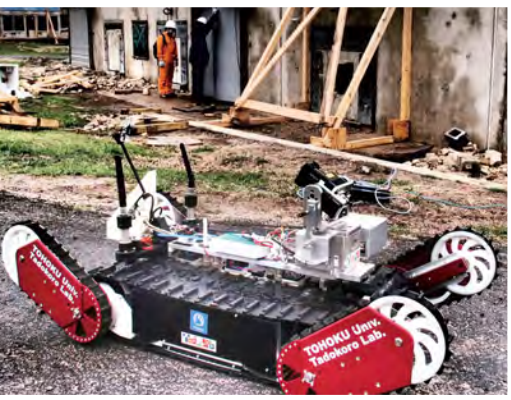
## Creating the Future with Heart and Technology

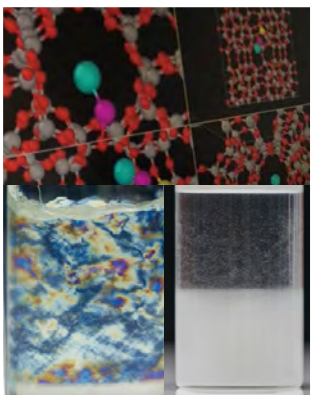


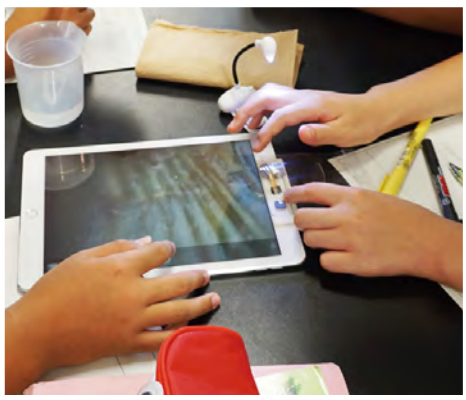








JST | SUSTAINABLE DEVELOPMENT GOALS

# Creating the Future with Heart and Technology

A new daily life driven by the Covid-19 pandemic: While experiencing many hardships, you may have more often thought again about “what a better society is,” “what a sustainable society is,” and “what happiness is.”

The UN General Assembly adopted the “Sustainable Development Goals (SDGs)” on September 25, 2015. How can we collaborate to realize a “sustainable society” by the 2030 deadline for achieving the goals while dealing with the problems of the new coronavirus?

SDGs hold “no one should be left behind” as the basic principle. Science and technology is supposedly one of the most crucial implementation tools for achieving the SDGs. What is the society we should aim for like? And what science and technology is necessary there?

The SDGs Special Issue 2021 introduces science and technology leaders’ future visions and initiatives, following 2020. Let’s think together about a “sustainable society” and its realization.

## What is Science Window?

We are surrounded by science and technology. Many innovations help us make our lives easier or our days more fulfilling. A lot of hope is placed on the development of science and technology. We are aiming for a better future through science and technology. As a first step, we have established Science Window, an online magazine full of fun information designed to be as accessible as possible.

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SDGs Special Issue 2021



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Marugame Shopping Street in Takamatsu-City, Kagawa Prefecture, aiming for economic circulation within the region (Provided by Yoshinori Hiroi)

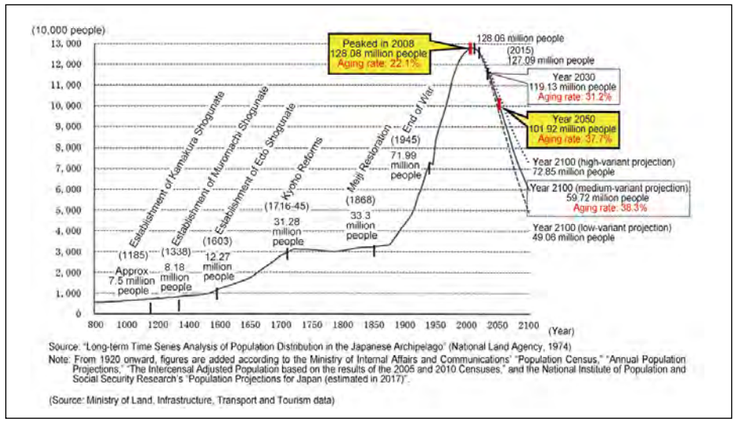
CHAPTER 01

# The Key to Happy Life Lies in Sustainable Welfare Society

《Interview with Yoshinori Hiroi》

We moved forward in the expanding population and wealth era, focusing on economics and efficiency. However, the current shrinking population and drastic changes in society and the environment are shifting us from the age where we all work together to climb a single path to the one where each of us can freely exercise our creativity. Yoshinori Hiroi, Professor at Kyoto University's Kokoro Research Center, says that in the coming era, it will be more important than ever to raise the level of happiness of each individual and that the key to achieving this is a decentralized "sustainable welfare society."

**Long-Term Trends of Japan's Total Population**




Source: "Long-term Time Series Analysis of Population Distribution in the Japanese Archipelago" (National Land Agency, 1974)
Note: From 1920 onward, figures are added according to the Ministry of Internal Affairs and Communications' "Population Census," "Annual Population Projections," "The Intercensal Adjusted Population based on the results of the 2005 and 2010 Censuses," and the National Institute of Population and Social Security Research's "Population Projections for Japan (estimated in 2017)".
(Source: Ministry of Land, Infrastructure, Transport and Tourism data)

Long-term trends of Japan's total population (Provided by Yoshinori Hiroi and translated by JST)

## The issue in this era of the declining population is "distribution" of wealth rather than "expansion" of it

Japan's population continued to grow since the Meiji era (1868-1912), reaching 128.08 million in 2008. However, after 2011, Japan entered an entirely declining population society, expected to continue.

"Japan's birthrate in 2019 was 1.36. If this level continues, anticipated Japan's population will be below 100 million after 2050. The rapid increase in unmarried and late married persons against the backdrop of unstable living conditions and employment is a factor of the declining birthrate. The spread of life insecurity and poverty, especially among the younger generation, is a serious issue, and there is an urgent need to support the younger generation," Hiroi points out.

In times like the high economic growth period, when population and economy expanded rapidly, each individual's share increased as the overall "pie" grew. Hence, the need to think about wealth distribution was not so great. However, wealth distribution becomes more important than wealth expansion in an era of a declining population.

## Wide disparity makes lower environmental performance

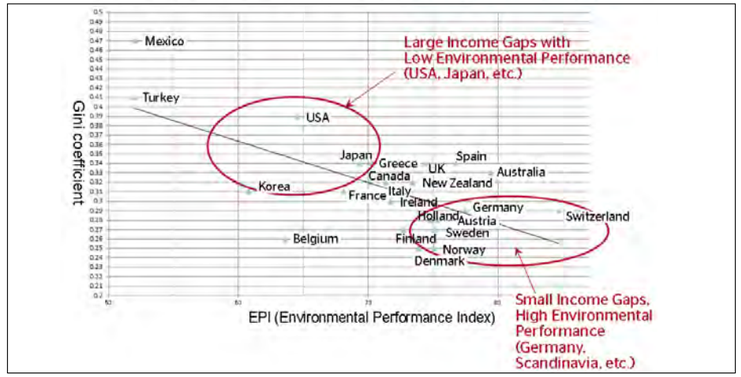
In response to these rapid social changes, the theme of "well-being" is now particularly attracting attention.

In the 2020 World Happiness Report released by the United Nations, Japan ranked 62nd. Although differences in national character and other factors exist, Japan ranked low in freedom of life choices, social support, and tolerance. The Nordic countries dominated the top spots.

Interestingly, there was a correlation between countries that the wider income disparity (Gini coefficient), the poorer environmental performance (*1). The USA is a typical example of a country with high inequality and low environmental performance, and Japan is in the same group if broadly classified. On the other hand, countries like Germany and Scandinavia have small disparities and good environmental performance.

"Sustainability is deeply related to the environment, and distribution and disparity are much to do with welfare. From the perspective of human well-being, we need to keep both in mind and aim for a 'sustainable welfare society' that can long survive with finite resources while ensuring individual livelihood security and fair distribution," says Hiroi.

**Sustainable Welfare Society Indicators**




Note: Gini coefficient is for 2011 (OECD data). EPI stands for Environmental Performance Index, which was established by the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network at Columbia University, to quantify and numerically mark environmental performance of state policies. (Source: Yoshinori Hiroi, *Postcapitalism*, 2015)
(Provided by Yoshinori Hiroi)

## Decentralized society predicted by AI

Hiroi, in collaboration with Hitachi Kyoto University Laboratory, set the question "Will Japan be sustainable in 2050?" They then predicted future scenarios from AI simulations based on approximately 150 social factors such as population, aging, and gross domestic product (GDP).

"The simulation results show that when considering the biggest juncture for the future of Japanese society is whether urban-intensive or decentralized, the latter is superior in terms of population and regional sustainability, health, happiness, and disparity. They also show the branching between the urban-intensive and decentralized scenarios will occur between 2025 and 2027, and the two scenarios will never intersect after that. In other words, we are getting close to the juncture of whether or not Japan will be able to realize a sustainable welfare society," says Hiroi.

Although we had never imagined in 2017 when these results were announced, the new coronavirus pandemic in 2020 ended up exposing the negative effects of the urban-intensive system, just as AI showed.

Hiroi was surprised at the coincidence between the AI results and the evils of overcrowded cities revealed by the covid-19. He is currently working on simulations of post-corona society in collaboration with Hitachi, Ltd., and others. He believes that cooperation with people of the humanities and social sciences who are good at pointing out social issues and the sciences and engineering who have various tools for solutions is essential for solving social problems.

## Multi-polar concentration is the most desirable form

Hiroi says that the new coronavirus epidemic has brought the vulnerability of

*1: "Environmental performance" is an index that analyses and quantifies the performance of environmental policies and environmental sustainability by governments and the private sector worldwide from various items.

Erlangen (population approx 100,000) (Provided by Yoshinori Hiroi)

In front of the station in Himeji-city: a "transit mall" just for pedestrians and public transportation is being promoted (Provided by Yoshinori Hiroi)

urban-intensive society to the light of day. What is necessary to realize a sustainable welfare society in the post-corona era, then?

"In the future society, the axis will shift from concentration to decentralization. It has two meanings. One is to achieve decentralization and avoid the adverse effects of excessive urban concentration. However, excessive decentralization makes too many low-density and unlivable towns in this depopulating society. Therefore, the most desirable form would be 'multi-polar concentration,' in which many concentrated cities exist to be the respective region's 'poles'," says Hiroi.

Hiroi cites the cities of Germany as a model for multi-polar concentration. In Germany, even cities of 50,000 or 10,000 people bustle with activity in the center, which becomes a space everyone can walk around and enjoy.

In Japan, regional cities with less than 200,000 people are hollowing out in most cases, and many of the central areas have turned into so-called ghost towns. However, there is a silver lining even in Japan. Takamatsu-city in Kagawa Prefecture and Himeji-city in Hyogo Prefecture are typical examples.

"Another meaning of what we call 'from concentration to decentralization' is the decentralization of life itself. The times of population growth represented by the Showa era were when 'people climbed a single path in groups.' However, people will design their way of living and working more freely than before taking advantage of telework in the future: the age when life design is decentralized. Increased degree of freedom in life choices will also lead to happiness," says Hiroi.

## From Local to Global

"In recent years, the younger generation is becoming more and more local-oriented. There is hope that we can move to a decentralized society if we can successfully shift our policies," Hiroi has expectations for the future. He cites the Ishitoro district in Gifu Prefecture as a model case for regional revitalization in Japan. In this district, young people who have made U-turns or I-turns are engaged in local revitalization activities centered on small-scale hydroelectric power generation. A few years ago, they achieved complete energy self-sufficiency and now supply energy to other regions.

The new coronavirus has shown adverse effects of excessive globalization, and localization is attracting renewed attention. Bottom-up development will become increasingly important from now on, starting from the local level and building up to the national and global levels.

## Transition to the Life Covid-19 Symbolizes

Since the scientific revolution in the 17th century, the science concept has shifted from substances to energy and then to information. Now that the information society is reaching a mature stage, what will be the next concept of the science axis?

Small-scale hydroelectric power generation in the Ishitoro district, Gifu Prefecture (Provided by Yoshinori Hiroi)

"In the future, it will shift to life. The concept of life here includes life science and life and ecosystems. Infectious diseases are also life-related issues, and I think this coronavirus pandemic is a symbolic event," says Hiroi.

Kurzweil, an American futurist, predicted that humans would eventually transcend life because life reduces to information. However, Hiroi points out that this "informational life view" ignores life's emergent or internal nature.

"Life is nothing but the accumulation of information. By pushing the informational life view to its limit, humans may transcend their physical limitations in a sense, but would it be a sustainable and happy future? In the future, people's attention will turn to life itself, and the concept of science will also shift," says Hiroi.

The shift from information to life will also impact the industrial structure. Life-related industries, specifically health and medical care, environment, livelihood and welfare, agriculture, and culture, will become more crucial than ever. Further, it is worth mentioning that these areas are local and small-scale. A society that places life at the center of its values is also a concept that will become the cornerstone to realize the localization and decentralized societies introduced earlier.

## Find what you care for and pursue it!

At the end of the interview, we asked Hiroi to message young people who will be the world's future leaders.

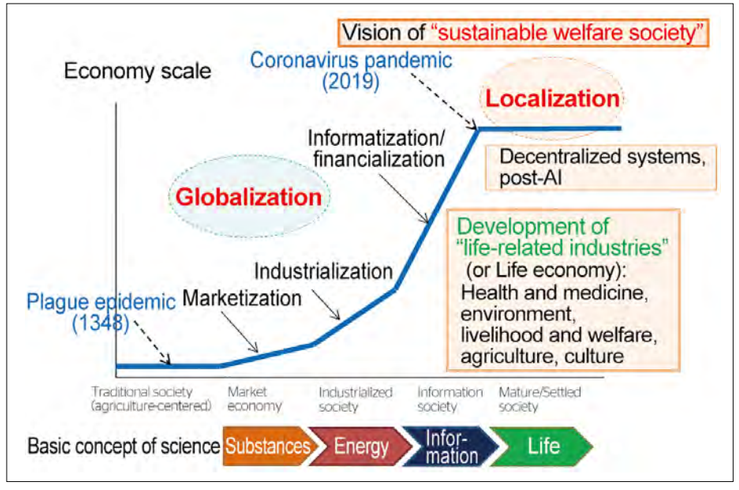
"I would like you to find what you care for or what you want to do and then pursue it. We are no longer in the era when we move toward a single goal. I think it is important for both society and individual happiness that each of us designs our own life and follow our respective paths," said Hiroi.

He also stressed the importance of thinking from a long-term perspective.

It is said that the human race has undergone three cycles of expanding growth and stabilization (making it sustainable) in history. The first was the hunting period, followed by the agricultural period that began about 10,000 years ago, and finally, the industrialization period that started nearly 300 years ago. Each transition period from expanding growth to stabilization was marked by significant cultural innovations, such as the appearance of the Lascaux Cave Paintings and Jomon pottery and the emergence of thoughts such as Buddhism and Greek philosophy.

Human beings faced with sustainability issues shifted from material to spiritual and cultural development. Now that we are in the third transition period in human history, we can see the groundwork laid for truly abundant spiritual growth. What cultural innovation will occur to create the future society rests on our shoulders.

**Evolution of Economic Systems and Coronavirus Pandemic**




(Prepared by the editorial staff based on materials provided by Yoshinori Hiroi)

## PROFILE

**HIROI Yoshinori**

***Professor at Kyoto University's Kokoro Research Center***

*Completed a master's degree at the University of Tokyo. He worked for the Ministry of Health and Welfare and then as a professor at the Faculty of Law and Economics, Chiba University, before assuming his current position in 2016.*
*Specializes in public policy and philosophy of science; he conducts a wide range of research, from policy studies on social security, cities, and local areas to views of life and death.*

Code for Japan connects the government and citizens (Provided by Haruyuki Seki)

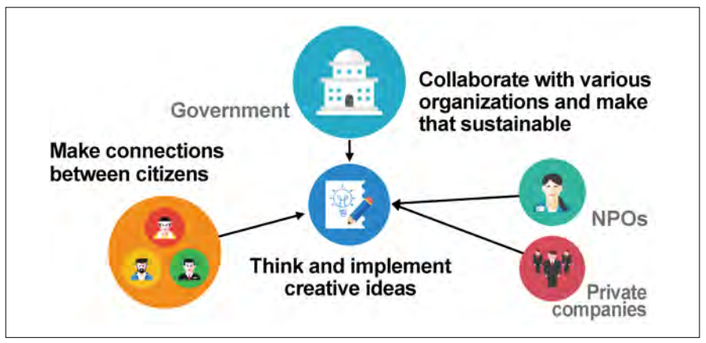
CHAPTER 02

# Think Together, Create Together; Resolving Local Issues through IT and Civic Community

《Interview with Haruyuki Seki》

The spread of new coronavirus infections has made us more aware of the need for digitalization. Against this backdrop, you can't overlook the "Civic Tech" movement, in which citizens use technology to solve local problems spontaneously. One of Japan's Civic Tech pioneers is Haruyuki Seki, Representative Director of Code for Japan. We asked him how to solve problems by using the power of technology and civic communities and about the future potentiality of Civic Tech.

**What is Civic Tech?**



(Original Japanese image was provided by Haruyuki Seki and translated by JST)

## Organization launched in response to the earthquake

Civic Tech is a coined word combining "civic" and "technology." It refers to "citizens taking initiatives in using technology to solve local issues." Until now, it was mainly local governments solving regional issues. However, citizens' voluntary efforts, connections among residents, and cooperation with various organizations will supposedly be needed to solve all problems.

Seki was initially an engineer involved in system development. The Great East Japan Earthquake of 2011 triggered him to start Civic Tech activities. Immediately after the quake, he and his colleagues launched "sinsai.info," a website that collects disaster information and displays it on a map, and managed the site recruiting engineers through SNS. Having seen the potential in the project based on people's voluntary cooperation, he became interested in Code for America, which creates communities in regions to conduct Civic Tech activities, and launched Code for Japan in 2013 to do the same in Japan.

The organization places importance on creating a "think together and create together" environment. They prepare places where people from different backgrounds, such as government, citizens, private companies, and researchers, can exchange opinions and work together across barriers. It is an image of a "translator" that facilitates communication among various groups and people.

## Building trust is more important than technology

In the first seven years since the establishment, Code for Japan repeated trial and error. Especially in the beginning, when the concept of "Civic Tech" was unknown, he did not make himself understood no matter how much he explained.

"Moreover, at that time, I was technology-biased and tried to look for issues that technology would solve."

Seki admits that he did not have a good grasp of the issues respective regions were facing then. Now that he has visited them in person, made communications, and has taken time to understand the local issues, he stresses the importance of building trust.

"I believe that trust is the foundation of innovation. Unless you repeat errors, you won't create anything new. Therefore, it's essential to have a solid relationship of trust where people can tell each other that it's okay to fail," says Seki.

## Projects launched in the wake of the new coronavirus

We introduce three projects in which the organization has engaged.

### (1) "COVID-19 Information Website" (Tokyo Metropolitan Government)

The organization developed this website on behalf of the Tokyo Metropolitan Government, released in March 2020. Many engineers and designers cooperated in creating and improving the site, which shows data such as the number of people tested and the number of patients in an easy-to-understand manner. The site's source codes are open to the public so that anyone can freely develop applications. Governments other than Tokyo and volunteers use them in more than 60 regions.

### (2) "Ouchi de Jikanwari" (Study at Home)

With all educational institutions closed, many children needed to take classes online or study at home. In response, the development of "Ouchi de Jikanwari," an online tool that allows teachers to share time schedules and homework assignments with students' families in an easy way, was developed. It is a service designed by volunteers who gathered at the Code for Japan's online development event, "Social Hack Day," officially released in October 2020.

### (3) "OPEN EATS JAPAN"

Following the fact that many restaurants came under pressure to close or


New coronavirus infection countermeasure website (Established by the Tokyo Metropolitan Government)

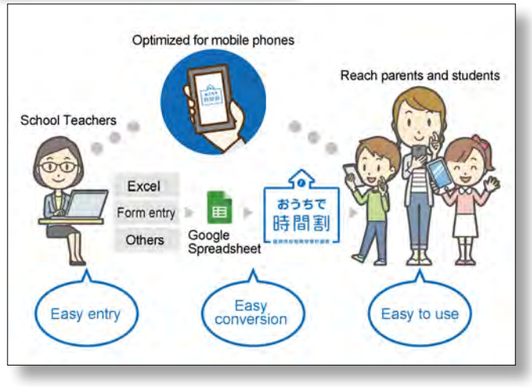


Image of "Ouchi de Jikanwari" (Provided by Haruyuki Seki and translated by JST)

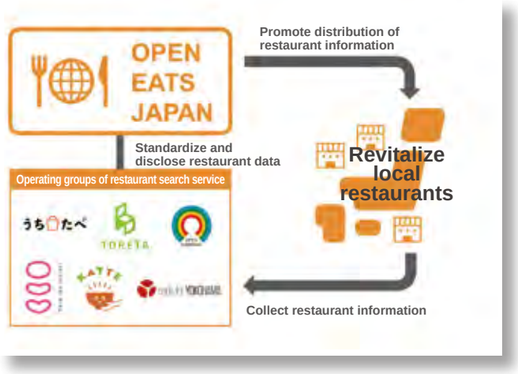
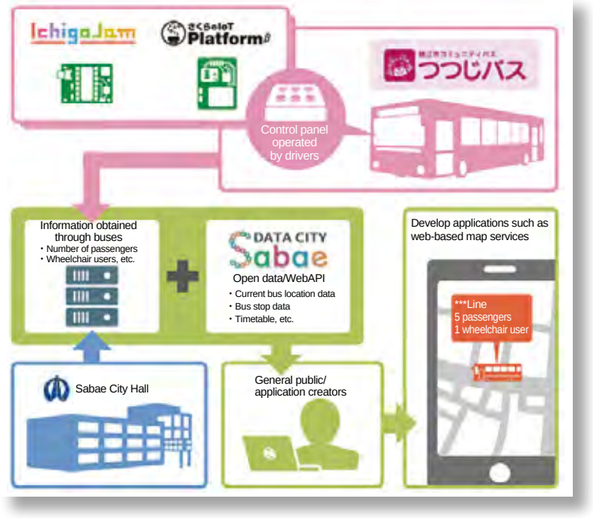



Image of "OPEN EATS JAPAN"
(Provided by Haruyuki Seki and translated by JST)




Tsutsuji Bus Operation App developed in the project
(Provided by Haruyuki Seki and translated by JST)

shorten operation hours, a project started in various locations to support restaurants that offer take-out and delivery services by making their information public. Code for Japan cooperated with private companies and local Civic Tech groups with information on restaurants to sustain this activity, making it possible to share the restaurant data collected in each area with various applications and services. The organization plans to release the data as open data (*1).

## "Local Field Lab" — Sending Corporate People to Local Governments

Seki and his team are also working to disclose and promote efficiency in governmental administration through digitalization. The Local Field Lab (*2) is a project in which private companies send their employees to local governments. Those dispatched work once or twice a week for three months in the host municipality. By working in the local government, the people from private companies can become familiar with the situation within the municipality, and regional issues, which leads to collaboration between the public and private sectors, creating some collaborative projects in real terms.

For example, Sabae-city in Fukui Prefecture has been receiving human resources from private companies since 2014. To date, the project has produced results in developing a childcare support app and a bus operation app, creating open data to support people with disabilities, and establishing a reservation system for specific medical examinations using electronic application services. This project also led to a joint research agreement with a venture company.

## Things citizens can do amid digitalization

In December 2019, the Act on Promotion of Digital Administration became effective, and new moves toward digitalization, such as the establishment of the Digital Agency, are accelerating.

"There has never been a better time for the collaboration between government and IT to be in the spotlight than now. I think it is a chance for change that will never come again," said Seki.

To make Civic Tech happen, the cooperation of citizens is indispensable. However, on hearing the word "Civic tech," some people may become hesitant, thinking you need to be familiar with IT and data to participate. Is there anything that citizens unfamiliar with technology can do? According to Seki, "Just like in the private sector, people in various positions such as sales, planning, and accounting are needed. Please feel free to participate." All you have to do is use your abilities to benefit the local community.

What sort of local issues that need solving are there, then? Seki says, "Each region has very different issues, and I would like each of them to think on their own (from the standpoint of the premise of Civic Tech)," before mentioning possible issues related to disaster prevention.

"For example, I think that hazard map information should be shared among local governments. Information on areas where many people are likely to miss their chance to escape in the event of a disaster is also important, but sharing the information is not progressing. Japan is a disaster-ridden country. We need to make sure that such data is well maintained."

*1: Data that can be freely reproduced, processed, and distributed by anyone within the allowed rules.
*2: Canceled due to the new coronavirus infection in fiscal 2020.

## Creating an environment that encourages the spread of Civic Tech

Promoting Civic Tech also needs to have an environment that facilitates its spread. For example, Code for Japan created a position of STO (Social Technology Officer) (*3) to connect technical people with NPOs (non-profit organizations).

"Many NPOs have been working on local issues for many years. Still, not all of them are good at using technology. If we can support NPOs by creating human resources and positions like STO, they will become more and more active, leading to solutions to local issues," says Seki.

Seki also points out the importance of the digitalization of governmental administration. For example, if citizens can freely send their opinions from their smartphones, their authentic voices will be conveyed to the government, possibly improving the relationship between the government and citizens. In addition, government operations need to be digitalized first to use open data actively.

"Although the use of open data is essential, the reality is that we have to create data from paper documents to share such data because daily operations have not been digitalized. The digitalization of the operations progresses will automatically lead to data release, and the data value will also be understood."

Seki is also a Digital Transformation (DX) Fellow of the Tokyo Metropolitan Government and an Executive Advisor to the Government CIO (Chief Information Officer) (*4). His activities that go back and forth between government and citizens will create a solid foundation for Civic Tech.

Members of Code for Japan with Audrey Tan, Digital Minister of Taiwan (front row, center), and Seki (right) (Provided by Haruyuki Seki)

## A "DIY City" Created by Local Residents

Seki's future vision is a city built by its residents with their own hands. While utilizing technology, the main focus remains on the residents and communities. He calls this a "DIY city." A typical example of this is Taiwan.

Taiwan has a system where citizens can post their opinions to the government, and if there is more than a certain number of supports, the legislature will consider them. In addition, each ministry has positions to encourage citizens' participation — a system put in place on the assumption that citizens will participate.

"I hope that more people will spontaneously get involved in community activities outside of work as a member of a city. It would be great if the act to use ones' skills to contribute to society could be a matter of course," says Seki.

*3: A position that maximizes the effectiveness of collaboration while using technology, IT, and management skills at NPOs working on solving social issues: A new post created by Code for Japan.
*4: A position that heads Information Systems and IT departments

## PROFILE


**SEKI Haruyuki**

***Representative Director of Code for Japan, a general incorporated association***

*With a motto of "using technology to make communities more livable," he actively works in various communities beyond the boundaries of companies. He promotes Japan's "Civic Tech," technology use involving citizens. He is also CEO of Georepublic Japan, a company that develops systems using open source GIS, and President of HackCamp, which helps corporates with open innovation. In addition, he advances start-up support policies of local governments and the use of open data as a part-time Chief Innovation Officer of Kobe-city and a Digital Transformation Fellow of the Tokyo Metropolitan Government. From November 2020 onward, he served as an Executive Advisor to the Government CIO, National Strategy Office of Information and Communication Technology (IT), Cabinet Secretariat.*


Non-disabled People Also Try Out the Wheelchairs during a City-walk Event

(Provided by WheeLog)

CHAPTER 03

# Making the Most Heartwarming Map in the World

《Interview with Yuriko Oda》

'STI for SDGs' Awards 2020 "MEXT Minister Award"

The 'STI for SDGs' Award is JST's framework to recognize remarkable local attempts in resolving social issues through science, technology, and innovation (STI). JST created this award to achieve sustainable development goals (SDGs) by encouraging horizontal expansion to other regions. For the second round of this competition in FY2020, the team behind the smartphone map application "WheeLog!" won the MEXT (Ministry of Education, Culture, Sports, Science and Technology) Minister's Award. Wheelchair users can use this app to add and share information on a map — things they noticed while visiting local facilities or moving around cities. We interviewed Yuriko Oda, the app's creator and CEO of WheeLog (a general incorporated association in Chiyoda-Ward, Tokyo) about the development process, the current state of barrier-free access in Japan, and her organization's future goals.

## 70 percent of app users are non-disabled

"There is a long slope angled at about 15 degrees, please be careful," "the hotel has an accessible room," "the restaurant has wheelchair seating, and the staff is accustomed to handling wheelchairs." Once you click the icon on the map displayed through the WheeLog! app, comments and photos from various locations will be displayed on your smartphone screen. Interestingly, it is not just wheelchair users who are commenting. In fact, 70% of app users are able-bodied people who do not use wheelchairs. Since the comments also show the writer's physical condition, readers can interpret the information in light of their own physical condition.

Oda says, "I feel that there are many people who are happy to give a hand if it will help others." This friendly map, created by the cooperation of many people,

Small things you notice in the city can be shared with other users through the map application "WheeLog!" (Provided by WheeLog)





At some beaches you can enjoy the ocean on a wheelchair — Oda and her son (Provided by WheeLog)

further utilizes the GPS function to record the actual route taken by the wheelchair as a "travel log." The app's public forum function allows users to interact with each other. Moreover, visualization of barriers provides an opportunity to further improve the cities.

## Accessibility information expands world for wheelchair users

Around the age of 20, Oda started to feel physical changes, like stumbling easily. Two years later, in 2002, she was diagnosed with distal myopathy. This is a rare disease where muscles in limbs situated far from the body core become atrophied, which afflicts several hundred people in Japan. "I won't be able to go anywhere," she thought. She became a wheelchair user and tended to stay in. But after giving birth in 2006, she wanted to be able to go out more with her child.

One day, she saw an internet post by a wheelchair user who traveled to the beach resort in Oarai, a barrier-free area, and enjoyed family time there. When Oda read this, she thought she too would be able to go to a seaside with her child. Then, using the information, she found a place that suited her body condition and enjoyed a day with her child at the beach. With barrier-free accessibility information, wheelchair users can also go out and their world will change — she was convinced.

Based on this experience, the first thing Oda started was her YouTube channel "Wheelchair Walker." In this, Oda shows viewers firststand that people in wheelchairs can also enjoy traveling in Japan and abroad. The channel currently has over 10,000 subscribers, and while she felt a positive response from her audience, she wanted more than to spread information in outgoing one-way videos — she hoped for a more interactive exchange. To seek advice, she contacted Associate Professor Fumihito Ito at Shimane University who studies support for people with disabilities. They were acquainted through research group meetings at the Ministry of Health, Labor and Welfare.

Every user should be able to share information, post photos including latitude and longitude information, and post comments — the pilot version of WheeLog! was developed based on Oda's idea to which Assoc. Prof. Ito set the specifications. This was also the period in Japan when the restaurant information-sharing app "Tabelog" became popular. Oda's idea was to create a platform that could share various facts about and awareness of cities by utilizing the power of digital tools. Development of the application took place with the cooperation from specialists in the field.

"Let's try applying for the Google Impact Challenge," came the suggestion from Ito. The "Google Impact Challenge" is a competition that seeks to solve social problems using various technologies. At the time, specifications for the WheeLog! app were just about finalized, but it would cost tens of millions of yen to actually bring it to fruition. The team won the Grand Prix in 2015 and was then able to raise the cost for development. "The judges felt the potential in us, even though we had no track record." Thus, the path to making the app a reality was paved.

## To be a more convenient app

At present, 38,000 locations are covered worldwide on WheeLog!, and the app's travel log has reached 7,500 kilometers. However, Oda and her team's drive to make it more user-friendly is inexhaustible. New ideas come up one after the other — to make the app multilingual, or to prepare a web version that can be used with a mouse rather than limiting access to smartphone apps which can be complicated for people with limited hand mobility. Accordingly, such ideas require R&D funds. In order to cope with this, the organization is also devising ways to utilize crowdfunding and to enter into domestic and overseas competitions to win awards. They have also come up with plans to find sponsors and to solicit small donations so that it can continue with what it has now.

WheeLog participates in numerous domestic and international competitions, including this one held in Dubai. (Provided by WheeLog)

Along with updates, the team is also working to make the app more popular and to accumulate more information. One such attempt is the city-walk event. Under Covid-19 restrictions, the organization limits the number of participants to just a few people. According to Oda, these events provide opportunities to "test-drive and play with wheelchairs."

The idea of playing with a wheelchair may sound improper, but there are many able-bodied people who have wanted to try navigating in wheelchairs. By having participants personally experience mobility in a wheelchair, we can expand its circle of friends and supporters. By venturing out into the city in a wheelchair, you become aware that an unnoticeable step only a few centimeters high can become a barrier. You will learn how to look at a city from a completely different perspective.

## Visualization may change cities

Recently, local governments in Japan have begun collecting accessibility information — for instance, on toilets in the city — and making that information freely available to the general public. While there is usable data for the WheeLog! app, Oda, an actual wheelchair user herself, often thinks that it would be more helpful if there were additional information. Having a photo of the specific spot is very important, for instance. By actually looking at the pictures, you can make a concrete judgment on whether you can use the facility or not. She wants to collaborate with local governments that are forward-looking about barrier-free accessibility, and to create a form in which each and everyone can help as much as they can.


Together with city-walk event participants (Provided by WheeLog)

Through the development of this app, Oda has also noticed a few things. Some facilities are trying very hard to adopt barrier-free accessibility but may not be good at public relations. Despite their efforts, there have been noticeable complaints that those facilities are simply not easy to use. "I hope that the WheeLog! app can help evaluate those who are working hard to enable better accessibility," says Oda. She also hopes that tourist sites highly evaluated by wheelchair users will have an influence over the accessibility of sites in other regions.

"I thought that accessibility would improve more with apps like WheeLog!, but things aren't that easy," Oda added. There are cases where the effectiveness of barrier-free can be demonstrated by national and local governments setting rules on what form of barrier-free is best.

A braille block with spaces for wheelchair tires (Provided by WheeLog)

Braille blocks, for example, are important for the visually impaired, but can be an obstacle for wheelchair and stroller users, depending on how they are placed. By arranging the blocks with a little space between them, one can move the tires of wheelchairs and strollers without hitting the blocks. Rather than just creating a situation where only one side is convenient, you should think about how to make things comfortable for many people without stopping to think. Making rules according to necessity will allow more progress in barrier-free accessibility.

The current app helps people in wheelchairs to go about with peace of mind. The next step is to smoothly provide information in times of emergency so people with disabilities can continue to live safely. When a major earthquake strikes, for instance, wheelchair users have to know where evacuation shelters are, what kind of state they are in, and if it's really OK for them to go there when each person's physical situation is different. Oda says she wants WheeLog! to be able to provide such information. Thus, the WheeLog! app keeps evolving.

Cities change over time, and it is necessary to change the map in the app accordingly. On the other hand, if the app successfully promotes "visualization," it may be possible to change the city itself in a direction that encourages barrier-free accessibility. This flexibility is possible because the map is not 100% perfect from the beginning. WheeLog! is a map where people "post information together." Each user can refer to or disregard the posted information at will. "There are many kind people all over the world," says Oda. She also hopes that the "most heart-warming map in the world," made better by user collaboration, will trigger the birth of other new support tools.

### PROFILE

**ODA Yuriko**

***Representative of General Incorporated Association WheeLog (CEO)***

*She developed distal myopathy around 2000 and was diagnosed in 2002. She invented the WheeLog! app to collect necessary information and to create functional specifications from the perspective of wheelchair users. She is also the representative of NPO PADM (Patients Association for Distal Myopathies), the representative of Wheelchair Walkers, and a judge for Her Abilities Award.*

Tatsumasa Oku, the president of Smileyearth, talking about the future of towel manufacturing (Provided by Smileyearth)

CHAPTER 04

# What You Need to Know Before Expo 2025!: Kansai's Unique Technology that Contributes to the SDGs

《Smileyearth》 'STI for SDGs' Awards 2019 "Excellent Practice Award"

《Research Center for BNCT of Osaka Prefecture University》

Akina Horikawa, fellow at Knowledge Mobility based System Institute (KMS) and science communicator

Ahead of the 2025 Japan World Exposition (Expo 2025 Osaka, Kansai, Japan), all eyes are on Science and Technology Innovation developments (STI for SDGs) to achieve the Sustainable Development Goals (SDGs). Kansai is a region of commerce, and many companies and organizations aim to contribute to the SDGs worldwide by using their unique technologies. We introduce Smileyearth (Izumisano City, Osaka), which has reduced the environmental burden of towel production, and the Research Center for BNCT of Osaka Prefecture University (Sakai City), which leads industry-academia-government collaboration towards the spread of new cancer treatment methods.

## The Challenge of the Towel Company Began in Japan's Dirtiest River

"Monozukuri Nippon Grand Award," sponsored by METI, the Ministry of Economy, Trade and Industry, shines a light on people who take on the challenge of manufacturing in the new era. Smileyearth, which won the 7th METI Minister's Prize in 2018, has only five employees but has had a strong presence with its enthusiastic efforts toward the SDGs, including winning the Excellence Award at the JST-sponsored "STI for SDGs" Awards in 2019.

The Senshu area of Osaka is the birthplace of Japan's towel production and boasts a history and tradition of about 130 years. Tatsumasa Oku, the president of Smileyearth, was born and raised in this area as the third generation of a towel manufacturer. In 1998, the Kashii River, which runs through the area, was ranked lowest in a nationwide survey of river water quality conducted by the Ministry of Environment. Oku, who was in the fifth grade at the time, felt pained to learn that his family's towel business was one of the reasons for this.

Generally, a large amount of water is used in towel production. Towels are highly absorbent, but their raw material, cotton, contains oil and repels water. This resulted in massive spills of treated water from the chemical agents and dyes used to remove oil and impurities.

"It is said that 500 grams of chemicals are needed to make one kilogram of towels. At times, annual production was tens of thousands of tons, and half that amount of chemicals were also used."

Japan's towel industry peaked around 2000 but has been shrinking ever since. Dominated by inexpensive imported products, the number of towel-related companies in Senshu, which used to be over 700, has now fallen to less than 100. However, Ryuichi Oku, the father of Mr. Oku, turned this challenge into an opportunity.

## Unique technology that focuses on cotton's natural purification

Towel manufacturing is generally divided into companies that make yarn from cotton, weave companies, and dye companies. While many of his competitors went out of business, Ryuichi bought their machinery and equipment and established an integrated production system at his company. He also approached Yuichi Kashiwada, who was undertaking organic cotton cultivation in Uganda at the time. Tatsumasa, the current president, also went to Uganda after graduating from university, and this was when the challenge of creating a genuinely organic towel began.

In general, even organically grown cotton is treated with chemicals when being made into towels. Oku questioned whether such towel production was "truly organic" and started to investigate on his own. He discovered that cotton has a self-purification function and then developed the "self-cleaning cotton method" that maximizes this function. He achieved the same effect as the conventional chemical-based scouring process using only cotton and water, reducing the amount of water used to about one-fourth and the chemical agents to one-fifth.

Tatsumasa Oku and Partner farmers in Gulu, Uganda (Provided by Smileyearth, photo taken in 2013)

Smileyearth is pursuing sustainability of towel production and the global environment with STI for SDGs. As an "SDGs manufacturer," the company has set nine goals to tackle — "Responsible consumption and production" "Life below the water," and others — out of the 17 SDGs goals.

Ultimately, Oku hopes to build a recycling system that reuses treated water as a water resource for cultivating crops and other purposes to realize a "Nature Towel Factory," a towel factory for a new era. Now, people connected through "water," like local farmers and fishermen, push him forward.

## Boron sheds new light on cancer treatment

The SDGs also include the goal of "Good health and well-being for all." There is growing hope for STI for SDGs in the medical field as well. The Research Center for BNCT at Osaka Prefecture University is playing a central role in industry-academia-government collaboration to promote the spread of a new cancer treatment method called Boron Neutron Capture Therapy (BNCT). The BNCT drug the center developed obtained pharmaceutical approval for the first time globally and then got covered by insurance in 2020.

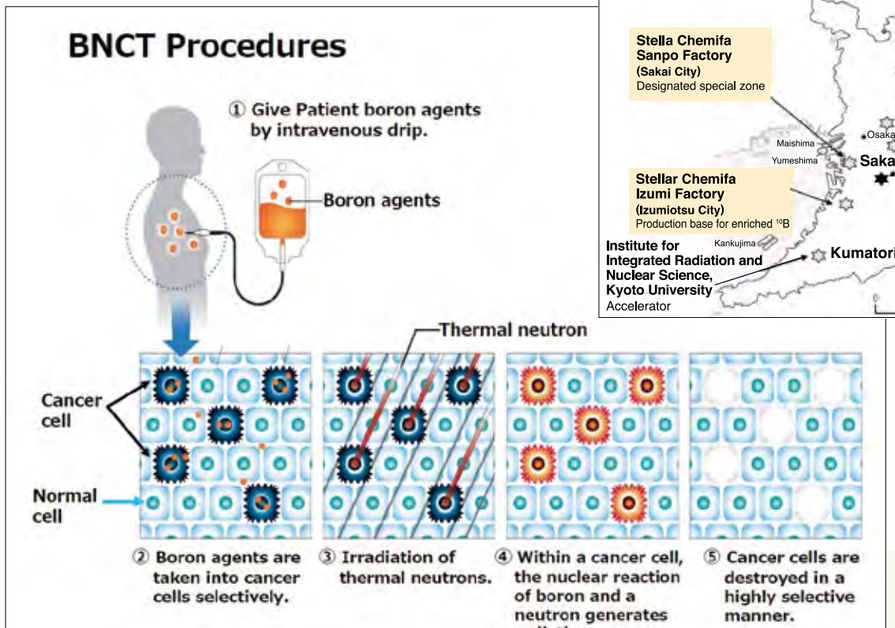
| | Chemical agent usage | Water usage | Fossil fuel usage | Amount of industrial waste |
|---|---|---|---|---|
| Conventional technology | ~ 500g | ~ 200ℓ | ~ 3ℓ | ~ 60g |
| Current technology | ~ 1g | ~ 55ℓ | ~ 0ℓ | ~ 0g |

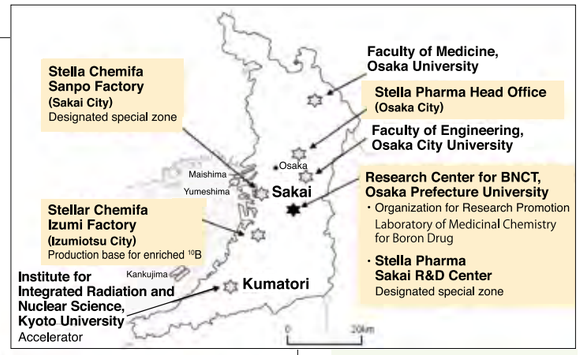
Numerical reduction table of Smileyearth (self survey): Chemical agent and water usage are comparisons between 2007 and 2015. The company achieved zero fossil fuel usage in 2018 and has been maintaining zero industrial waste since 2008. (Prepared based on the image provided by Smileyearth)

BNCT is a type of radiation therapy. The boron drug is administered intravenously so that boron can be taken up by the cancer cells in advance, and then be irradiated with a low-energy thermal neutron beam to destroy the cancer cells. Since it does not damage normal cells, it is expected to be a treatment method with a lower physical burden.

BNCT's principle was put forward in the United States in 1936, and its research had been going on for a long time. However, Mitsunori Kirihata, Director of the Research Center for BNCT, Osaka Prefecture University and Project Professor of the university's Organization for Research Promotion, says, "Solving the two bottlenecks was essential to succeed in the clinical application of BNCT."

The first issue was boron. There are two boron isotopes, boron-10 ($^{10}$B) and boron-11 ($^{11}$B), that exist in nature at a ratio of 1:4. However, only boron-10




BNCT's element technologies are gathered in Osaka. (Prepared based on the image provided by the Research Center for BNCT, Osaka Prefecture University)

BNCT treatment and boron drugs (Provided by the Research Center for BNCT, Osaka Prefecture University)

splits in response to thermal neutron radiation. In other words, technology to enrich boron-10, which only occurs at a rate of 20% naturally, was required.

Stella Chemifa, a chemical manufacturer headquartered in Osaka City, made this possible in Japan. In 1999, Kirihata met Tomoyuki Asano, an employee of the company, which led to the full-scale development of boron compounds for BNCT. Today, Stella Pharma, a subsidiary of Stella Chemifa and chaired by Asano, is the only company in Japan engaged in developing drugs exclusively for BNCT.

## Blessed with "harmony of people" more than anything else

In addition to this, BNCT research institutes are concentrated in the Kansai region in various fields such as medicine, pharmacology, and physics, including the Institute for Integrated Radiation and Nuclear Science, Kyoto University, which has led the world's BNCT research. This rare environment greatly supported development of BNCT.

The second issue was the neutron irradiation equipment. Transporting patients from the hospital to the research reactor was not practical. Sumitomo Heavy Industries, Ltd. solved this problem by developing a compact neutron generator to be installed in hospitals.

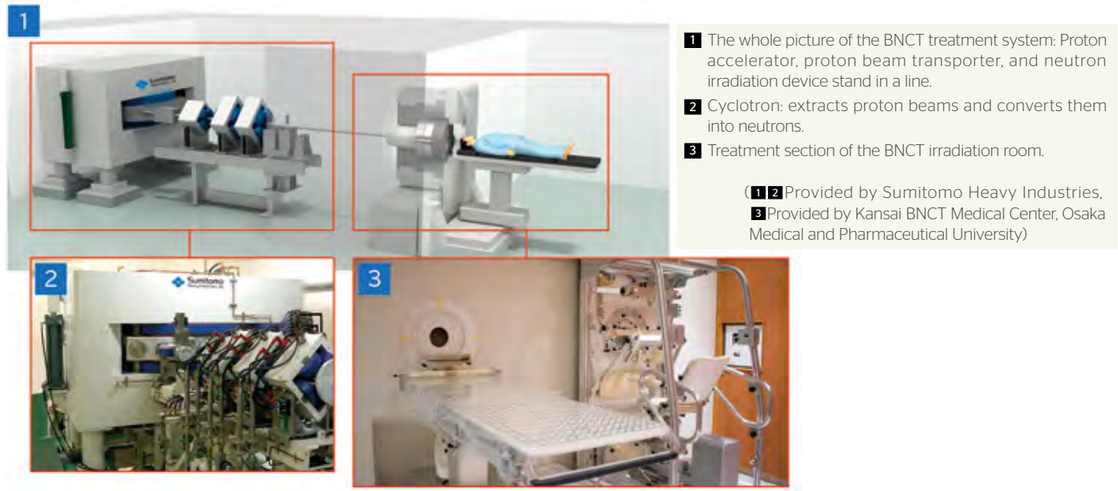
Looking back on the development to date, Kirihata says that he has been blessed with "heavenly timing, a local advantage and harmony of people." As for the local advantage mentioned earlier, BNCT's element technologies gathered in the Kansai region was a significant factor. In regard to the opportunities 'heavenly timing,' the trend of promoting industry-academia-government collaboration was important. Stella Pharma's commercialization development was supported by JST from 2008 to 2014 and the Japan Agency for Medical Research and Development (AMED) from 2015 to 2019. The base of this industry-academia-government collaboration was the Research Center for BNCT, which started in 2014 on the Nakamozu Campus of Osaka Prefecture University.

Kirihata says that he was blessed with the "harmony of people" more than anything. "Mr. Asano, who established

Dr. Kirihata explaining about BNCT








1 The whole picture of the BNCT treatment system: Proton accelerator, proton beam transporter, and neutron irradiation device stand in a line.
2 Cyclotron: extracts proton beams and converts them into neutrons.
3 Treatment section of the BNCT irradiation room.

(1 2 Provided by Sumitomo Heavy Industries, 3 Provided by Kansai BNCT Medical Center, Osaka Medical and Pharmaceutical University)

Stella Pharma to deliver this technology to patients, and the doctors who cooperated in the clinical trials — the thoughts of the people involved was a major driving force."

Kirihata also expresses his enthusiasm to focus on nurturing specialized human resources in the future. "First of all, we need to continue fundamental research to expand the range of cancer applications. On the other hand, it is also essential to look at medicine from the larger perspective of the global environment surrounding us, rather than just chasing technology. What thought system can we build for sustainable development, and how can we use our expertise? It overlaps with the idea of the Expo, and I would like to value human resource development as well."

## Kansai companies that stand out on a global scale

Many other companies in Kansai have developed their unique ways of doing business while carrying on their traditional industries. METI selects "100 Global Niche Top Companies" that have established a leading position in the world market in a specific product or service field. The list has been put together twice in the past, in 2013 and 2020, and 113 companies were selected in 2020, of which Kansai companies did remarkably well, with 21 selected from Kyoto, Osaka, and Hyogo prefectures.

On the other hand, in the World Economic Forum's "Global 100 Most Sustainable Corporations in the World (Global 100 Index)," which annually ranks the world's 100 most sustainable companies, five Japanese companies ranked in 2021. Companies from Kansai also made their presence felt here. Takeda Pharmaceutical Company Limited, selected for the sixth consecutive year, was founded in Osaka City, and Sekisui Chemical Co., Ltd., ranked four years in a row, is also headquartered in Osaka City.

Kansai has the power to lead the world in achieving the SDGs. The actions of every one of us are also essential to realize the theme of Expo 2025 Osaka, Kansai, "Designing Future Society for Our Lives." Now is the time for us to think about the future of science, technology and humanity — what kind of planet will we pass on to the next generation?

## PROFILE

**OKU Tatsumasa**

***President of Smileyearth Corporation***

*He was appointed as the official coordinator of friendly exchange between Japan and the Republic of Uganda in 2017, received the METI Minister's Prize at the 7th Monozukuri Nippon Grand Awards in 2018, and was presented the first Ambassador's Commendation at the Embassy of Japan in Uganda in 2019.*

**KIRIHATA Mitsunori**

***The Director of the Research Center for BNCT, Osaka Prefecture University, and project professor of Organization for Research Promotion at the same university***

*Ph.D. (Agriculture). Having retired after working as a professor at the Graduate School of Agriculture and Biological Sciences / Life and Environmental Sciences, Osaka Prefecture University, he assumed his current position as a project professor of Research Center for the 21st Century and Organization for Research Promotion at the same university.*

"Quince," a Rescue Robot

Developed by Satoshi Tadokoro's group (Photo provided by Satoshi Tadokoro)


CHAPTER 05

# Beyond the Two Great Earthquakes: Building a Disaster-Resistant Nation with "Tough" Robots

《Interview with Satoshi Tadokoro》

As Japan moves forward with efforts to build a disaster-resistant nation based on the Great East Japan Earthquake lessons, the use of robots in times of disaster has been attracting attention. Professor Satoshi Tadokoro of Tohoku University is a pioneer who has been leading the research and development of such robots in Japan. After his own experience in the Great Hanshin-Awaji Earthquake, he began developing robots that could "help people in need" in the event of a disaster. Having developed tough robots that can perform well at a disaster scene, what has he been thinking about, and what kind of future does he envision?

## To "help people in need"

The origin of Tadokoro's robot development goes back to his childhood. At the time, animated films featuring robots such as "Astro Boy" were trendy. Growing up watching such anime, he majored in precision engineering and entered research and development, keeping his interest in robots.

Initially, Tadokoro was intensely interested in improving the efficiency and performance of robots as machines. However, his first turning point was at the Great Hanshin-Awaji Earthquake that occurred on January 17, 1995 and claimed the lives of approximately 6,500 people. While the damage was widespread, mainly in the Kinki region, Tadokoro witnessed the devastation as one victim in Kobe. A thought came to his mind, and memories of his childhood.

"Science and technology should be able to solve these problems, but the robots we have today are not able to 'help people in need.' On the contrary, no researchers even exist who try to achieve that. At this rate, we will not develop technology that can save human lives even in 100 years. I don't know if we can do it or not, but we should start even from the grassroots."

We will develop robots that we can use in times of disaster to save as many lives as possible. That was the moment when "disaster relief" and "robots" came together in Tadokoro's mind.

## Starting with listening to the victims

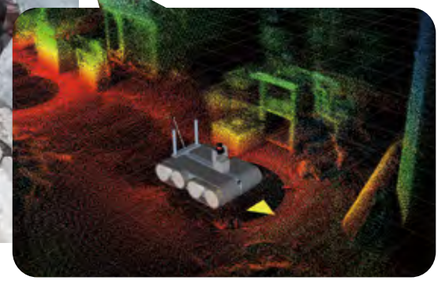
Tadokoro began his journey with great determination, but the road ahead was difficult. In the 1990s, most of the robots were so-called industrial robots engaged in assembling industrial products. So, many people wondered whether "robots that save human lives" could be the subject of research in the first place.

The first thing Tadokoro did was to interview the rescuers. Then, he conducted hearings and discussions with the victims as well as the firefighters and volunteers who rescued them. By doing so, he surveyed the actual situation of "how they rescued and how they got rescued." Then, he analyzed the results to extract ideas for what robots can support parts of rescue. For example, in the case of a rescue by diving into debris, he divided each task into "reaching the location of the person in need of rescue," "finding him/her," and "examining his/her condition" and then narrowed down which tasks can be handled by the robot.

In addition, he set up a study group in the academic society to identify issues regarding robots for disaster relief, involving other researchers in the process. The technology got better and better through the repeated discussions, the robot's mobility advanced, and they also realized the miniaturization of peripheral devices such as infrared cameras. This way, the disaster relief robot was taking shape that could withstand practical use little by little.




Quince in operation. Initially developed to go into enclosed spaces such as underground or inside buildings to conduct surveys. (Provided by Satoshi Tadokoro)



3D image captured by Quince (Provided by Satoshi Tadokoro)

## Quince's Contribution to Fukushima Nuclear Power Plant

Amid such efforts gaining social recognition, Japan was struck by another unprecedented disaster, the Great East

Tadokoro is also actively involved in RoboCup as a fellow of the RoboCup Japanese Regional Committee. Photo shows participants of the 2016 summer camp for RoboCupRescue Robot League. (Provided by International Rescue System Institute)

Japan Earthquake. It is still fresh in our memories that earthquakes and tsunamis, and accidents triggered by them have caused tremendous damage. In response, Tadokoro and his research group deployed Quince, an emergency disaster response robot, in a search operation to investigate the inside of the Fukushima No. 1 nuclear power plant. As a result, it gained a detailed assessment of the damage and contributed to the later formulation of a work plan for the plant.

The development of Quince got greatly aided by an initiative that had been underway since before the Great East Japan Earthquake. That is "RoboCup," an international contest aiming to develop new technologies through competition robot development. Tadokoro had already launched the Rescue Division in 2001, which competes in the performance of robots at simulated disaster sites, as a new division of RoboCup. Tadokoro says that as the competitions went, "a system was created in which many researchers and students who came together without being paid, came up with ideas to solve various technical problems." Under such circumstances, the foundation of Quince, which combines high mobility with multiple crawlers and autonomous mapping in a closed space, was created in a bottom-up manner.

Tadokoro recalls his experience of the Great East Japan Earthquake, "It was the first large-scale disaster in human history where many robots were used in practice, tested, and achieved some success. On the other hand, first-deployed robots could not be used immediately in the field and often failed because it was for the first time. Due to the wide media coverage, the general public became more aware of the robots."

## Coping with the harsh conditions is required in a disaster

The word "tough" often appears as a keyword in developing robots that Tadokoro is trying to reach. The term "tough" generally means "hard to break" or "tireless," but the concept of "tough" he is pursuing has a different meaning.

"For robots to be effective at disaster sites, they must be able to perform under a variety of harsh and adverse conditions. For example, it's useless if you could not do the job because the debris was too steep, or you could not see because it was too dark. Therefore, we must remove the constraints one by one so that the technology can work under severe conditions. This is the meaning behind the word "tough": ability to demonstrate the effectiveness of technology even under difficult site conditions," says Tadokoro.

Many unforeseen circumstances can occur in actual disaster relief situations like roads are bumpy or blocked with heavy objects. There are also many times when a robot's environmental awareness and autonomous intelligence do not work well. Tadokoro stresses that disaster rescue robots are required to have the ability to overcome them, find the person in need of rescue, and carry out rescue operations: in a word, capable of functioning under the severe conditions required at disaster sites.

## Closing the gap with user needs

Nevertheless, realizing functions and performance under the problematic conditions demanded by users is beyond current science and technology limits. It is impossible to realize the production of an all-purpose robot. There is a trade-off between the usage conditions and functions or performance.

Tadokoro says it is essential to determine what is required, based on how the equipment is used in practice, to develop "tough" robots. "In a situation where the capacity is limited, it is necessary to sift through the functions and create the best system for the purpose. To do so, we need to fill the gap between the user side and the researcher side working on the development." In the beginning, the actual robot users and the developers do not agree on what they are wanting. The goal is not to create technology but to create a tool that can effectively deal with disasters. Therefore, the development of disaster relief robots requires creating a forum

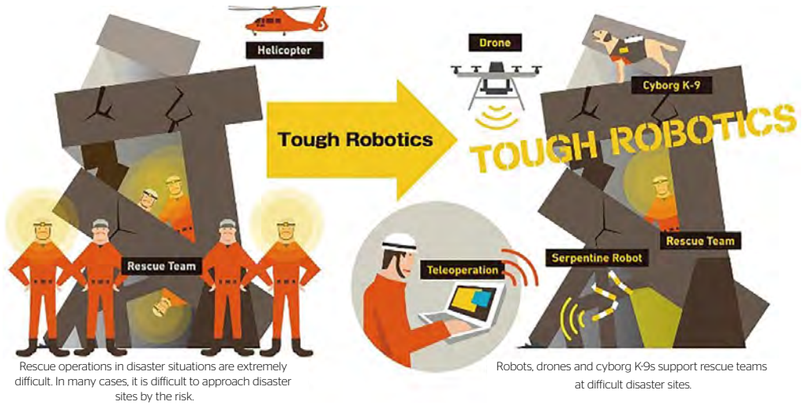



Image of Tadokoro's "tough" robot technology (tough robotics)
(Source: https://www.jst.go.jp/impact/program/07.html, translated by JST)

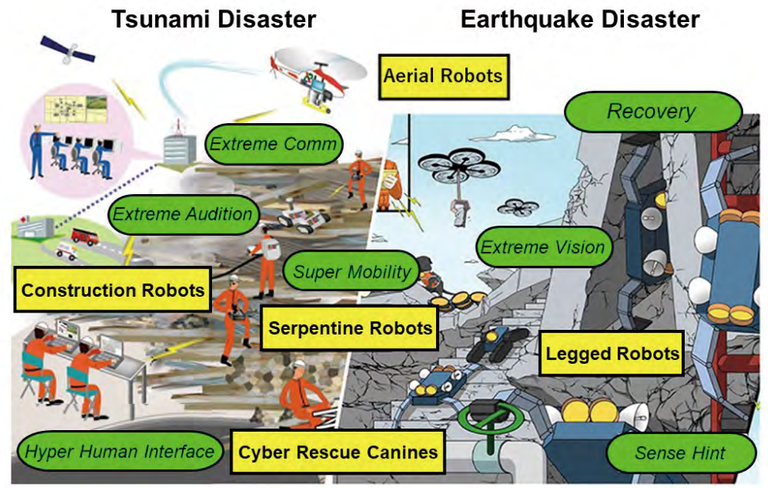



Image of an application example of a disaster relief robot in the event of a large-scale earthquake or tsunami (Original image was provided by Satoshi Tadokoro, and translated by JST)

that connects and allows the two parties to exchange opinions and understand the respective positions.

"To be able to cope with the harsh conditions required in a disaster" and "to close the gap with user needs." These two points, according to Tadokoro, are issues that have been addressed over the past ten years, from the Great East Japan Earthquake to the current spread of the new coronavirus infection.

## Using the technology of disaster relief robots in times of peace

"Most of the damage caused by the Great East Japan Earthquake, which people had called 'unexpected,' was predictable. It's the same with infectious diseases. It had been predicted for a long time that a pandemic (global outbreak) would one day occur, and in fact, SARS (Severe Acute Respiratory Syndrome) spread. We could have prepared for it if we had wanted to. However, I think there is still an aspect where the necessity of such preparations has not been seriously considered, and a decision has not been made as to whether we should prepare for it or not," says Tadokoro.

The importance of creating a social infrastructure based on the premise that disasters will occur and a system to support it is no different for disaster relief robots. Tadokoro believes that "only science and technology have the power to solve this problem." He proposes to build an "ecosystem" focusing on disaster relief robots as a peacetime precaution. One way to do this is to actively utilize the technology developed for disaster relief robots in the ones that we use during ordinary times. Using technologies created for disasters in peaceful times, we must promote technological development and lower the barriers to social implementation.

It is necessary to change all researchers, companies, and public organizations involved in development to achieve this. There is a need to promote research & development to solve social issues and expand support systems for young researchers to take on the challenge of developing new technologies. However, Tadokoro says that the most important thing is "raising the public's awareness, the biggest end-user."

Like an infectious disease, you never know when a large-scale disaster will strike. In other words, everyone who lives today can be a party to it. Therefore, rather than leaving research & development to a specific person, everyone should think about using the technology, which is the kind of "preparedness" we need to face our shared challenge of disasters. I believe that such preparedness is also essential to counter the threat of the new coronavirus that we are now facing.

## PROFILE

**TADOKORO Satoshi**

***Professor, Graduate School of Information Sciences, Tohoku University***

*He received his master's degree from the University of Tokyo in 1984 and became an assistant at the Faculty of Engineering, Kobe University, in 1986. After working as an assistant professor at the same university, he assumed his current position in 2005. From 2014 to 2018, he was ImPACT (Program for the Promotion of Innovative Research and Development) Program Manager for "Tough Robotics Challenge." He has received several awards, including the Commendation for Science and Technology by the MEXT minister. He specializes in the research & development of robots and ICT for supporting emergency response, recovery, and prevention of disasters, based on manufacturing technology. He is an IEEE Fellow and a Ph.D. in Engineering.*


**Disaster Mitigation, Anywhere Science Experiment Package**

For 6th graders. The package contains several types of experiment materials. (Provided by SEC)

CHAPTER 06

# Science Experiments Anytime, Anywhere; Package Development at Ochanomizu University

《Science and Education Center (SEC), Ochanomizu University》

It is not easy to conduct science experiments in disaster-affected areas due to school space and equipment loss. Such being the case, the Science and Education Center (SEC) of Ochanomizu University has developed "Disaster Mitigation, Anywhere Science Experiment Package," a compact kit that allows students to conduct experiments anytime and anywhere. Amid the covid-19 pandemic, the package is drawing attention as a science learning material during school closures.

## The slogan is "Mystery, Discovery, and Inspiration"

"Whoa, amazing!"

When the magnified image of daphnia is projected on a large monitor screen, even an adult raises a voice with joy. The antennae with fine hairs, the beating hearts, the inside of the digestive tracts through which food goes, etc. — I got drawn into the microscopic world projected large and couldn't help but sigh at their delicate shapes. This image of daphnia was not taken using a regular microscope. It was a tablet device with a small lens plate attached to the camera part that captured it.

"It's just a tablet, but it works great, doesn't it?"

Kazuyoshi Chiba, SEC's Director at Ochanomizu University, said that with a smile. "Real/Actual things have the power to attract people. You get inspired when you look at daphnia with your own eyes or try to turn on a miniature bulb with your own hands, don't you? That is the gateway to science."

Inspiration moves and grows people. SEC has been active since 2005 with the slogan "Mystery, Discovery, and Inspiration," emphasizing inspiration in science. Its goal is to promote science education and science communication that conveys science content in an easy-to-understand manner.

Attaching a tiny lens plate allows viewing daphnia on a tablet device and sharing on a screen. (Provided by SEC)





Liquid nitrogen experiment at Tokyo's Kita-Ward Ojizakura Junior High School, December 2020: The students are observing a pinning effect of the superconductor. (Provided by SEC)

It is difficult for university teachers to visit elementary, junior high, and high schools to give classes frequently. Therefore, Chiba and his colleagues are developing various programs to encourage science teachers nationwide to play an active role in science communication. One of their unique activities is the collaboration with the Kita-Ward.

"When visiting elementary, junior high, and high schools, we university teachers opt just to provide support. We have the school teachers stand in front and practice their roles in an actual class. That is because we want them to make the class content their own."

Chiharu Sadamitsu, who has been building a long-term collaborative relationship with the Kita-Ward and works with Chiba at SEC, screams with joy, "Every year, we receive more requests for experiment support than we can handle."

## Supporting education in areas affected by heavy rains and typhoons

The Great East Japan Earthquake triggered Chiba's team to support science education in disaster-hit areas. After the quake, they heard desperate voices from the Iwate Prefectural Board of Education, with which they had an exchange, that "science education is what needs supporting." They were shocked to know the dire situation of science education in the affected areas.

Even after a major disaster like the Great East Japan Earthquake, schools themselves recover in about a month. However, experiments and practical studies that require special classrooms and equipment cannot resume for more than a few months. There is often not enough space in rented school buildings, and some schools have not had regular classes for over a year. We wanted to do something to avoid long-term interruption in science education," says Chiba.

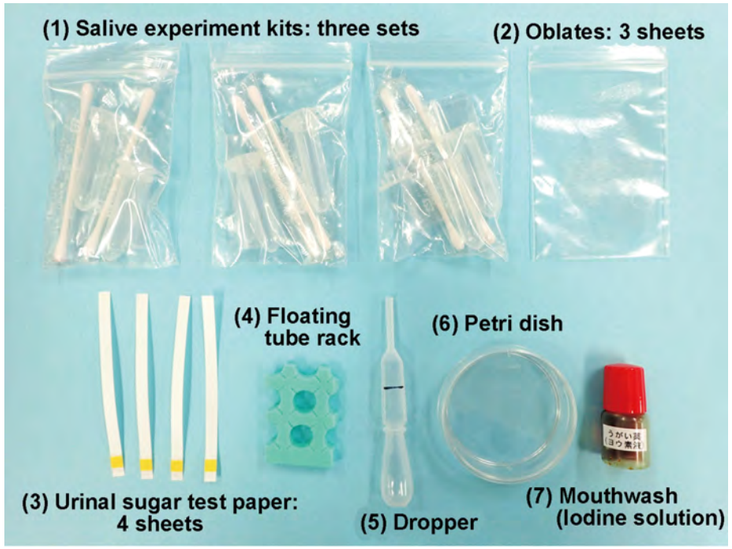
In September 2011, Chiba and his colleagues went to the quake-hit areas in Iwate Prefecture. In November, they held a training session using the learning materials they had developed at SEC. While conducting training, on-site classes, and providing teaching materials, they keenly realized the need for a compact science experiment package that would fulfill the contents of study guidelines and textbooks even in disaster times and allow anyone to conduct science experiments anytime and anywhere.

In 2016, they launched a project to develop experiment materials that correspond to the units of the study guidelines for 3rd-year elementary school through 3rd-year junior high school, and create "Disaster Mitigation, Anywhere Science Experiment Package" that contains experiment kits for respective grades. Soon after the launch, the Kumamoto earthquake struck, and the SEC members rushed to the hit area with the kits under development.

SEC members holding the "Disaster Mitigation, Anywhere Science Experiment Package" experiment kits. From left: Akihiro Osaki, Kazuyoshi Chiba, Chiharu Sadamitsu, and Hiroaki Sato

After that, in parallel with the development of the experiment kit, they continued to visit the areas affected by the Western Japan Heavy Rain, the Hokkaido Eastern Iburi Earthquake, and the 2019 Typhoon No.19 to support science education.

However, some disaster-hit areas refused to allow them to go in there, and the team realized the need to make the importance of science education in times of disaster known. Then, SEC has been proactively reaching out to areas yet to experience a disaster, such as Kochi Prefecture, which is expected to be severely damaged by the Nankai Trough Earthquake, and steadily conveying the importance of science education in times of disaster.




An experiment kit that enables conducting "Experiments on food digestion using saliva" at home, which couldn't be done in schools due to the prevention of new coronavirus infection. (Provided by SEC)

## Amid the Covid-19 situation, now is the time to use learning materials

During the closure and even after reopening, many schools have not conducted observations and experiments as before to prevent infection. Usually, only limited areas are affected by disasters, but the new coronavirus has impacted the world. It is a disaster of unprecedented scale.

"We urgently need a new system to ensure that science education is not interrupted in the event of a countywide disaster. As a foundation for this, we believe that we can use the science learning kit for disasters we have built up so far," says Chiba.

In May and June 2020, Chiba's team, together with Noriko Kawashima, a teacher at Tokyo's Bunkyo-Ward Dairoku Junior High School, had already developed learning materials such as "Experiments on food digestion using saliva" (*1), which you can do at home. They then held home experiment classes online for children experiencing school closure or limited school attendance due to the covid-19 pandemic. They felt that it was possible to conduct experiments even when they could not meet face to face.

In addition, there are advantages only to this learning material, which you can not find in general science tools. Whereas only one or two science experiment kits are provided per group, which reduces the amount of time for experiments per person, every student can have one SEC tool, which allows them to experiment from start to finish to study more.

Chiba says that the covid-19 also made him re-realize the importance of science education. Every day, a flurry of words that require a scientific background, such as antibodies, PCR, and effective reproduction numbers, are heard on TV. No one can be free of science in today's society. Scientific knowledge is necessary to make appropriate judgments about various information, and not only scientific knowledge but also an explorative attitude acquired through experiments is helpful for any future career. Enriching our lives — That must be the role of science.

*1: This initiative was awarded the 2020 Toray Science Education Prize. (https://www.toray-sf.or.jp/en/activity/science_edu.html)

## PROFILE

**CHIBA Kazuyoshi**

***Director of the Science and Education Center (SEC), Ochanomizu University,***
***Professor, Graduate School of Humanities and Sciences, Education, Ochanomizu University***

*In parallel with his research in developmental biology, his specialty, he conducts activities to promote science education and science communication.*





# Experiment and Observation Kits

## Compact and Easy-to-Prepare Kits

**The experiment and observation kits developed by SEC are all compact, take up little space, and are designed to make learning fun. We introduce four of them.**

**Notes**

All these materials are designed to make with easy-and-inexpensive-to-get materials. In addition to the four listed below, SEC's web page provides information on preparing and using a wide variety of learning materials.
(Ochanomizu University Science Materials Database: http://sec-gensai.cf.ocha.ac.jp/home/english)

### 1 Tablet microscope

As mentioned at the beginning of this article, the tablet device can quickly change to a microscope with an attachment of a special lens plate. Since tablet devices are often delivered as relief supplies relatively early, they are useful in science education in disaster-hit areas. By using this tablet microscope, you can observe organisms such as plankton and the crystal's growth.

A macro lens sold at one coin store is also good enough for observation. Using a screen-sharing application, you can easily show each other's screens, which are popular among children saying it's fun.

(Provided by SEC)

### 2 Multi-colored magnetic-field observation case

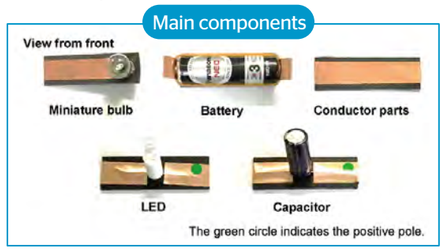
Cut colored twist ties (a vinyl-covered wire to hold the bag's mouth, available at one-coin stores, etc.) into a rectangular shape, place them in a transparent container such as a petri dish, and fasten the lid of the container with adhesive tape.
When you bring a magnet close to them, the ties will sparkle along the lines of magnetic force.

This colorful magnetic-field observation case contains a wish of Chiba's team that children affected by disasters will feel a little brighter.

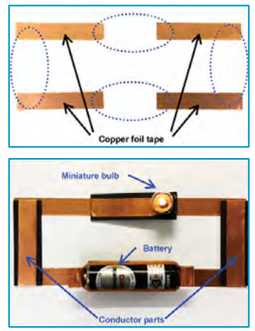
(Provided by SEC)

### 3 Circuit card (magnetic version)

A postcard-sized metal sheet (surface insulation) with copper foil tape attached is used as a foundation; This is an experimental learning material that creates a circuit by placing a miniature bulb, a dry-cell battery, etc., integrated with a magnetic sheet on it. You can easily see where each part is connected.




The circuit card is highly expandable and can be combined with various components such as miniature bulbs, motors, capacitors, and programming parts, providing a wide range of learning opportunities for students from third grade to eighth grade.




SEC's Sato controls the on/off of a miniature bulb by combining it with programming parts.

Circuit card and main components (Provided by SEC)

### 4 Three-dimensional terrain of the surrounding area using a 3D printer

Nowadays, you can get a 3D printer for tens of thousands of yen. Many schools have already introduced one, and it is now possible to request the creation of products from 3D data at a low price. SEC's Osaki also produces kits using a 3D printer. First, a neighboring terrain model is created using the 3D printer data of the three-dimensional map (*2) published by the Geospatial Information Authority of Japan (GSI), then plastic clay is pressed on it. The topography can be duplicated by pressing the paper clay onto the plastic clay with the terrain transferred. Suppose each student receives one of those. In that case, they can learn about evacuation routes and potential dangers by overlapping them with hazard maps, which is suitable for disaster mitigation classes.

(Provided by SEC)

*2: *Making a 3D Model (GSI Map Edition)* (GSI, https://maps.gsi.go.jp/3d/creating.html)

Members of the Robot Science Club at Otemon Gakuin Otemae Junior and Senior High School

CHAPTER 07

# Creating a Society where "Everyone Can Smile" through Robotics Education and SDGs

## 《TEAM EXPO 2025 Otemon Gakuin Otemae Junior & Senior High School Robot Science Club》

'STI for SDGs' Awards 2021 "Next Generation Award"

The Robot Science Club at the Otemon Gakuin Otemae School has gone beyond the boundaries of school club activities to realize many full-scale "robot projects." Their activities cover a wide spectrum, winning prizes at international robot contests, developing robots that solve social problems, and providing robotics education to local people. The students set their themes, work together to solve problems, and spread information, and outside parties have evaluated their efforts highly. The club has also registered for the "Co-Creation Challenge," a TEAM EXPO 2025 program promoted by the Japan Association for the 2025 World Exposition in preparation for Expo 2025, Osaka, Kansai, Japan. We will introduce the unique initiatives of these junior and senior high school students working to "create a better society through robot development."

Students set their theme and work together on the "robot project."

### Daring to challenge the world's top robotics contest

As we passed through the school's historic gates, a new prefab building was in stark contrast to Osaka Castle tower in front of us. Inside the building, about 30 students were working in groups. Some discussing their ideas, some looking at computer screens, and some making something with Lego blocks. We were in the "Tech Lab," the club room of the Otemon Gakuin Otemae Junior and Senior High School's robot science club.

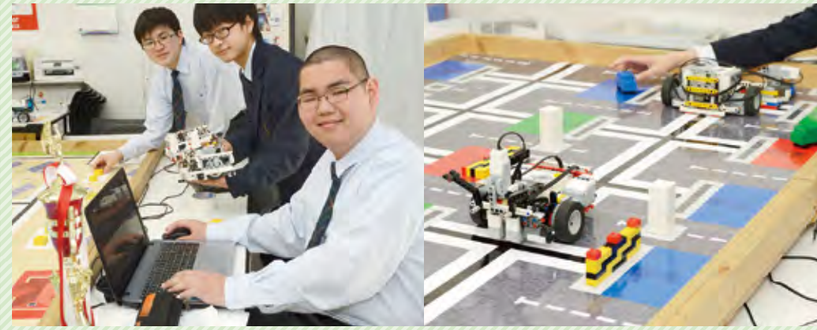




Up ahead, a robot made with "Lego Mindstorms" carried blocks of various colors. Watching it in earnest was a team of three people entering the WRO (World Robot Olympiad), an international contest for autonomous robots.

"We can't control the robot during a competition, so we have to program all the movements in advance," explained club member Nakamura, who is in charge of software. "It's difficult to build effective communication so that Nakamura can program," said another member, to whom Nakamura replied, "Because I'm asking too much." Another different member cuts in, "We do fight sometimes." Exchanges such as this showed us the good teamwork of those who aim to make a better robot.

"This year, we want to win first place at the WRO Japan and go to the International Final," — I felt the quiet confidence in their words.



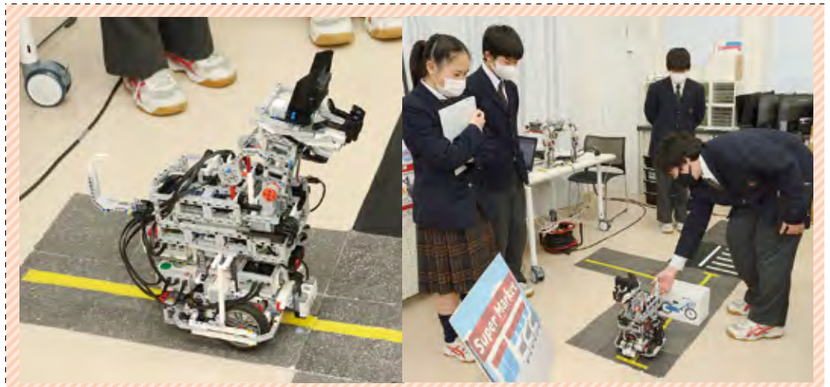
Three students challenging the global robotics contest, WRO, are all known as "the strong ones" who have won top prizes in past competitions. From right to left: Nakamura, Nishizumi, and Shimizu

### An advanced guide-dog robot that has inherited the technology of their predecessors

Right behind the WRO team, a miniature "city" with features resembling a hospital, traffic lights, and roads was built, and a dog-shaped robot was sitting on top of it. "It's a guide dog robot called 'Ai-dog(*1)'," said Furumoto, in charge of information sharing for the team. "Currently, about 3,000 people in Japan need guide dogs, but there are less than 1,000 available guide dogs. We have developed this robot to solve the problem."

After being activated, Ai-dog asked me, "From where to where do you want to go?" I answered, "From my house to the supermarket," then it began to move. It ran autonomously, following the Braille blocks embedded in the road, bypassed obstacles, stopped at a red light, and proceeded again at a green light. When it reached its destination, it wagged its tail and it stopped.

Ai-dog is the second model, taking over and improving the first model made by their predecessors. The tires are bigger to go over level differences, the signal recognition rate increased, and the total size is smaller. A quadrupedal robot that can climb stairs is also under development for testing on public roads shortly. Furumoto concluded her demonstration by saying, "We aim to create a society where everyone can smile."



Guide Dog Robot "Ai-Dog" that automatically runs to a voice-directed destination

### IoT power strips contribute to relieving climate change issues

Two more club members, Iga and Minakata have developed an IoT power tap that remotely controls the power switch and the output to prevent electricity waste. Minakata gave us a demonstration of controlling the air volume of a fan connected to the tap.

For the theme of "climate change," the two students discussed how to solve the problem many times with their advisor, Fukuda-sensei (teacher). Iga, who had little experience in robot development, was initially like, "I have absolutely no

*1: The name of "Ai-dog" derives from the meanings of supporting the owner's eyes and being close to the heart to support the mental aspect (i.e., "love" in Japanese).

The IoT power strip (left), which prevents electricity waste by remote control of devices like cellphones, won the best prize in the open category at the WRO Japan 2020. This project also contributes to achieving the SDGs.

idea what Minakata is saying" "But I made this after doing my research, understanding the words, and thinking about how I could get them across better." She pointed to the poster that outlines the development in an easy-to-understand manner.

On the other hand, Minakata, who has a wealth of experience in robot development, says that he was surprisingly "gloomy" as a junior high school student. As he developed robots, he gradually gained confidence in his skills. "I think I was able to grow up looking at my seniors, who told me that I was 'better than they were'," he said, looking a little embarrassed.

## Sharing information at SDGs seminars using robots

The team lead by Yamamoto, the club manager, has been working on the planning and managing of "Save Our Earth," a seminar to think about the SDGs and global environmental issues through robots. The large diorama on the floor is a model expressing various environmental problems. Seminar participants can operate robots on this model and learn about environmental issues by turning off the lights in the houses, separating plastic bottles from empty cans, removing garbage from the ocean to clean it while having fun.

The members who created the model said they had a hard time making the design easy to understand and enjoyable for the participants. "This time, we tried to build the robot with just a 'push' action. Children were like 'Oh!' when they saw the house lights go off with the 'push' button." The members who spoke also seemed to have enjoyed running the seminar.

Participants are not only from Osaka but also from neighboring areas. Yamamoto said that it was essential to spread their activities, not just to develop things. She would like to continue developing programming materials and sharing information after going to university. Miyagawa, the deputy club manager, expressed his thoughts on the future, saying, "There used to be nothing that interested me, but now I hope to get a job where I can use my strengths through programming."

Club members and the handmade dioramas that members used in the "Save Our Earth," a seminar that helps people understand the SDGs and global environmental issues through robots

## RoboCup Junior Disaster-Relief Robots compete using practical technology

One robot moves around the maze-like field. Surrounding it are students trying "the RoboCup Junior Rescue Maze." The maze resembled a disaster area, and the competition is to deliver relief supplies to victims as quickly as possible. The shape of the maze changes each time, and obstacles resembling rubble are placed randomly. "We program the maze through trial and error so that participants can pass through any field," said a member in charge of software. "The appeal of this project is that you can be of use to society while learning technologies."

The only junior high student (2nd grade) in a senior high team, Fujimura, talked about the charm of cross-grade interaction. "I can absorb things from senior students — things that I wouldn't understand if I were with students of the same grade." At first, he was unsure of what to expect, but he gradually became closer to them as he worked with his seniors. Egawa, the team leader, added, "It is an education method in which seniors teach juniors instead of teachers."

Over in RoboCup Junior, where the competition is in practical technology, Otemon has many strong rival schools. "Schools that have processing facilities can build full-scale metal robots. We can't beat them with power (equipment), so we compete with programming (knowledge)." In his remarks, we could feel his pride and belief that he would not lose to them with software.

## Oil spill recovery robot developed in collaboration with a private company

At the back of the room, a pure white machine caught our eyes. It looked like a water wheel, different from other Lego robots. It was an oil spill recovery robot developed by Egawa and Kuratomi. Kuratomi said, "We started developing this robot after the oil spill accident in Mauritius." The idea of recovering oil spills by combining water purification agents manufactured by a company they met through club activities and robot technology was born.

The "RoboCup Junior" team, where seniors and juniors work together to compete with programming skills

The mechanical model the two students invented, the "pure white water wheel," was prototyped using a 3D printer. To get prototype funds, they applied for a grant from a foundation that supports technological development. "It's not unusual to look for supporters by ourselves," said Egawa. "Fukuda-sensei also tries to look for one for us, but basically, we do it ourselves and give a presentation to potential supporters."

The oil spill recovery robot developed using a water purification agent produced by a company they met: They bought the 3D printer for the prototype with grant money. They created the robot through trial and error, seeking opinions from university professors and private companies.

Mr. Fukuda, the advisor, watches over the students.

## What I'm most happy about is seeing my students grow

During the interview, the advisor, Fukuda-sensei, left all the explanations to the students and never cut in. The students also spoke freely and conveyed their initiatives in their own words. Fukuda said, "The students who participate in the competitions give electrifying presentations." But, he added, many of them wanted to join an athletic club but couldn't or are a little withdrawn. "I am most happy when I see these children grow up and the lights switches on in them. That's what keeps me doing this job," he smiled.

## PROFILE

**Otemon Gakuen Otemae Junior and Senior High School Robot Science Club**

*The club started in April 2014 with six members from junior and senior high schools and teacher Tetsuya Fukuda as an advisor. In 2020, the club registered for the "Co-Creation Challenge," a TEAM EXPO 2025 program, with a "robot development project for solving SDGs by young people in Osaka."*

A video of the clubs "WRO2019 Otemon Challenger" (Advanced Marine Debris Recovery Robot) presentation can be seen at the following link (YouTube):
https://www.youtube.com/watch?v=21R_0-SNZ8s

Akira Isogai, Professor at the Graduate School of Agricultural and Life Sciences, the University of Tokyo, explaining cellulose nanofibers

CHAPTER 08

# Bringing about a Decarbonized Society with New Technologies

《Interview with Akira Isogai and Akira Oda》

Research and development for a decarbonized society is attracting attention as a necessary solution to the social issues we will face as a society in the future. We asked Akira Isogai, Professor at Graduate School of Agricultural and Life Sciences, the University of Tokyo, and Akira Oda, Assistant Professor at Graduate School of Engineering, Nagoya University, about their research and the prospects for a decarbonized society.

## Cellulose nanofibers are comprised of plant fibers

Since the Industrial Revolution, humans have built affluent lives using fossil fuels such as coal and oil. On the other hand, this development has caused various problems, such as accumulated non-degradable garbage, marine microplastic problems, abnormal weather, and global warming. And now, there is a need to build a decarbonized society. A decarbonized society is a society where we reduce the emission of greenhouse gases such as carbon dioxide ($CO_2$) and recover the emitted $CO_2$ to nullify greenhouse gas emissions in real terms.

Isogai has developed a technology to produce cellulose nanofiber (CNF), a plant-derived material that can contribute significantly to the decarbonization of society. It is three nanometers thick (a nano is one billionth), only 1/30,000th of a hair. Despite being that thin, cellulose is very strong and can be chemically given various functions, drawing attention as a new industrial material.

"Cellulose is made up of linear chains of glucose, which is produced by photosynthesis using $CO_2$ absorbed from the atmosphere. It accounts for about 40% of the weight of trees and is the most abundant polymer stored on earth. Since it is plant-derived, it can be reproduced, and even if incinerated after use, it does not increase $CO_2$ in the atmosphere. Cellulose is a material that can contribute to a decarbonized society if it replaces plastics and other materials derived from fossil fuels," says Isogai.

Water and ordinary pulp (left): Water and CNF mixture looks transparent (middle), but with an orthogonal polarizer, you can observe CNF dispersing (right).

## Industry-academia collaboration will expand practical applications

Isogai had been studying the use of cellulose since he was a graduate student, but it was not easy to extract cellulose fibers. A turning point came in 1995. A Dutch research group reported their study results. The group used a substance called TEMPO (organocatalyst) as a catalyst to oxidize starch at standard temperature and pressure without using organic solvents. Isogai thought that the TEMPO catalyst could be applied to cellulose, a polysaccharide like starch, and worked to research his idea. In 2006, he and his graduate students succeeded in developing technology to obtain CNF by treating pulp fiber with TEMPO catalyst without using large amounts of energy or harmful chemicals.

He took the result to the industrial world. Then, in addition to the merits of contributing to global warming countermeasures, the ability to add a variety of functions drew attention, which drove many companies to enter industry-academia collaborative research and development. CNF production methods other than TEMPO catalysts also progressed, with some already being put to practical use.

One example is paper diapers for nursing care with metal ions that have deodorizing functions attached to their CNF. Ballpoint pens that allow us to write without applying pressure are also commercially available — by mixing CNF as a dispersant, the ink becomes homogenized and smooth. It is also used as an admixture in concrete, shampoo, rinse, etc.

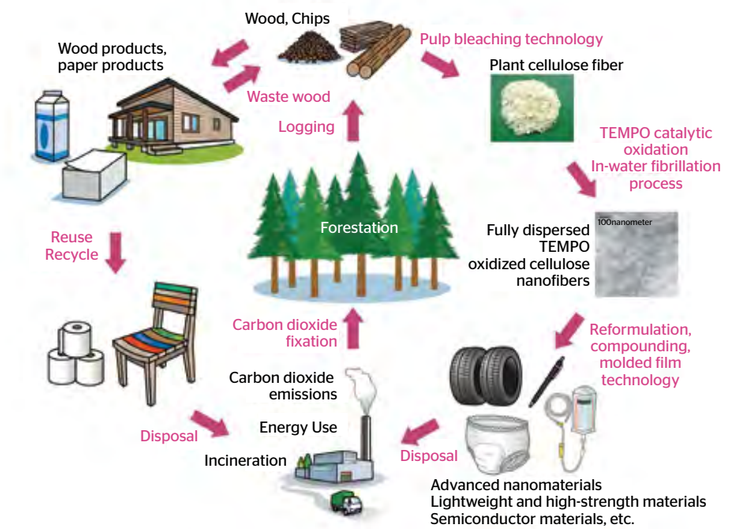
In addition, a film that is impermeable to oxygen has been developed by blending CNF into it. If CNF is applied in packaging materials, deterioration of food and medicine due to oxidation can be reduced. Since we consume a massive amount of packaging materials derived from fossil fuels, even if CNF replaces only some of them, $CO_2$ emissions will decrease considerably.

Isogai is also looking at the application of CNF to tires. Soot (carbon black) is added to tire rubber to increase stability, but as tires wear away gradually, the carbon black is discharged into the environment. In that regard, CNF will not negatively impact the environment even if it is released as the tire becomes worn. "CNF and rubber go well together and increase strength when they are mixed. Automobile tires using CNF have already been developed and are on the market, becoming a promising alternative candidate for reducing their environmental impact."

## Utilizing the advanced technologies of Japan's paper industry

At present, CNF is still expensive due to its low production volume, and its use is limited to applications that bring high functionality with little added volume. In the future, if manufacturing it at low cost and in large quantities becomes possible, the range of applications will surely expand. In this way, we hope to replace petroleum-derived materials with CNF even if it is little by little.

The Japanese paper industry has advanced technology to create high-quality papermaking pulp and electricity. "There is a lot of unused thinned wood in the mountainous areas of Japan. By making use of it, we will be able to revitalize the forest industry in Japan. Although there are some problems, we have raw materials and technologies. If we can create a new biomass-derived sector in Japan, we will contribute to the global issues we face," says Isogai. Because of its wide range of applications, contributions to the various goals of the SDGs are also expected.




The carbon stored in woody biomass has long been used in circulation (left side of the figure). In addition to this cycle, CNF will create a circle of new materials (right side of the figure) that can be used as cutting-edge materials. (Original image from "JST news," December 2017, and translated by the editorial department)

■CNF's potential contributions to the SDGs

| Goal | CNF's contribution | Goal | CNF's contribution |
|---|---|---|---|
| 2 ZERO HUNGER | Since CNF film is impermeable to oxygen, it can extend the expiration date of pharmaceuticals and foods. So, we can expect it to be used as a long-time-storage food packaging container. | 12 RESPONSIBLE CONSUMPTION AND PRODUCTION | Quantitative and qualitative expansion of the use of CNF can contribute to building a recycling-oriented social infrastructure for energy and materials made from renewable plant resources. |
| 6 CLEAN WATER AND SANITATION | By incorporating CNF into equipment for creating freshwater from seawater, the equipment may become solid and stable, facilitating freshwater security. | 13 CLIMATE ACTION | An increase in the use of CNF can reduce $CO_2$ emissions from the combustion of fossil resources and contribute to the prevention of global warming and abnormal weather. |
| 7 AFFORDABLE AND CLEAN ENERGY | Cellulose fibers can be obtained during the CNF production process, and biomass power generation will be possible simultaneously. It is an environmentally compatible process and can reduce electricity derived from fossil resources by expanding the CNF usage. | 14 LIFE BELOW WATER | Plant-derived CNF is biodegradable, which will solve the problems of marine microplastics and accumulated plastic waste. |
| 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE | CNF produced from cellulose fibers is a new bio-based nanomaterial and furthering its use will lead to new industries and technological progress. | 15 LIFE ON LAND | The cycle of afforestation, silviculture, logging, utilization, and reforestation of woody resources that become raw materials for CNF: Proceeding with it will enrich forests, reduce water pollution, facilitate the fixation of $CO_2$ in the atmosphere, and protect the richness of the land. |

(Prepared by the editorial department based on the materials provided by Isogai)

## Aiming for decarbonization by realizing "Fairytale Reaction"

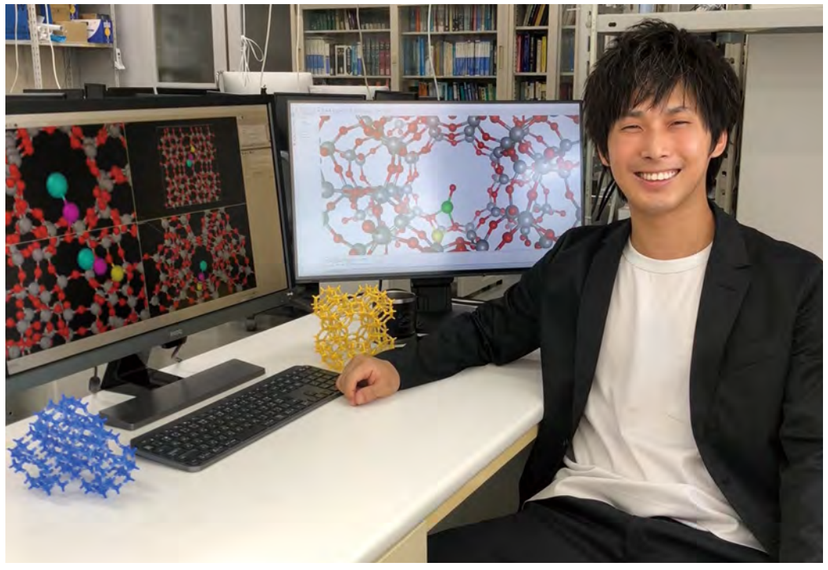
Meanwhile, Oda is conducting research that will help contribute to energy issues.

The amount of available natural gas reserves, which are currently used as gas in homes, is increasing due to advances in mining technology. Methane, the main component, produces less $CO_2$ when burned than oil or coal and is getting a lot of attention as a clean fuel. However, because methane is a gas at ordinary temperature and pressure, transportation and storage costs are high. So, converting it to methanol, a liquid at ordinary temperature and pressure, has been a requirement.

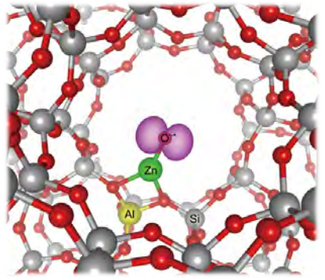
On the other hand, the reaction to convert methane into methanol has long been called a "fairytale reaction" among chemists. Oda explains the reason for this. "The only difference between methane ($CH_4$) and methanol ($CH_3OH$) is the presence or absence of one oxygen atom. To convert it to methanol, just one oxygen atom addition to methane is necessary, i.e., partial oxidation. However, methane is a very stable substance with strong bonds between atoms, and it takes a lot of energy to break the bonds between hydrogen and carbon. Despite this, when energy is applied, methane is completely oxidized to $CO_2$ and water."

Oda and his research group have discovered "oxyl," active oxygen which can partially oxidize methane at low temperatures to prevent the reaction from going too far. Oxyl is in a state where it can receive electrons easily and is therefore easily incorporated into the CH bonds of methane. Oda and his colleagues succeeded in producing oxyl using a porous zeolite catalyst. And they used it to synthesize methanol from methane at room temperature.

The wide practical application of this technology would enable efficient transportation and storage. Oda points out additional advantages to directly converting methane to methanol, which has a greenhouse effect 25 times greater than



Simulating oxyl inside zeolite pores on the computer (Provided by Akira Oda)



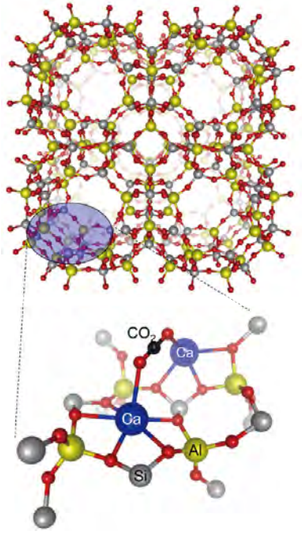

Successfully created oxyl (pink in the center) using zeolite (Provided by Oda)

$CO_2$. "Methanol is easy to handle as a chemical feedstock and can be used as a raw material for various substances. Methane has been used almost exclusively as a fuel because it is very stable as a substance and difficult to handle. But if it can be converted to methanol, it will have a much wider range of uses as a fuel and as a chemical raw material, just like ethane and propane."

## Developing technology for low concentration $CO_2$ capture

Oda and his colleagues have also developed a $CO_2$ adsorbent by placing calcium ions on zeolite. They have confirmed that it can selectively adsorb $CO_2$ even from gases containing $CO_2$ at concentrations as low as 400 to 5000 ppm (ppm is a concentration unit indicating parts per million).

"It is difficult to stop all $CO_2$ emissions, and in the future, technology to remove $CO_2$ directly from the atmosphere will be required. It is not easy to collect $CO_2$ that has diffused into the atmosphere, but if we can establish a technology to concentrate the diffused $CO_2$, it will collect $CO_2$ and be used in a wide range of ways. I believe that the development of $CO_2$ adsorbents will lead to technology that can directly remove $CO_2$ from the atmosphere," Oda expects further advances.




$CO_2$ adsorption on Ca ions arranged inside the pores of zeolite (Provided by Oda)

Oda had discovered the phenomenon that led to the creation of oxyl when he was an undergraduate student. However, he was told that the phenomenon was interesting but unbelievable. He was frustrated that he couldn't explain it well. "I wanted to convey the message more clearly, and to do so, I had to understand it better, so I did my best to research it. But before I knew it, I had completed my doctoral program (laughs). After that, as I combined experiments and calculations in my research life, I solved the mystery like unraveling a string, which led to this discovery."

Some experts from early on highly evaluated Oda's research. In 2013, when he was a graduate student, he was awarded the Nishina Prize, which recognizes outstanding graduates (or soon to-be) of science and engineering graduate schools in Okayama Prefecture. He was selected as a PRESTO (Precursory Research for Embryonic Science and Technology) researcher by JST. When he heard about the partial oxidation of methane, Oda was shocked to learn that the "Fairytale reaction exists!" This discovery is the fruit of his desire as a student to be able to create chemical reactions that a high school student could write but cannot realize. With this as a first step, he hopes to further contribute to constructing a decarbonized society.

## PROFILE

**ISOGAI Akira**

***Professor, Graduate School of Agricultural and Life Sciences, the University of Tokyo***

*Received Ph.D. in 1985 from the Graduate School of Agriculture, the University of Tokyo. After working as a postdoctoral fellow in the Department of Chemistry at the Institute of Paper Chemistry, USA, and as a professor at the University of Tokyo, he was appointed as the current position in 2020. Honorary Academic Doctor of Aalto University, Finland.*

**ODA Akira**

***Assistant Professor, Graduate School of Engineering, Nagoya University***

*Completed a doctoral course at the Graduate School of Natural Science and Technology, Okayama University, in 2015. After working as a visiting researcher (JST Sakigake researcher) at the Graduate School of Natural Science and Technology, Okayama University, he assumed his current position in 2019.*

'STI for SDGs' AWARD

'STI for SDGs' Awards 2020

# List of Awarded Initiatives

The 'STI for SDGs' Awards is an awards program that recognizes excellent initiatives to solve problems in local communities using Science, Technology and Innovation (STI). The program aims at the further development of the initiatives and their application to other communities facing similar problems in order to achieve the Sustainable Development Goals (SDGs).

sdgs-award@jst.go.jp https://www.jst.go.jp/sis/co-creation/sdgs-award/

## MEXT Minister Award

### The COI Cites, Tokyo University of the Arts

Development of "Daredemo Piano® (The Auto-Accompanied Piano)" — Universal use for people with disabilities to the elderly

Accompaniment and pedals follow the melody played by a single finger — The COI developed a piano with an automatic accompaniment function that allows anyone to play brilliantly. It has a wide range of applications, including education for children with disabilities and improvement of senior citizens QOL (Quality of Life).

## JST President Award

### Smolt, Inc., University of Miyazaki

Development of global warming-responsive species and sustainable production of salmon roe through recirculating aquaculture of cherry salmon

Based on the research seeds of Miyazaki University, Smolt independently developed heat-tolerant cherry salmon seeds. It realized complete recirculating aquaculture with the local community, aiming for sustainable production of fish meat and fish eggs.

## Excellent Practice Awards

### National Agriculture and Food Research Organization (NARO)

Optimizing regional water use through ICT-based paddy management


NARO developed an ICT-based water supply and drainage management system for paddy fields, "WATARAS," and a regional agricultural water distribution management system, "iDAS." It also proposed flood damage reduction technology using paddy fields.

### Japan Aerospace Exploration Agency(JAXA)

Protecting satellites that support people's daily lives from space debris to realize a sustainable society

JAXA developed "RABBIT," a risk analysis app that helps quickly, safely, and appropriately avoid collisions with space debris. The app is provided free of charge, contributing to the conservation of the space environment.

### Pine Grace

Utilization of unused local resources by veterinary science and forestry

Pine Grace developed creams and other products for livestock and pets by effectively using leftover wood from the forests of Sakhalin spruce, the "tree of Hokkaido." It also contributes to the creation of jobs in the region.

### Kochi University, Shizuoka Institute of Science and Technology, University of Miyazaki

Cross-Institutional initiatives to spread "gabion basket technology" that balances disaster prevention and environmental aspects

The universities focused on the traditional civil engineering technology "gabion basket" and scientifically verified it through cross-institutional research. The results have been used to promote the spread of the technique in Japan and overseas.

## Next Generation Awards

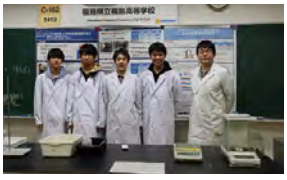
### Otemon Gakuin Otemae Junior and Senior High School Robot Science Club

Robot development activities aimed at solving SDGs issues based on design thinking

Junior and senior high school students, the future society players, proactively and cooperatively think over the causes and solutions of social issues such as the SDGs and develop robots to solve them.

### Fukushima Prefectural Fukushima High School

Development of secondary battery using magnesium and iodine



High school students in Fukushima Prefecture, who have been taking energy issues personally, created an inexpensive and safe secondary battery using magnesium and iodine, extractable from seawater.

JST SUSTAINABLE DEVELOPMENT GOALS

JST supports the Sustainable Development Goals

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