STST 2024

2024 Tongali GAP Fund Seeds Collection

Selected Tech Seeds For Startup in Tongali

Japan Science and Technology Agency　University-Based New Industry Creation Fund Project　Startup Ecosystem Co-Creation Program

STST 2024

THROUGH RESEARCH,
WE PIONEER THE FUTURE AND SOCIETY.

The Tokai Network for Global Leading Innovation (Tongali) implements
GAP funds and incubation programs utilizing the Japan Science and Technology
Agency's Research Results Deployment Project
<University-Based New Industry Creation Fund Project: Startup Ecosystem Co-creation Program>.
This initiative aims to foster university-based ventures in the Tokai region.
We introduce the promising business seeds with limitless potential from researchers selected
for this program in fiscal year 2024.

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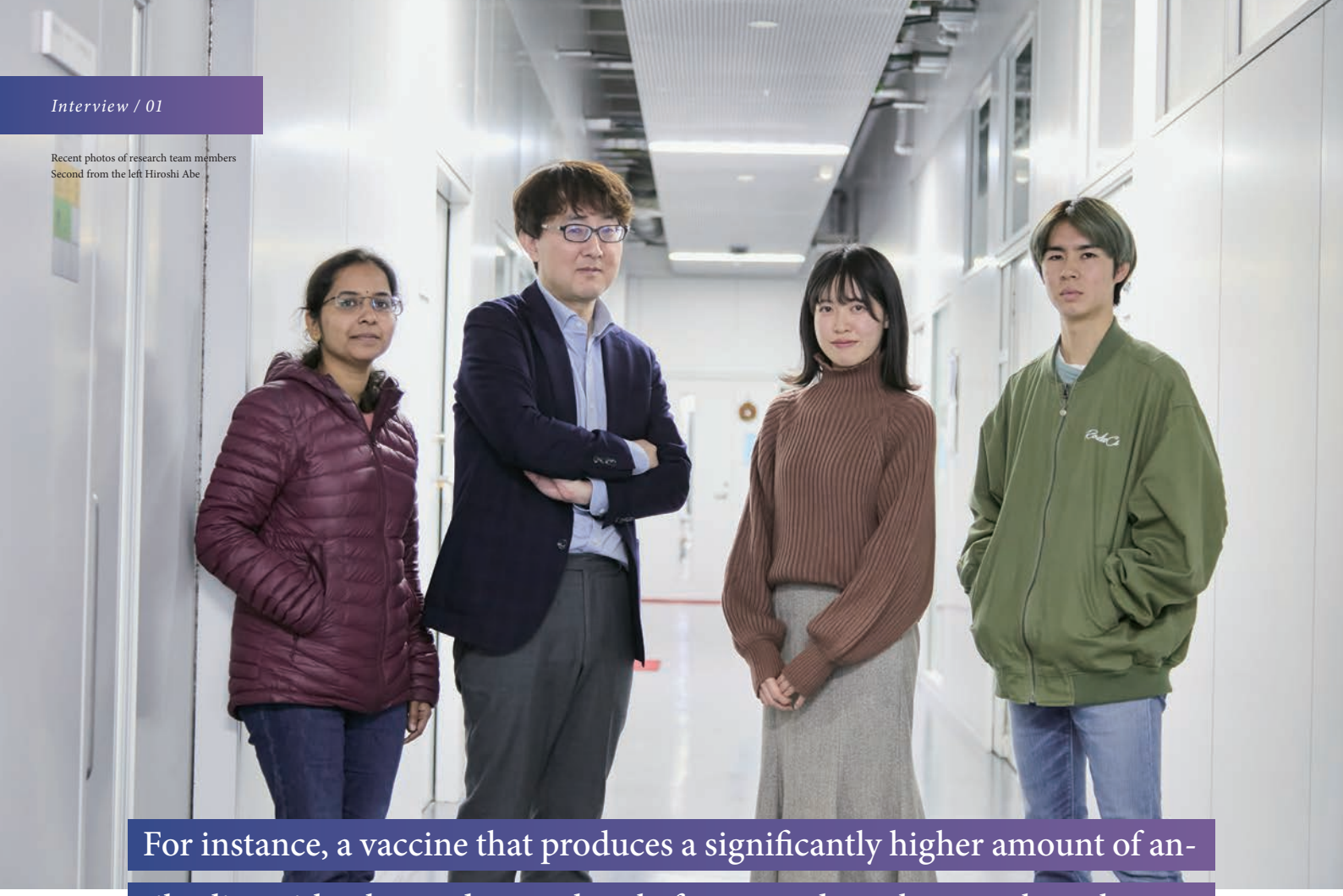

Recent photos of research team members
Second from the left Hiroshi Abe

For instance, a vaccine that produces a significantly higher amount of antibodies with a lower dosage than before, or a drug that attacks only cancer cells — this represents a new generation of drug discovery technology.

Nagoya University / Hiroshi Abe

Commercializing Circular RNA Technology

We are now in an era where mRNA itself can be used as a drug. However, the main challenge has been its stability within the human body.

When COVID-19 vaccines were introduced, many people likely heard the term "mRNA" (messenger RNA) for the first time. Explaining exactly what mRNA is can be complicated, think of it as a blueprint for producing desired proteins.
In human cells, protein synthesis constantly takes place using this blueprint, enabling the body to grow and the heart to function. One of its roles is to produce antibodies—proteins that fight off viruses.
mRNA vaccines work by introducing mRNA, which serves as the blueprint for the desired antibody, directly into the body, thereby prompting the immune system to produce those antibodies internally.
The downside of mRNA as a drug is that it is easily degraded in the body. mRNA is naturally designed to be broken down by enzymes after production of target protein. It's highly reactive and unstable. Therefore, when using mRNA as a medicine, it must be packaged in a stable delivery vehicle to ensure it isn't immediately degraded once administered into the body. The COVID-19 vaccines achieved this by using such a delivery mechanism, becoming the world's first groundbreaking mRNA pharmaceuticals. However, the lipid nanoparticle (LNP) delivery vehicle used in those vaccines triggered inflammatory reactions, leading to strong side effects like fever. While the success of an actual mRNA drug was epoch-making, it also highlighted the challenges of mRNA-based medicine.

To deliver mRNA alone without using a carrier, it is necessary to increase the stability of the mRNA itself.

In principle, the mRNA developed as a drug is harmless to the human body. If we can stabilize mRNA on its own without any delivery materials, adverse reactions could be avoided. This led to the development of a technology to make a normally linear mRNA assume a circular form. A circular molecule, having no ends, is very stable; but as a result, it becomes difficult for it to be translated (i.e. to produce protein) in the body. Therefore, in earlier approaches, a long nucleotide sequence called an IRES was attached to act as a translation start signal. Optimizing this IRES sequence was an attempt to improve translation, but that method never resulted in circular mRNA surpassing the translational efficiency of linear mRNA, and the very long IRES made manufacturing difficult.
Linear mRNA, on the other hand, has a cap structure at one end that serves as a signal to start translation. We focused on this, and subsequently attempted to introduce a cap structure into a circular mRNA. Generally, a cap structure is thought to promote translation initiation only when present at the end of an mRNA. Introducing a cap into the interior of a circular mRNA was unprecedented — an "unthinkable," yet revolutionary, idea. We named this concept internal cap-initiated translation (ICIT) and devised two molecular designs to achieve it. The first is a capped circular mRNA with a branching segment to which a cap structure is introduced (we call this Cap-circRNA). The second is another form of capped circular mRNA in which a cap-bearing molecule (an artificial capped oligonucleotide) is introduced in a distinct way (we call this CapAsRNA).

Innovative capped circular mRNA – stabilization leads an explosive increase in protein production.

Both of these novel molecules proved capable of inducing the ICIT phenomenon. First, as intended, Cap-circRNA's cap structure functioned as a translation initiation marker, allowing the target protein to be synthesized at high efficiency. Moreover, thanks to its high stability, the circular mRNA could be translated repeatedly. Compared to a competing technology — a circular mRNA using an IRES-dependent method — we observed over 200 times higher protein production with Cap-circRNA, an absolutely overwhelming performance. Even compared to conventional linear mRNA, its superior performance was evident: whereas protein yield from linear mRNA decays over time, the yield from Cap-circRNA actually increased over time due to its stability, and by 50 hours it produced more than tenfold the amount of protein produced by the linear mRNA.

On the other hand, CapAsRNA likewise achieved a similarly large protein output, but by altering the cap mechanism it exhibited a different function compared to Cap-circRNA. It works as a switch. Circular mRNA generally starts translation once it enters a cell. For example, we can design a CapAsRNA that encodes a cell-killing therapeutic protein such that it turns ON in cancer cells but stays OFF elsewhere. This CapAsRNA will then automatically distinguish between cancerous and normal cells at the single-cell level, producing the therapeutic protein only in cancer cells. In normal cells it remains OFF, so theoretically it causes no side effects. In fact, when we conducted experiments targeting liver cancer cells, the CapAsRNA operated only in the cancer cells and synthesized over 50 times more therapeutic protein than a typical circular mRNA.

Furthermore, the artificial capped oligonucleotide used in CapAsRNA can even be utilized on its own. Many circular RNAs are known to exist in living organisms. By introducing this artificial capped oligonucleotide into cells, we can enhance the translation of those endogenous circular RNAs in a similar way, achieving increases in protein production like we saw with CapAsRNA.

Unprecedented precision medicines: their principles hold untapped potential.

Having confirmed the principle through lab experiments, so we decided to pursue commercialization with a drug discovery venture. I've arranged for a student from my lab who was involved in the research to carry the project forward as a student-led startup — I'd like to see them set sail as a venture originating from our lab. There are a mountain of tasks ahead, from regulatory approval to designing production methods, but I hope to support the enthusiasm of these young researchers with my experience. I plan to provide the necessary support not only up until the launch of the business but also after it's up and running. By tackling such cutting-edge research, I would be delighted if my lab itself can serve as an incubator for startups — that would be the ultimate fulfillment for me as a researcher and an educator.

The significance of this research lies foremost in the two types of capped circular mRNA (Cap-circRNA and CapAsRNA) and the artificial capped oligonucleotide we developed, and in their potential to create an entirely new class of medicines. In short, it opens the door to developing precision drugs with no side effects. The concept of a medication that can be controlled at the level of individual cells is a completely novel idea that hasn't existed before. Additionally, the ICIT mechanism suggests that a similar mode of translational control by RNA might actually be occurring in living systems. Many papers have reported analogous phenomena. If we can shed light on such translation control mechanisms, it will lead to a deeper understanding of biological processes and various diseases. Beyond that, of course, it could enable the development of entirely new types of medicine. Above all, it's simply fascinating on an intellectual level.

Today's world calls for a positive cycle where the university, as a research institution, pioneers new knowledge and technology, and students use those results to start new ventures. And I believe this is entirely appropriate. Research that can quickly return value to society should be commercialized, and research that still needs time can simply be continued. I believe both are equally valuable.

Hiroshi Abe

Profile

Nagoya University
Hiroshi Abe

Professor, Laboratory of Bioorganic Chemistry, Department of Chemistry, Graduate School of Science, Nagoya University

- 1995.4–1996.3: Laboratory of Pharmaceutical Manufacturing (Prof. Shunichi Hashimoto), Faculty of Pharmaceutical Sciences, Hokkaido University.
- 1996.4–1998.3: Master's program, Laboratory of Biophysical Chemistry (Prof. Naoki Kamo), Graduate School of Pharmaceutical Sciences, Hokkaido University.
- 1998.4–2001.3: Doctoral program, Laboratory of Medicinal Chemistry (Prof. Akira Matsuda), Graduate School of Pharmaceutical Sciences, Hokkaido University.
- 2001.4–2002.3: Department of Chemistry (Prof. JoAnne Stubbe), Massachusetts Institute of Technology.
- 2002.4–2005.5: Department of Chemistry (Prof. Eric T. Kool), Stanford University.
- 2005.6–2013.8: Researcher, RIKEN Ito Nano Medical Engineering Laboratory (PI: Yoshihiro Ito).
- 2013.9–2015.3: Associate Professor, Laboratory of Medicinal Chemistry (Prof. Satoshi Shudo), Graduate School of Pharmaceutical Sciences, Hokkaido University.
- 2015.3–Present: Professor, Department of Chemistry, Graduate School of Science, Nagoya University.
- 2020.4–Present: Professor, Glycoscience Core Department, Nagoya University (Tokai National Higher Education and Research System).

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Focusing the latest wisdom of the entire medical community on a single patient with a difficult-to-diagnose — a brand-new medical framework made possible by the current era.

Nagoya University / Taiki Furukawa

Validation of a Remote Multidisciplinary Diagnostic Platform for Interstitial Lung Disease Based on a Nationwide All-Japan Registry, and Commercialization of a Treatment Program and Medical Device

A healthy lung that should be soft and rubbery like a sponge turns into a rigid, dried loofah. Depending on the underlying cause, the very medication can become poison — such is the difficulty of interstitial lung disease.

Interstitial lung disease is a disease in which the lungs, normally flexible and elastic like rubber, become fibrotic (scarred) and stiff, losing their ability to expand and contract, and gradually making breathing impossible. The causes are varied and often hard to pinpoint, which is a major challenge. As diagnostic accuracy has improved, the number of diagnosed patients has statistically increased, and interstitial lung disease has now risen to the 10th leading cause of death in Japan. In reality, there may be even more cases than reported.

The most common form, idiopathic pulmonary fibrosis (IPF), accounts for about 40% of interstitial lung disease cases. Other potential causes (differential diagnoses) are vast, including connective tissue diseases like rheumatoid arthritis, or viral and bacterial infections, among many others. In any disease where interstitial lung disease arises as a complication, the 5-year survival rate drops significantly. For example, if a patient has IPF, using a drug for a collagen vascular disease related interstitial lung disease might actually accelerate the IPF's progression. This is why a prompt and accurate diagnosis is critical. Yet the most reliable diagnostic method, the multidisciplinary discussion (MDD), requires a team of three specialists — a respiratory physician, a chest radiologist, and a lung pathologist — all with extensive experience diagnosing interstitial lung disease. Only a limited number of medical institutions in the country can assemble such expert teams. Furthermore, it's not uncommon that some cases can only be properly diagnosed after observing the patient's course over time, and about 30% of cases need to be re-evaluated. Clinicians must be willing to overturn an initial diagnosis and continually assess the patient's progression objectively. To save as many patients as possible, the top priority is to not overlook IPF, which is both the most frequent and one of the most prognostically dire forms. How to make the limited expert MDD teams accessible to far more patients is the crucial first step to saving lives.

Delivering Expert Team Diagnoses to Patients Nationwide
Enhancing Accuracy Through AI Support and Patient Data Collection

The five-year survival rate for idiopathic pulmonary fibrosis (IPF) is estimated to be between 30% and 50%—lower than that of many cancers. In recent years, drugs that can slow disease progression have become available; the earlier treatment begins, the sooner progression can be delayed—though these are not curative treatments. When diagnosis is difficult, surgery may be required for a definitive test, yet not all patients are physically capable of undergoing such procedures. To improve diagnostic accuracy, it is essential to enhance the precision using various tests such as chest CT scans and blood analyses. Moreover, ongoing monitoring and continued treatment after diagnosis are critically important. Ideally, patients' conditions would be monitored daily, enabling tailored treatment or rehabilitation advice in real time.

However, the reality is that the number of expert teams capable of making accurate judgments is limited, and so is the information available to guide those decisions. At the same time, ongoing support for patients is essential.

To address this issue, we have begun building a comprehensive framework that includes:

1.Online Multidisciplinary Discussion (MDD) by expert teams — a high-precision remote diagnostic board

2.AI-assisted diagnostic and prognosis tools using a nationwide case database

3.An integrated medical system that collects and analyzes daily patient data using at-home pulmonary function testing devices, and provides personalized treatment nudges

We initiated this effort as a commercialization project. In FY2022, we received support through the GAP Fund STEP 1, and in the current year, the project has been selected for STEP 2.

These led to the launch of the All-Japan Interstitial lung disease Registry (PROMISE Study), aimed at verifying the clinical value of online MDD diagnoses and the utility of AI systems in supporting diagnostic decisions.

Three mechanisms working together for accurate diagnosis and effective treatment. We designed and developed an integrated system in which three components collaborate to improve diagnosis and treatment for interstitial lung disease:

1.Online MDD Diagnosis: The ideal solution to the shortage of expert teams for MDD would be simply to increase the number of such teams. However, with the success of component (2) below – which achieved AI diagnostic accuracy on par with expert inter-rater agreement – we changed our approach. Now we aim to use AI for most cases, and only in difficult cases do we call upon an expert MDD review. This makes nationwide remote diagnosis far more feasible. We plan to have this remote diagnosis covered by health insurance, aiming to create a service that anyone can realistically utilize.

2.AI for Diagnosis, Prognosis, and Treatment: Our AI development has progressed considerably. We achieved an IPF diagnostic accuracy of 83.6%, which is on par with the agreement rate among expert clinicians and much higher than the ~50% accuracy of general respiratory physicians, and we have obtained a patent for this diagnostic AI. Using data from the PROMISE trial, we also developed an AI that predicts prognosis with 86% accuracy (patent pending). Furthermore, using treatment outcome simulation, the system can recommend the optimal medication for each patient. Entrusting each step — diagnosis, prognosis prediction, and therapy selection — to AI is a first in the medical field. We are now in the process of getting this AI system approved as a medical device.

3.Daily Monitoring Device: The third component is a compact lung function testing device that the patient uses at home. It collects critical vital data daily and transmits it to the treatment AI (component 2), which continuously updates the follow-up and prognosis predictions and informs the physician. If any important warning signs appear, the system immediately issues an alert to prompt the patient to seek care, functioning as a safety net. The device also has features to encourage patients to perform their at-home treatment activities — from taking medication to daily rehabilitation exercises. We have filed two patents related to these home-care support technologies. In addition, we obtained approval in Japan for a monitoring device (imported) to be used for tracking these patients. Specifically, we have built a monitoring tool that wirelessly connects a smartphone with a testing device (managed via an app) and links to the hospital's AI system via the cloud. This setup is already in place, allowing patients to use it at home.

Ultimately, the aim is not merely developing new tools. It's about designing and building a next-generation medical system.

The world has changed in the time since we began this project. I can feel that the medical community's perception of remote diagnosis has evolved, as has the willingness of patients to input their own treatment data — society is becoming more receptive to this kind of system.

Looking back at the project, our technical progress was relatively smooth; I feel we executed our plan steadily. The challenge, perhaps, was speed.

At the same time, we have also been working to establish the necessary social frameworks (such as regulatory and institutional support) to make this project viable. For example, because our platform relies on MDD reviews by specialists, we created a certification system for MDD physicians to ensure the quality of participating doctors and keep track of our expert pool.

With every step into uncharted territory — be it remote diagnosis or medical AI — we encountered the wall of "no precedent." Overcoming one barrier often meant solving another new problem first. In hindsight, the sheer number of challenges we've had to tackle is a testament to how fundamentally new this project is. Yet day by day, I feel the tangible sense that we are creating a new structure for healthcare. It's a system that supports the individual points of doctors and patients with a network (a "plane") of services like MDD and AI. It's a system where not only the visible team members, but the entire medical society in the background functions as a dynamic team supporting the patient — going beyond just serving as a static database. Such a mechanism has never existed before. But to face diseases like interstitial lung disease — a difficult illness that remains poorly understood — we need a system that enables an all-hands approach at any time. There is still so much work I need to do. That's why we would warmly welcome people who can help drive the development and maintenance of our medical AI, or who can take on designing and operating the structures needed to make this a viable enterprise. In a "no precedent" world, any gaps in knowledge can be covered with effort. What we truly need are teammates with the drive to take on this challenge and work hard together. We are eagerly recruiting such people to join us.

(Note: Dr. Furukawa's previous project was featured in the GAP Fund Program brochure "STST2022," available at the Tongali website: https://tongali.net/x/stst/)

Taiki Furukawa

Profile

Nagoya University
Taiki Furukawa

Deputy Director, Medical IT Center, Nagoya University Hospital

- 2011: M.D., Nagoya University School of Medicine. Completed initial residency at Tosei General Hospital, then entered the field of respiratory medicine.
- Worked at the department of Respiratory Medicine, Nagoya University Hospital and RIKEN Image Processing Research Team.
- 2018: Appointed Special Assistant Professor at the Medical IT Center, Nagoya University Hospital; Deputy Director of the Medical IT Center since 2023.
- Awards include the Fukuchi Award and presentation prizes from the Japanese Respiratory Society and the Japanese Association for Medical Artificial Intelligence. Has also served as a committee member for the Japanese Respiratory Society's Insurance Committee, among other roles.
- Actively promotes remote diagnosis, AI-based diagnosis, and decision support in the management of interstitial lung disease.

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Overcoming the challenges of nucleic acid therapeutics — touted as "next-generation medicines" — through an unconventional approach. A completely new structural concept that enables the creation of drugs that were previously impossible to make.

Nagoya University / Hiroyuki Asanuma

Commercializing Acyclic Artificial Nucleic Acids as a New Modality in Nucleic Acid Therapeutic Development

Nucleic acid therapeutics: A new option in molecular targeted drugs that precisely attack the molecules causing disease and symptoms.

A specific molecule that causes a disease or symptom—Drugs that precisely target and regulate the function of such molecules are known as molecular targeted therapies. Most of these drugs are used in cancer treatment, but they are also being developed for autoimmune diseases. There are various types of molecular targeted drugs, such as small-molecule drugs and antibody therapies, and in recent years, a new category has emerged: nucleic acid therapeutics. This rapidly advancing field is gaining attention as an innovative approach to treating cancers and genetic disorders.

"Nucleic acids" is a collective term referring to DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). DNA is often described as the blueprint for building an organism, and what this blueprint actually describes is how to make proteins.

Proteins—chains of amino acids—carry out a wide range of essential biological functions. DNA stores genetic information, which is transcribed into messenger RNA (mRNA) and used to synthesize proteins. Understanding this mechanism is key to understanding how nucleic acid therapeutics work.

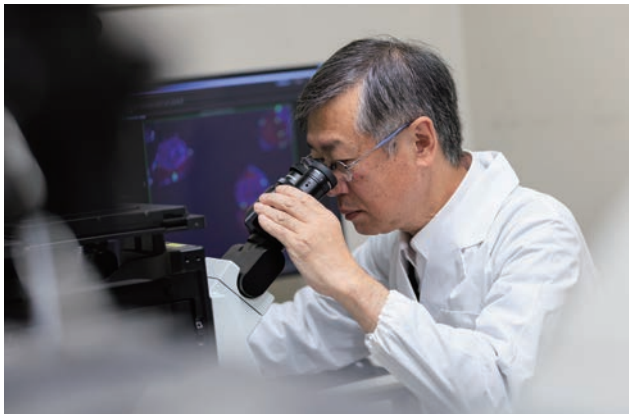
mRNA consists of a chain of substances called nucleotides. After copying the necessary information from DNA (transcription) as mRNA, it moves to a structure called the ribosome. There, amino acids are linked together in the sequence specified by the nucleobases on the mRNA (a process called translation) to produce a desired protein. Nucleic acid therapeutics intervene in this process. They can inhibit the transcription or translation of mRNA, or even degrade the mRNA itself, thereby preventing the production or activity of harmful proteins.

Nucleic acid therapeutics, also known as next-generation medicines, have major advantages—but also pose significant challenges.

Nucleic acid therapeutics work by targeting and eliminating the root causes of illness, directly acting on the underlying source of the disease from the outset. Because of this precise mechanism, the effects of these medications are readily achieved, and given the limited impact of medication, the burden on the body is reduced. These drugs are essentially synthetic DNA or RNA, designed based on the identification of disease-related genetic sequences. A key feature of this approach is that the therapeutic molecules can be rationally designed using computers, allowing for a significant reduction in trial-and-error during the development process.

As a result, the time required for new drug development—which traditionally took years—can potentially be shortened to just a few months. Another advantage is that these drugs can be produced through chemical synthesis, making them relatively inexpensive to manufacture.

However, there are downsides as well. Normally, what happens if DNA that isn't native to the human body gets inside us? It gets eliminated in an instant. Just like a pathogen, it's recognized as a foreign invader, and our enzymes immediately go to work breaking it down. This is a vexing problem. Mechanistically, its structure needs to resemble human DNA or RNA; otherwise the intended mechanism (binding to the target, etc.) won't work. But if the structure is too similar, the enzymes will recognize it as "DNA (or RNA) that's not human" and promptly degrade it. To overcome this, chemical modifications to DNA were developed. These modifications prevent enzymes from recognizing the molecule as DNA, and to an extent this approach works. However, depending on how the DNA/RNA is chemically modified, the modified nucleic acid or its breakdown products can end up being toxic, which is not a trivial issue for a medicine.



A solution that seemed absurd at first glance – overcoming nucleic acid drug drawbacks by altering the backbone structure.

Natural nucleic acids such as DNA and RNA contain a five-membered ring structure called ribose. Due to its ring structure, DNA can maintain its famous double-helix form. When creating synthetic nucleic acids, it is common practice to incorporate ribose to mimic natural nucleic acids and apply chemical modifications to prevent enzymes from recognizing them as natural DNA/RNA. In fact, most of the synthetic nucleic acids studied so far have included ribose, and it has long been commonly understood that without ribose, these molecules would not function properly. Once synthetic nucleic acids have fulfilled their therapeutic role, they are broken down in the body. However, in some cases, either the nucleic acids themselves or their degradation products can exhibit toxicity, posing side effects that cannot be ignored in the context of drug safety.

This is where our specially designed artificial nucleic acids come into play. We developed two types of *non-cyclic* artificial nucleic acids that, despite lacking the usual ribose ring structure of natural DNA/RNA, can still recognize DNA and RNA. By removing the ribose (the ring), the backbone structure is drastically different from natural nucleic acids, which makes our molecules extremely resistant to enzymatic degradation. At the same time, because we can confer the ability to hybridize with DNA/RNA, these molecules have high affinity for RNA and can properly exert their intended mechanism of action on target sequences. In addition, when the drug has done its job and is being broken down, enzymes will not mistake it for a natural nucleic acid, so it maintains a high level of safety. In short, this is an entirely new-concept artificial nucleic acid that overturns conventional wisdom.

There are further advantages. The synthesis of our molecules is extremely simple, which potentially keeps production costs low. Its flexible structure allows for diverse functionalization. In other words, our artificial nucleic acids retain all the strengths of nucleic acid drugs while overcoming their weaknesses. In fact, across many benchmarks, they delivered performance equal or superior to competing technologies. We are now launching a new startup venture to develop nucleic acid therapeutics using these *acyclic* artificial nucleic acids as a drug discovery platform.

First, in the drug discovery arena, we want to create drugs that simply couldn't be made before. Beyond that, we aim to push the possibilities even further.

We are considering two routes for our business plan. One is a pipeline model: we ourselves will identify therapeutic targets and develop nucleic acid drugs for them, then license these out to pharmaceutical companies or biotech companies to receive royalties and related revenue. The other pillar is a co-development model: we work jointly with pharma/biotech partners who provide targets, collaborating on drug design. In this model, we would earn license fees for our artificial nucleic acid technology and milestone payments as the research progresses. We have already begun work on concrete drug development projects.

Currently, the nucleic acid drug we are developing is a treatment for polycystic kidney disease. We're targeting Autosomal Dominant Polycystic Kidney Disease (ADPKD), a genetic disorder where fluid-filled cysts form in both kidneys and gradually enlarge. It's the most common hereditary kidney disease. In a joint research effort with Dr. Noritoshi Kato of Nagoya University School of Medicine, we identified a target sequence for ADPKD. When we administered a new nucleic acid drug based on our technology to mice, it clearly suppressed the growth of the cystic kidneys. Importantly, we observed no toxicity of concern at all. Not only did the treatment halt disease progression, but the mice's kidney function showed signs of recovery — a result that gave us great confidence.

Creating drugs that couldn't be created before using acyclic artificial nucleic acids alone holds immense potential, but the future scope of this technology doesn't stop there. Take DNA nanotechnology, for example. This is a field in which DNA's structural properties are used to design and construct nanoscale structures, with applications spanning medicine, materials science, nanomachines, and more. The two types of non-cyclic artificial nucleic acids we developed could play an interesting role in that field as well. Opening up yet-unseen possibilities with a new technology — that is precisely where the true thrill of R&D lies.

Profile

Nagoya University
Hiroyuki Asanuma

Professor, Department of Biomolecular Engineering, Graduate School of Engineering, Nagoya University

- Ph.D. in Engineering from The University of Tokyo (completed doctoral program in Industrial Chemistry).
- Formerly Researcher at Fujifilm Ashigara Laboratory; Assistant Professor at The University of Tokyo Graduate School of Engineering; and Associate Professor at The University of Tokyo Research Center for Advanced Science and Technology. Has been a full Professor at Nagoya University Graduate School of Engineering since 2005.
- Engages in research on the design of photo-functional nucleic acids via nucleic acid analogs, and on the creation and application of acyclic artificial nucleic acids.
- Reference publication related to this work: Chem. Commun. 2022, 58, 3993 (DOI: 10.1039/d1cc05868a).

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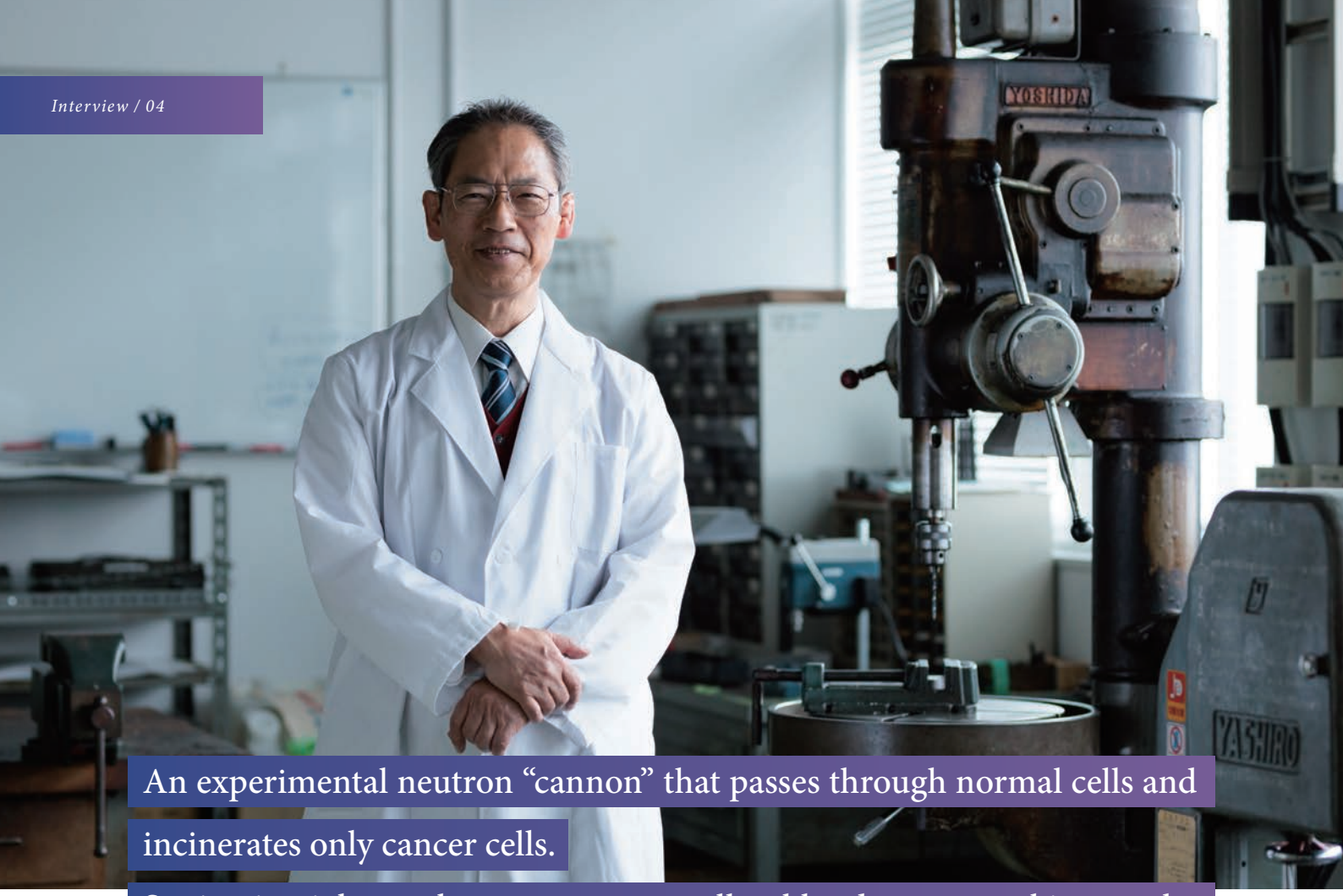


An experimental neutron “cannon” that passes through normal cells and incinerates only cancer cells.

Setting its sights on breast cancer as well as blood cancers, taking on the challenge of clinical implementation.

Nagoya University / Akira Uritani

Commercializing BNCT-Based Therapy for Blood Cancers and Breast Cancer

Everyone has dreamed of being able to eliminate only the cancer cells — and this can be achieved not by magic, but by science.

In cancer surgery, for instance, you typically have to remove even the healthy tissue around a tumor. No matter how carefully a tumor is resected, there's a high chance microscopic cancer cells remain hidden nearby. How wonderful would it be if we could selectively wipe out the cancer cells, including those tiny ones mingling among normal cells? It sounds almost like magic, but it isn't. Under certain conditions, here in Japan there is a treatment (covered by insurance) that does exactly that: a cancer therapy called BNCT.

BNCT stands for Boron Neutron Capture Therapy. In June 2020, BNCT was approved for insurance coverage for the indication of “unresectable locally advanced or locally recurrent head and neck cancer.” Here's how it works: Cancer cells have a tendency to hoard certain compounds that normal cells do not readily take up. If we attach boron to such a compound and administer it by IV drip, the drug will distribute preferentially to cancer cells only. Then, when we irradiate the area with neutrons, the boron atoms undergo a nuclear fission reaction that destroys the cancer cells from within. The reaction is contained within the cancer cells, so the surrounding normal cells are hardly affected.

BNCT is a type of radiation therapy and, in principle, it can work on any cancer. However, hematopoietic stem cells (which produce blood) are the most radiation-sensitive cells in the body, so BNCT was long thought to be unsuitable for blood cancers. We have now gotten past that hurdle thanks to two developments: the creation of a drug that delivers a much higher concentration of boron to cancer cells, and the development of an irradiation device that produces high-quality neutrons. In other words, the pieces are in place to make BNCT for blood cancers feasible.

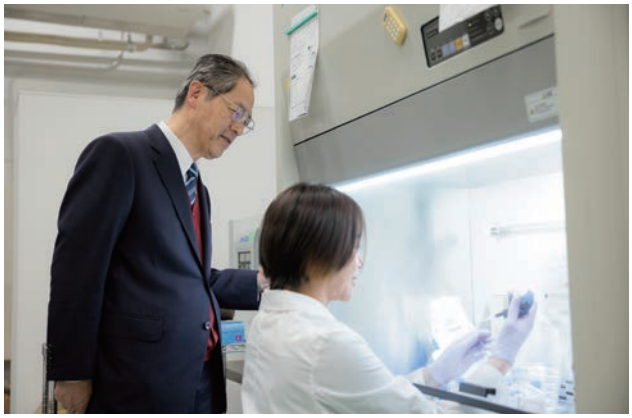
Performing BNCT on hematopoietic stem cells — a seemingly outrageous idea. Using a one-of-a-kind technology to initiate a new blood cancer treatment business.

By combining two patented technologies—OKD-001, a novel drug developed at Okayama University that contains an exceptionally high concentration of boron, and a compact accelerator-based neutron source developed at Nagoya University that produces neutrons with the ideal energy spectrum while avoiding unnecessary radiation—we have created a path to make BNCT treatment for hematopoietic stem cells a reality.

Our treatment protocol begins with harvesting hematopoietic stem cells from the patient. These cells are then exposed to BNCT in order to destroy any cancerous cells they may harbor. Meanwhile, the patient undergoes chemotherapy to eliminate cancer cells within the body. Fortunately, there are effective chemotherapy drugs for blood cancers. Administering these at higher doses eliminates both cancer cells and the patient's remaining hematopoietic stem cells. Finally, the patient's own BNCT-treated stem cells are reintroduced through autologous transplantation, eliminating the risk of rejection.

The harvested stem cells are cryopreserved in special containers called graft bags, which can be irradiated directly with neutrons to reduce the risk of infection.

The systemic treatment to eliminate cancer cells from the patient's body can be carried out at a local medical facility, while the BNCT procedure for the stem cells is performed at Nagoya University, which is equipped with the neutron source. Medical-grade cold-chain transport bags, already commercialized for use in COVID-19 vaccine distribution, are used for safe, long-distance, low-temperature transport and storage. We have begun proof-of-concept trials to move toward commercialization using this framework.This initiative was supported by the GAP Fund in FY2022 and forms the foundation of our current progress.



Graft bag durability tests: cleared. Now turning our sights to breast cancer.

In moving toward commercialization, we conducted efficacy tests for a new drug called OKD-001 and durability tests for the graft bag used in the procedure. The graft bag passed the durability tests with no issues — it can be used as designed. And in experiments, the new drug produced overwhelmingly superior results compared to existing agents. The next step is to carry out clinical trials of the new drug, which means proceeding with the drug approval process. In the treatment protocol we envision, the BNCT procedure is performed on harvested cells ex vivo (outside the body) using the graft bag, so OKD-001 is never directly administered into the patient. After treating the cells, the drug is removed by centrifugation, leaving only a minuscule amount of drug with the hematopoietic stem cells. Therefore, we anticipate the drug could receive approval relatively quickly.

While we advanced our research, a new opportunity emerged. When we presented our work, a group reached out to us expressing interest — a medical institution that performs radiation therapy for breast cancer. After we commercialize the BNCT treatment for hematopoietic stem cells, the next step we had envisioned was to apply this therapy to solid tumors inside the body. Unexpectedly, that opportunity has come sooner than we thought. The target would be a type of breast cancer known as triple-negative breast cancer, which tends to be particularly aggressive. Triple-negative breast cancer accounts for 15–20% of breast cancer cases. It progresses quickly and has a high risk of recurrence, and because it doesn't respond to hormonal therapy or HER2-targeted treatments, the available treatment options are limited compared to other breast cancers. Since no definitive treatment exists yet for this subtype, the institution took notice of our research.

If we move BNCT into breast cancer, we need to reconsider our strategy for OKD-001's drug approval, because in that scenario the drug would be administered directly into a patient's body. We are examining various strategies, but for now it seems best to proceed as originally planned: first obtain drug approval for the ex vivo hematopoietic stem cell application (as initially designed), and use that step as a foothold before moving on to clinical trials for in vivo use in patients.

Ex Vivo (outside the body) and In Vivo (inside the body) – adjusting course to pursue two pillars of commercialization.

As expected, our plan now is to first commercialize, as originally planned, the "BNCT autologous transplant" for hematologic malignancies (Ex Vivo business; ex vivo meaning outside the body). Building on the know-how and funds obtained from that, we will then aim to realize an in vivo BNCT treatment for triple-negative breast cancer (in vivo meaning inside the body).

In the in vivo program, by using our highly potent new drug OKD-001, we can minimize the accumulation of boron drug in organs like the lungs, blood vessels, and heart (which are sensitive and limit the radiation dose). This means we can aim to eliminate the cancer while keeping side effects to surrounding organs in check. Moreover, our neutron generator — the Dynamitron — can perform multi-port irradiation from multiple angles without moving the patient. This is expected to allow neutrons, which normally don't easily reach deep into the body, to penetrate to the deep-seated tumor. The neutron output is also very high, with no high-energy neutrons mixed in and low gamma-ray contamination, which makes it extremely well-suited for BNCT treatment of solid tumors inside the body.

The main challenge remaining for commercialization is to further improve the reliability of the equipment. We are planning system upgrades to address this, and prospects are good. In fact, being able to contemplate the in vivo treatment path at this stage is a positive development — it's a domain we always wanted to tackle eventually, so better to start sooner. Most importantly, we now have to determine the optimal path to get OKD-001 approved and consider what to be mindful of when expanding to clinical use. Expertise in medical and pharmaceutical areas like drug approval isn't something we in the engineering field can cover by ourselves. If we can bring on board various specialists in medicine and pharmacology as partners, we can accelerate the commercialization. And above all, it will be a big step toward our ultimate goal: making BNCT applicable to all cancers and turning cancer into a curable disease.

We are planning to launch the ex vivo business by 2027. There are still numerous hurdles to overcome by then, but we intend to push forward steadily.

(Note: Professor Uritani's previous project was introduced in the GAP Fund Program brochure "STST2022," available online: https://tongali.net/x/stst/)

Akira Uritani

Profile

Nagoya University
Akira Uritani

Professor, Department of Energy Engineering, Graduate School of Engineering, Nagoya University

- Withdrew (after obtaining required credits) from the doctoral program in Nuclear Engineering at Nagoya University Graduate School of Engineering. Ph.D. (Engineering).
- Served as Assistant Professor and Associate Professor at Nagoya University Graduate School of Engineering, then as Senior Researcher at the National Institute of Advanced Industrial Science and Technology (AIST). Has been a Professor at Nagoya University Graduate School of Engineering since 2005.
- Former director of the Japan Society of Applied Physics and current director of the Japan Society of Atomic Energy. Specializes in radiation measurement and its medical applications.
- Since 2013, in collaboration with a private company, began developing a neutron source using the world's first Dynamitron and lithium target, and initiated fundamental research on BNCT.

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Peritoneal dissemination – cancer cells scattered throughout the abdominal cavity.

A new therapy to quench the wildfire of metastasis efficiently.

Nagoya University / Mitsuro Kanda —— Antisense Drug for Gastric Cancer Peritoneal Dissemination (Phase I Clinical Trial)

A particularly dire form of metastasis, with a one-year survival rate of only around 20%, had nonetheless been long consigned to the back burner.

To get straight to the point: we are working on a new, effective treatment specifically for peritoneal dissemination, one of the most pernicious forms of gastric cancer metastasis. "Cancer" is not one single entity — even cancers in the same organ can progress in completely different ways. However, until now, most research and treatments have focused on addressing each cancer type by organ (for example, "if it's gastric cancer, use this treatment protocol") rather than focusing on differences in metastatic patterns. Approaches outside of the standard organ-by-organ treatment paradigm have scarcely been tried.

From the perspective of saving as many patients as possible, that conventional approach makes sense: developing treatments for the majority of gastric cancer cases and thereby improving overall survival in gastric cancer. Indeed, through such efforts, the overall survival rate for gastric cancer has steadily improved. But if you pay attention to the differences in progression patterns, you realize something has been completely left behind: peritoneal dissemination. Unlike "hematogenous metastasis" or "lymphatic metastasis," where cancer cells spread gradually through the bloodstream or lymphatic system, peritoneal dissemination occurs when a gastric tumor grows and then directly sheds a large volume of cancer cells throughout the abdominal cavity. Because hematogenous and lymphatic metastases occur in many types of cancer, research has understandably prioritized them. Peritoneal dissemination, on the other hand, is mostly limited to gastric, pancreatic, and ovarian cancers, so it was inevitably put aside. As a result, to this day there is no effective treatment for it, and the one-year survival rate after diagnosis is only about 20%. (It's such an aggressive condition that the usual 5-year survival metric for cancer can't even be applied.)

A spark ignited by gastric cancer turns into an explosion, spreading flames wherever it lands. Standard chemotherapy can hardly keep up.

Currently, there are three major types of realistic cancer treatments: surgical therapy, which removes cancer through an operation; radiation therapy, which attacks cancer with targeted radiation; and pharmacotherapy, which uses anti-cancer drugs to kill cancer cells. Peritoneal metastasis from gastric cancer refers to a condition where countless cancerous nodules of varying sizes have spread throughout the abdominal cavity. Removing all of them surgically or targeting each one individually with radiation is virtually impossible. Pharmacotherapy is the only realistic option. However, pharmacotherapy involves delivering drugs—by oral administration or intravenous infusion—throughout the entire body in hopes of reaching and killing even the tiniest, hidden cancer cells. But in the case of peritoneal metastasis, which spreads and grows rapidly like a raging wildfire, this approach is, quite literally, a drop in the ocean. The treatment simply cannot keep pace with the disease's progression.

This leads to the first approach: implanting a drug reservoir directly into the abdominal cavity to deliver anti-cancer agents continuously and locally to the peritoneal metastases. Building on this, the second approach aims to further enhance the effectiveness of treatment by developing a drug specifically designed for this method.

In fact, a clinical attempt has already been made using a reservoir to deliver an existing chemotherapy drug—paclitaxel—directly into the abdominal cavity. While this did show some improved efficacy, it fell short of expectations. This underscores the need for a drug uniquely suited to the characteristics of peritoneal metastasis, which is why research into the second approach is now of critical importance.

Stays in the abdomen and annihilates the cancer – a drug concept unlike any existing chemotherapy.

We have set out to develop a drug that can effectively eradicate peritoneal dissemination, and we identified three conditions the therapy must meet, assuming we will deliver it directly into the abdominal cavity where the metastasis resides:

1.Stay at the tumor site: The drug must not easily wash away from the sites of peritoneal dissemination. If the therapeutic molecule is too small, it will pass readily through tissues and get carried off via lymphatic fluid or bloodstream, spreading throughout the body. If the drug won't remain where we need it, it can't exert sufficient effect. Therefore, the drug's molecular size needs to be large, so that it stays in the abdominal cavity and doesn't easily leak away.

2.Enter cancer cells easily: The drug must possess properties that allow it to be readily taken up by cancer cells. The downside of making a molecule large is that it typically crosses cell membranes poorly, meaning the cancer cells in the peritoneum might not absorb it well. Fortunately, a team at Osaka University had succeeded in developing a drug that meets these first two conditions. By collaborating with that team, we saw a clear path to satisfying this requirement.

3.Highly potent against peritoneal metastasis: The drug should be especially effective in eliminating peritoneal dissemination. This is where our own research contributed uniquely. Through extensive observation and testing from various angles, we discovered a certain protein (called SYT13) that is frequently produced by cancer cells that readily cause peritoneal dissemination. When we experimentally inhibited the expression of SYT13 with a therapeutic agent, the cancer cells that were causing peritoneal dissemination could no longer proliferate. It was exactly the effect we had hoped to see.

No matter how "immortal" cancer cells may be, if they can't multiply or move, they will eventually die out — deprived of oxygen and nutrients. Using this strategy, we were able to develop a new drug that meets all three conditions. This new treatment method can drastically improve our ability to halt peritoneal dissemination. To use an analogy, if conventional systemic chemotherapy is like fighting a massive wildfire (peritoneal metastasis) with a mere drizzle, then our new therapy is like continuously pouring a torrent of fire suppressant directly onto the flames.

We hope to ease the suffering and improve the prognosis of patients who, unfortunately, develop peritoneal metastasis.

The expected benefit of this therapy boils down to improving survival outcomes. In mouse experiments, we have confirmed very strong efficacy, and we anticipate it can significantly extend survival time after treatment. By preventing the bowel obstructions caused by the metastatic lesions, reducing malignant ascites build-up, and decreasing the morphine needed for pain management, it should also improve patients' quality of life. Our aim is that, even if someone is stricken with such a severe illness, they won't have to abandon all hope and can still live their life as fully as possible. And if this approach succeeds, we could potentially extend it to peritoneal dissemination arising from pancreatic and ovarian cancers as well.

From a business standpoint, as of FY2025 we are finally about to initiate a clinical trial (Phase I) in human patients. It has taken many long years to reach this point. At each stage, we formed various teams and relied on the efforts of many people to get here. However, I believe the real challenge starts now. Even after reaching clinical trials, countless new treatments have failed to reach clinical practice. But if we don't take on the challenge, we will never open new doors. Our plan is to tackle each step carefully, with no corners cut.

I'd like to add one more thought. I feel that this endeavor is something made possible precisely because we leveraged the university startup model. A typical pharmaceutical company, being an ordinary business, would from the outset be compelled to invest in areas with large patient populations — in other words, targets where they can help the greatest number of people. Of course, that is very important, because it's an efficient way to save as many lives as possible. On the other hand, it's not acceptable to simply ignore patients who are in dire, hopeless situations just because they are fewer in number. I believe this is where the significance lies in a clinician like myself, who is actually involved in frontline medical care, engaging in research and development. If this venture-style approach can save lives that would otherwise be abandoned by a pure numbers game, it becomes another way to save lives — a complementary means to rescue even more people. That's how I see it.

Mitsuro Kanda

Profile

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- 2001: M.D., Nagoya University School of Medicine.
- 2010–2012: Visiting researcher, Johns Hopkins University (USA).
- Gastrointestinal surgeon focusing on esophageal and gastric cancers, while actively conducting translational research on gastrointestinal cancers.
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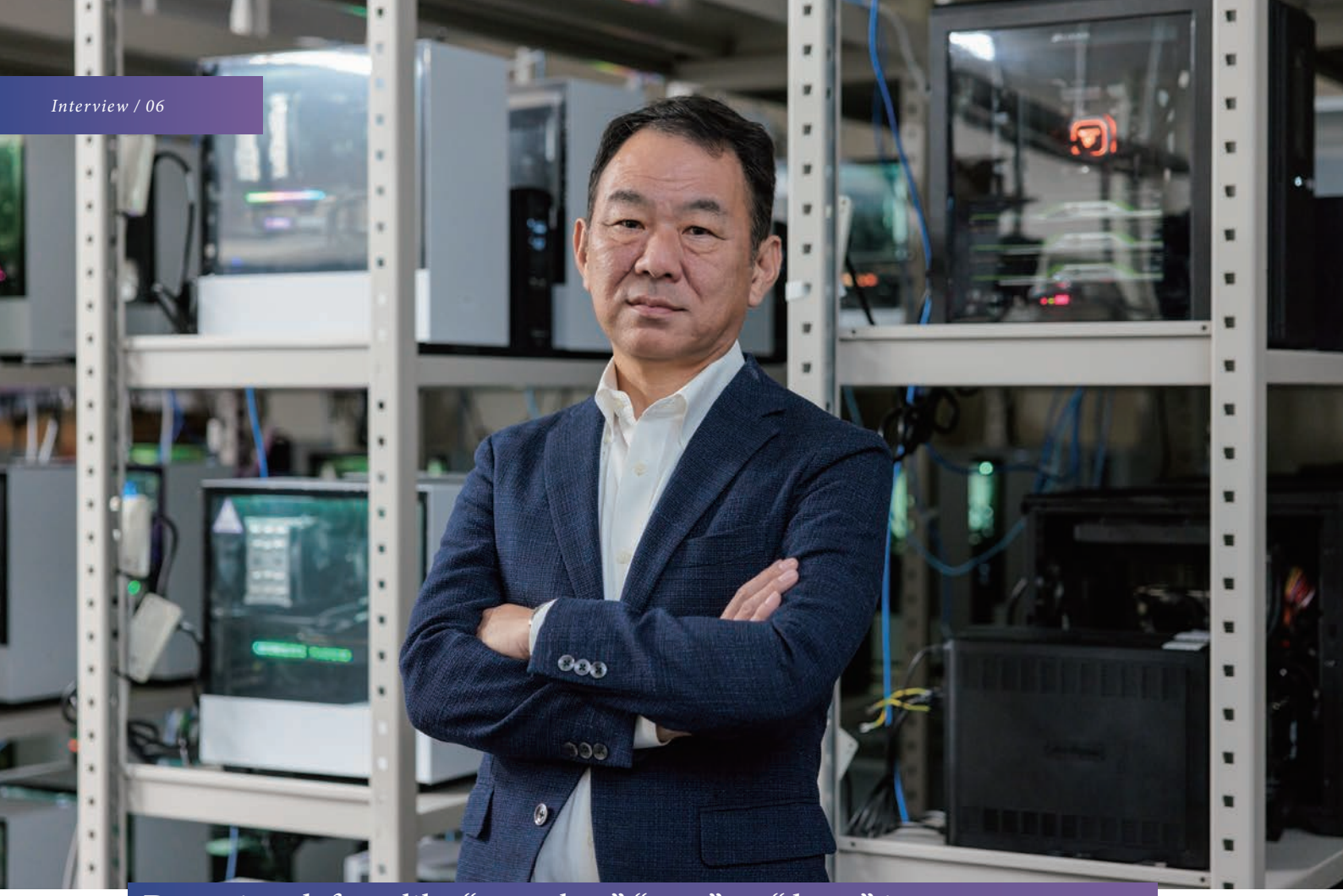


Detecting defects like “scratches,” “rust,” or “dents” in components — A technology to achieve expert-level visual inspection with AI.

Gifu University / Kunihito Kato

General-Purpose Visual Inspection AI Technology Using a Vision Language Model (VLM)

“Solving the severe labor shortage with AI” — it turned out to be an extremely tough problem that was much easier said than done.

In manufacturing, there is a task called visual inspection, where workers check parts for defects such as scratches, rust, or dents to ensure product quality. It’s a crucial step where human inspectors use their eyes to spot flaws. Many factories have introduced machines for automated visual inspection that use sensors or cameras to detect defects. However, the reality is that such systems are only practical if you have a production scale large enough to justify the cost.

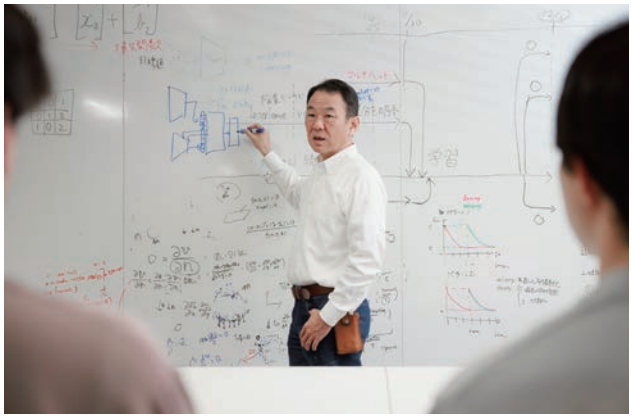
This task, though simple in concept, requires maintaining close attention over long periods and an eagle eye to catch even tiny defects, so it takes skill and training — and virtually every company is facing a shortage of people for the job. Hence the thought: can’t we have AI (artificial intelligence) do this? Anyone with a bit of tech knowledge has probably had that idea. Indeed, AI that never gets bored or tired, and can remain constantly focused, seems perfectly suited to such work. In fact, AI-based image inspection has been researched in various fields. However, to train an AI to tell good products from bad, you need a huge number of images of both classes.

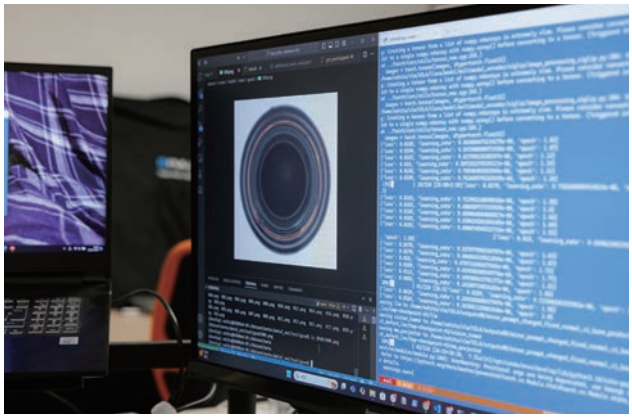
And that is the problem. In a factory, the defect rate might be less than 1% — perhaps at most 1 defective part out of 100 made. Meanwhile, training an AI typically requires on the order of thousands of images. You simply can’t gather enough sample images of defective products. Even if you somehow could, an AI that learns from, say, a few thousand examples will make its judgments based on those seen examples, and it won’t be able to explain why something is classified as defective. In short, without a whole lot of ideal conditions lining up, implementing AI for this was thought to be unfeasible.

The advent of large language models has overcome previous limitations, enabling learning from far fewer samples.

A major change has come about recently: AI has started to truly understand language. The key technology is the “large language model.” Generative AIs like ChatGPT are prime examples that leverage this. And what a change it has brought: AI can now grasp abstract concepts expressed in words, and even explain things in words. Furthermore, by incorporating not just language but also images, audio, video and other data types and processing them all together, AI performance has been improving by leaps and bounds.

Let’s illustrate with the visual inspection example. Humans understand what a “scratch” is as a concept, even though no two actual scratch marks are exactly alike. We learn the concept of “scratch” by verbal explanation and by seeing actual examples, and then we can recognize a completely new scratch mark — in a different location or a different shape — as a scratch and distinguish it from a non-defective surface. Because we understand what “a scratch” means, we don’t need to see a thousand or two thousand scratches to know one when we see one, and we can even describe it. AI has now acquired the ability to do the same thing. In other words, AI can learn what a “defective product” looks like without requiring an enormous number of defective examples. It can also explain why it determined a part to be “defective.” This not only overcomes the issue of having few samples, but it also makes clear the previously black-box reasoning behind the AI’s judgments. It’s a revolutionary breakthrough.





Making AI-powered inspection viable even for small factories – research to turn visual inspection automation into reality.

Let's return to the visual inspection task. Traditional automated visual inspection absolutely required programming explicit rules to identify defects. That demands tremendous time and cost, and even then, the solution you get is typically limited to detecting one specific kind of defect in one specific process. This is why such systems have been limited to large-scale facilities — if you only produce a few hundred units a year, you'd never recoup the investment. Yet you cannot eliminate the inspection step; it has to be done by humans if automation isn't practical. Today in Japan, there are about 1.4 million visual inspectors, constituting roughly one-fifth of all factory workers. Meanwhile, the labor force is on a steady decline. Seasoned inspectors are retiring and leaving the workforce one after another. If we don't do something, the very continuation of manufacturing industries will be in jeopardy.

This is where the latest AI advances come in. If we had a "general-purpose visual inspection AI" powered by a Vision Language Model (VLM) — essentially a large language model augmented with vision capabilities — we would no longer need to develop complex, onerous defect-detection programs. With an amount of input information comparable to what we'd give a human trainee (and far more efficiently than training a human), we could automate visual inspection. Moreover, because it would be general-purpose — in other words, usable for many different applications — one AI system could perform multiple inspection tasks across different process steps. The most labor-strapped small and mid-sized companies could introduce such AI at low cost.

We have been working on AI for image recognition for some time, and we were quick to adopt this large-scale vision-language model approach. By having the AI learn broad knowledge relevant to inspections, we are developing a "general-purpose visual inspection AI" that can perform inspections given a textual description of the criteria and just a few example images. In November 2023, we filed a patent for an "inspection method using vision-language models." In December of the same year, we announced research results showing that quality inspection could be achieved with only two sample images, which sparked huge interest — we started receiving inquiries from numerous companies both domestically and abroad.

Supporting both general-purpose and specialized solutions – staying a trendsetter in an ever-accelerating AI field.

In our research, we've tested the system on various sample sets — products in food and manufacturing, natural objects like hazelnuts, and so on — to see if it can distinguish good vs. defective items. It appears there are still areas it's strong in and areas it's less so. As researchers we, of course, aim for 100% accuracy, but there's also a practical perspective: even ~80% accuracy could be sufficient if the remaining unclear cases can simply be flagged as "unable to judge." If humans then only need to inspect the 20% of parts that the AI isn't confident about, the workload for people drops to 20%. In other words, a task that needed 5 inspectors could be handled by 1, after AI pre-screening.

We are also considering developing specialized AI solutions tailored to particular factories or industry needs. For example, an automaker might want a company-specific AI that suits their entire group of manufacturers, from the parent company down through all suppliers. Or in the aviation industry, one might need an industry-specific AI specialized in inspecting certain categories of components. Since such specialized AIs don't need to be broadly general, it's easier to push their accuracy even higher for the specific task. In fact, though we can't disclose names, we have already received exploratory inquiries from several large global corporations.

Of course, even an automated inspection system will still require hardware like sensors to capture visual information of parts and mechanisms to separate out defective items. Our role will be to provide the core software that powers the judgment. But this is significant — it's said that roughly 15% of the cost of an inspection machine is the programming. We can slash that portion dramatically. And once the system is up and running, it will accumulate sample data from its operations, which can in turn lead to further improvements in accuracy.

Kunihito Kato

Profile

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Kunihito Kato

Professor, Informatics Course, Department of Electrical, Electronic and Computer Engineering, Faculty of Engineering, Gifu University

- Completed M.S. in School of Computer and Cognitive Science at Chukyo University in 1996; entered the doctoral program the same year (withdrew after obtaining required credits toward Ph.D.).
- Currently Professor in the Department of Electrical, Electronic and Computer Engineering, Faculty of Engineering, Gifu University. Director of Artificial Intelligence Advanced Research Center, Gifu University.
- Ph.D. (Information and Cognitive Science). Served as a faculty member at the University of Maryland in 2011.
- Engaged in research on image recognition and computer vision, with a focus on deep learning and its applications.

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An unmet medical need spanning 70 years – Taking on the challenge of small-diameter artificial blood vessels.

Nagoya University / Yukikazu Takeoka

Development and commercialization of fully endothelialized small-diameter artificial blood vessels

With the establishment of artificial grafts for the aorta, graft replacement surgery appeared to have solved its challenges.

When there is dissatisfaction or insufficiency but no means of resolving it, this is called an unmet need. In the medical field, where such needs can be matters of life and death, they are referred to specifically as unmet medical needs, which often serve as the starting point for the creation of new drugs or the development of new treatments. Many such needs still remain today.

Small-diameter artificial blood vessels with a diameter of less than 6 mm are one such example. Artificial blood vessels for the aorta—a vessel where damage, as in the case of an aortic aneurysm or aortic dissection, can suddenly become life-threatening—were developed relatively early. Since American cardiac surgeon Michael DeBakey performed the first artificial blood vessel replacement surgery in 1954, steady progress has been made. Large-diameter artificial vessels with an internal diameter of 10 mm or more, and medium-diameter vessels with an internal diameter of 6–8 mm, have reached a generally satisfactory level. However, below that size, the difficulty level rises sharply. Nearly 70 years have passed since the development of artificial blood vessels began, and yet they have not been realized.

Large- and medium-diameter vessels need to carry a high volume of blood and thus require great strength. But because they are thick, ensuring strength is easier – a robust "hose" compatible with the body will function. Current grafts achieve over 30 years of durability. Considering that diseases like diabetes (which often necessitate vascular grafts) mostly increase around people's 50s, one surgery provides a graft that lasts a lifetime. However, small-diameter vessels are not so simple – the required mechanical properties change. And in a society with increased longevity, most causes of death are cancer or vascular diseases, so the need for artificial blood vessels is only rising.

The unique branching issue of small-diameter vessels, and the significant impact of thrombosis, have become bottlenecks.

Blood vessels branching off from the aorta split repeatedly and become gradually thinner, and their vessel walls also become thinner. By the time they reach the limbs or head, their diameter falls below 6 mm and they are considered small-diameter vessels, continuing to branch further. Blood vessels pulse with each heartbeat; if the vessel wall is thin, the pulsation amplitude becomes larger. If one of two branch vessels is replaced with an artificial graft, one branch will pulsate strongly while the other does not as much. This mismatch can cause blood flow to stagnate or the junction to tear. Large-diameter vessels, such as the aorta, and medium-diameter vessels, which are located close to the aorta, are less affected by branching and therefore do not present a problem.

Another formidable challenge for small-diameter artificial blood vessels is thrombosis. A thrombus is a clot formed when blood coagulates. If it grows large, it can obstruct blood flow, and in severe cases, completely block a vessel. Thrombosis begins when certain proteins adhere to the inner wall of a blood vessel and act as a nucleus for clot formation. Although this can occur in any vessel, narrower ones are more easily blocked. Healthy blood vessels have the property of preventing such proteins from adhering.

Meanwhile, the inner wall of a blood vessel is lined with a tissue called vascular endothelial cells. These cells extend from the aorta to the capillaries, covering the inside of every vessel and maintaining vascular health. Platelets, which are the cells that form the basis of a thrombus, and vascular endothelial cells each adhere by using adhesion proteins as their foothold. Without these adhesion proteins, it is difficult for such cells to attach.

Weak forces are absorbed flexibly, strong forces are resisted robustly. Thrombi are prevented from adhering, while endothelial cells are encouraged to adhere.

So, what exactly characterizes a healthy small-diameter vessel? First, the branching issue – in terms of materials, it comes down to the vessel's textural properties. When we study the mechanical properties of a blood vessel, we find that it is soft when little force is applied, but strongly resists when a large force is applied. If graphed, the vessel's resistance (stress) versus applied load follows a J-shaped curve: the stress rises only gradually at first, then beyond a certain point it increases sharply. This reflects that the vessel is a composite of soft elastin and stiff collagen. We need to make our graft from a material that reproduces a similar curve.

Next is thrombosis. The key is not simply whether proteins tend to adhere, but which proteins are likely to do so. Among the proteins prone to forming the basis of a thrombus, the most representative is fibrinogen, which is involved in the blood coagulation process and plays a role in hemostasis. Since artificial blood vessel materials are foreign to the human body, fibrinogen reacts to them and attempts to cover their surfaces.

On the other hand, fibronectin is involved in the adhesion of vascular endothelial cells and functions in tissue repair and wound healing. Ideally, fibrinogen should not adhere, while fibronectin should adhere well — and there is a material that perfectly meets this requirement. It is a polymer called PMEA. When at a temperature above body temperature, PMEA becomes a viscous liquid and is not recognized as foreign by biomolecules or cells in the blood, making it less prone to thrombosis. Conveniently, fibronectin adheres well to it.

When silica microparticles of 100 nm or smaller are added to PMEA, the material solidifies into a soft, rubber-like substance. Moreover, it exhibits the same J-shaped curve as blood vessels. These achievements were the results obtained through the GAP Fund in FY2021.

"Little by little, but steadily, we are getting closer. Until our long-cherished goal is realized, we want to keep pressing forward tenaciously."

We have already achieved free-form shaping of this PMEA–silica composite using a 3D printer. However, to use it as a blood vessel, we need to match exactly the J-curve exhibited by real vessels. A cow's blood vessel, for example, reaches a sharp rise in stress at around 100% strain, whereas our initial composite had the curve ramping up at around 400% strain. Through further research, we learned to control the composite's curve so that the inflection point shifted from 400% strain down to 100%. Moreover, instead of the conventional method of mixing silica particles, we developed a new technique using only carbon-based compounds and have already filed a patent application. Bit by bit, we are steadily getting closer to our goal.

At present, we have extended durability to about 5 years in tests, but further improving longevity is one of the issues to tackle. It is well known that vascular endothelial cells collectively form one of the body's largest endocrine organs, meaning blood vessels are not merely pipes to carry oxygen and nutrients. Perhaps related to this, small-diameter vessels differ quite significantly from the aorta; the vessels themselves, like nerves, seem to bear a function in ensuring the body's normal operation at the periphery. Ensuring the graft can be completely covered with endothelial cells is crucial.

I am continually struck by the thought that the human body remains a frontier filled with unknowns. Who in the past would have imagined that a vessel's mechanical properties change with its size? There is still so much unknown about endothelial cells as well, which makes the problem even more challenging. But precisely because of that, it is rewarding. We have been accumulating materials research to overcome biocompatibility issues, and gradually aligning the graft's stress characteristics closer to the real thing. In collaboration with medical experts—and using approaches possible because we are not clinicians—we aim to realize a small-diameter artificial blood vessel. It is an adventure full of excitement, where unexpected events keep occurring one after another.

(As of May, 2025)

Note: Prof. Takeoka's previous work was introduced in the GAP Fund Program promotional booklet STST2021, available at the following URL: https://tongali.net/x/stst/ .

Yukikazu Takeoka

Profile

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Yukikazu Takeoka

Associate Professor, Nagoya University Graduate School of Engineering

- 1996–1998: Postdoctoral Researcher, Department of Physics, Massachusetts Institute of Technology (MIT).
- 1998–2004: Assistant, Faculty of Engineering, Yokohama National University.
- 2004: Associate Professor, Graduate School of Engineering, Nagoya University.
- 2007–present: Associate Professor, Graduate School of Engineering, Nagoya University.

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Using a revolutionary analysis approach to make early detection of the 'king of cancers' (pancreatic cancer) possible – bringing the future of AI-powered medicine into reality.

Nagoya University / Taisuke Baba

Development of an AI-Based Urinary Metabolite Test for Predicting Pancreatic Cancer

Pancreatic cancer is a notoriously deadly cancer with only about a 10% five-year survival rate, and there is no realistic way to find it before it becomes too late.

Let me say at the outset: my story involves two challenges, and a technology that answers one of those challenges is used to solve the other. One challenge is how to utilize AI in medicine. The other is the early detection of pancreatic cancer – a representative of intractable cancers.

First, let's address the challenge of early detection of pancreatic cancer. Cancer is the number one cause of death in Japan; pancreatic cancer ranks fourth among cancer deaths, yet its five-year survival is only 9.9%. Today, overall cancer survival has improved to 68.4%, which makes this figure for pancreatic cancer extremely poor. In the United States, pancreatic cancer is even projected to become the second-leading cause of cancer-related death by 2030. Globally as well, the importance of tackling pancreatic cancer is very high.

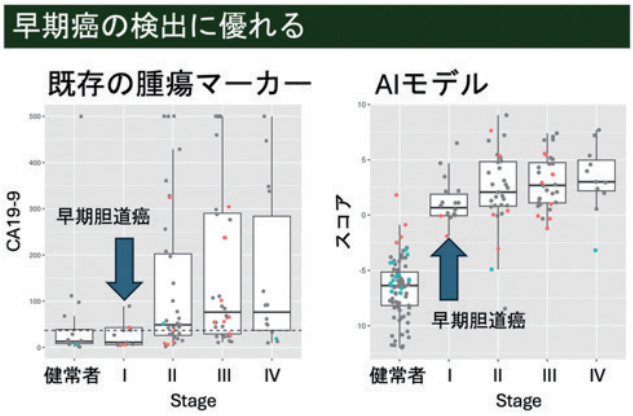
Why is the prognosis so poor? The biggest reason is that early detection is difficult. The pancreas lies deep in the body, behind the stomach, and symptoms only appear once the disease is quite advanced. If it is found at under 1 cm in size, the five-year survival rate is a respectable 75%, but only about 0.8% of cases are discovered at that stage. By the time a tumor reaches ~3 cm, five-year survival drops to 10–20%, and if there are metastases, life expectancy is only 4–6 months – essentially fatal. In other words, if it could just be found early, pancreatic cancer outcomes would be not so different from other cancers. Apart from the somewhat more complicated surgery due to its deep location, it's similar to others.

Moreover, although there are many other reasons pancreatic cancer is daunting (such as the slow progress in developing effective chemotherapy), if caught early it can be treated as well as other cancers. Early detection, after all, is the key.

For example, blood or urine tests. How long are we going to continue with a doctor poring over a dozen lab results?

Now, about the other challenge: AI. AI is of course highly anticipated in medicine. There are many domains it could be applied to, one of which is analyzing blood and urine tests. At present, doctors interpret on the order of a few dozen lab values to guess if there are any disease indications. But take urinalysis: using mass spectrometry for an untargeted analysis, we can now read more than 1,500 metabolite data points from a urine sample. Could a human doctor analyze that? You can imagine how unrealistic that is. Naturally, we turn to AI for help.

With such advances, it's expected that what we can learn from a urine test will increase by orders of magnitude. Perhaps AI could even detect disease signals that we've never been able to find before – say, the early hints of pancreatic cancer. Meanwhile, existing tumor markers for pancreatic cancer had the problem of poor sensitivity for early-stage disease. Thus, numerous comprehensive analyses were conducted in search of markers that work for early pancreatic cancer. But in conclusion, none have been found yet. And my hypothesis is that none will ever be found. Why? Because even cancers in the same organ vary greatly from patient to patient. With such enormous diversity, it's impossible for there to be one tumor marker that universally rises in all pancreatic cancer patients.



Analyzing the myriad metabolites obtainable from urine with AI. Detect abnormalities without relying on any one biomarker.

That said, it's far too early to give up. We have AI, which excels at analyzing large volumes of data. Rather than relying on a single metabolite as a marker, we can use a wealth of data to detect distinctive patterns. Pancreatic cancer is a prime example of a cancer that causes metabolic abnormalities. If it's present, there should be traces of it among the metabolites in urine. The chances of finding those traces are high.

Now, an untargeted analysis of urine (measuring as many metabolites as possible and analyzing them) yields data on over 1,500 metabolites. However, it's not that we get absolute values (like "Metabolite X is 0.8 mg/dL"); we get a multitude of relative values. This creates a problem: combining each dataset is difficult. Furthermore, each run of the mass spectrometer introduces unique errors. For these reasons, applying untargeted metabolomic analysis in clinical practice had been deemed extremely difficult.

But leaving this mountain of treasure untouched would be a terrible waste. Through trial and error, we developed a machine learning algorithm that can accurately predict samples. Because as long as the data remain relative values, we couldn't evaluate them, we convert the data into a format that can be evaluated. We call this the Inverse Pairs Boosting (IPB) method. This has made it possible to apply our test clinically.

We succeeded in predicting the presence of cancer with high accuracy not only for pancreatic cancer but also for bile duct cancer, another cancer with poor prognosis and difficult early detection. As a technology that enables use of comprehensive metabolite analysis in actual clinical settings, it is a very unique breakthrough. With the IPB method patented and our footing secure, we have now launched into commercialization.

Established as a testing technology for pancreatic and bile duct cancers. With this as our banner, make AI-based testing the next-generation standard.

A great advantage of this test is that it uses a urine sample. For instance, if a precancerous pancreatic cyst is found, regular monitoring with MRI or endoscopic ultrasound can dramatically increase the chance of catching early pancreatic cancer. In reality, however, such intensive surveillance is not feasible. A urine test, by contrast, can be performed even at small private clinics. The cost can be greatly reduced, and healthcare resources can be used more efficiently. Most importantly, this way one can get tested casually every year. For early detection, being able to test frequently and easily is extremely important.

Tools for comprehensive analysis – next-generation sequencers, etc. – are appearing one after another, and costs that were astronomical have plummeted in no time. Going forward, we can expect such tools to become part of routine diagnostics.

The IPB method is a way to eliminate the errors inherent in comprehensive analyses. In other words, it can be applied not only to pancreatic and bile duct cancers, but to any disease that involves metabolic alterations. For example, it could potentially be used for diagnosing chronic inflammatory diseases or Alzheimer's, assessing disease risk, predicting treatment efficacy – expanding beyond cancer testing. And all of these various health insights might be predicted from the same single dataset obtained from one urine test. "Obtaining a massive amount of data from one urine test and then reading various health risks from it" – with AI, urine testing could change in this way. Doesn't the idea of AI-era urine tests sound exciting?

To be honest, programming is a hobby of mine. Shortly after I started my studies in the US, the COVID-19 pandemic forced me to stay at home, and I spent that time immersing myself in self-taught programming development on my research theme at the time – pancreatic cancer. Meanwhile, Nagoya University had begun this research even before I started work on it; when I finished my overseas study and happened to take a position here, I coincidentally chose this same research theme. Thanks to that, I get to marry a surgeon's sense of mission with my love of programming. I feel very fortunate.

Taisuke Baba

Profile

Nagoya University
Taisuke Baba

Assistant Professor, Nagoya University Hospital, Department of Surgical Oncology

- 2007: Graduated from Nagoya University School of Medicine (M.D.).
- 2015–2019: Ph.D. in Comprehensive Medical Science (obtained 2019) from Nagoya University Graduate School of Medicine.
- 2019–2022: Research Fellow, Harvard Medical School / Massachusetts General Hospital (Liss Laboratory).
- 2022–present: Assistant Professor of Surgical Oncology, Nagoya University Hospital.

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Bringing hope to bile duct cancer with deep-ultraviolet LEDs, significantly reducing the burden on patients through minimally invasive treatment.

Nagoya University / Toshio Kokuryo

Deep-UV LED Cancer Treatment Device – Validating Its Commercialization

Treating bile duct cancer traditionally requires a large portion of the liver to be removed, and there was no avoiding a severe burden on the patient's body.

At our institution we have performed a total of 2,300 bile duct cancer surgeries. The first thing to know is that in bile duct cancer, surgical resection is considered the only effective curative treatment. However, even for early-stage cancer, an extensive liver resection is needed, resulting in an extremely heavy burden on the patient.

About 20,000 people are diagnosed with bile duct cancer each year, and roughly 70% of those are inoperable cases. Even when surgery is possible, there are major constraints due to the tumor location or the patient's liver function. The recurrence rate after curative resection is around 50%, so there has been a strong demand for developing less invasive treatments that impose less burden on patients. Although chemotherapy has advanced, in many cases ultimately surgery is still needed, so a fundamental solution hasn't been reached. Particularly in cases where the cancer's progression narrows or blocks the bile duct, treatment options become extremely limited. In surgery, we have no choice but to remove not only the lesion but also a large area of otherwise normal liver, which inevitably causes significant stress on the patient.

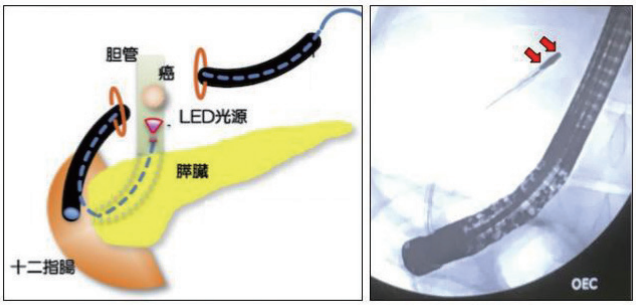
Our research team has been pursuing a new approach to this challenge: a treatment method using deep ultraviolet (DUV) LED light, which emits an especially short wavelength of ultraviolet light. It is a minimally invasive therapy that irradiates the inside of the bile duct directly via endoscope.

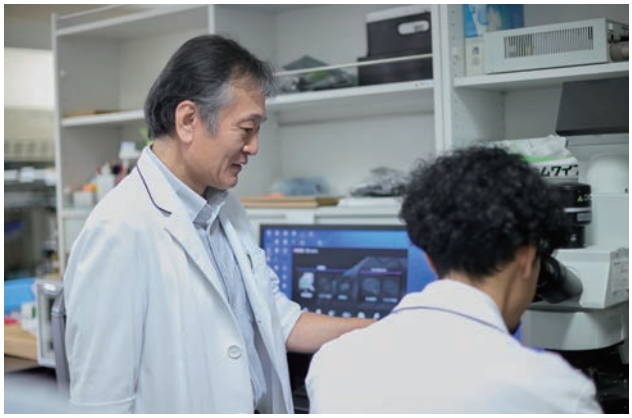
A new therapy that induces cancer cell death by DUV-LED acting directly on DNA.

The therapy we are developing uses a deep-UV LED. Deep UV refers to light in the 250–350 nm wavelength range, and this band has the characteristic of coinciding with the peak UV absorption wavelength of DNA. In cells, DNA's double helix normally unwinds for transcription, allowing cell division, but if deep UV causes damage, that process is blocked and the cell ends up dying.

A major feature of this therapy is that it does not use the photosensitizing drugs required in traditional photodynamic therapy. Therefore, there's no worry about side effects like phototoxicity. The treatment is performed using an endoscope. In practice, an endoscope inserted through the mouth is advanced to the duodenum, then a catheter is fed into the bile duct from there to deliver the light. The device used is very small (on the order of 2–5 mm) and designed to be operable within the bile duct, which has an inner diameter of about 1 cm.

In foundational experiments using mice, we set up three groups: one receiving irradiation once a week, one twice a week, and an untreated control group. We thoroughly verified the effects. The irradiated groups showed clear tumor shrinkage; the tumor areas became ulcerated and later turned into scabs. Furthermore, the tumors gradually shrank and ultimately progressed toward complete healing. Based on these research results, we obtained a patent for the treatment device in 2019.





Bringing hope to bile duct cancer with deep-UV LED – Greatly reducing patient burden with minimally invasive therapy.

The greatest significance of this therapy is that it does not require open surgery. With endoscopic deep-UV treatment, you can irradiate the tumor directly from inside the bile duct, allowing the normal liver tissue to be preserved. This means we can avoid the large-scale surgeries that were once unavoidable, leading to improved quality of life for patients. To be sure, as with other treatments, there is some damage to normal cells, but it has been reported that DUV light does not induce carcinogenesis.

As a crucial step toward practical application, we conducted a proof-of-concept experiment in pigs. To confirm the feasibility of reaching and irradiating the bile duct via endoscope, we first used contrast imaging to verify the position inside the bile duct, then performed the irradiation. After irradiation, we resected the area to examine it. We confirmed that at the irradiated site, the mucosal layer was missing and an erosion had formed. Until now, deep UV light has been used for industrial sterilization and disinfection, but this experiment revealed a new possibility for using it in cancer treatment.

There are still a few technical issues with the device under development. We've identified points to improve, such as the lateral strength of protective sheaths and resistance to twisting during endoscopic manipulation, and stress on wiring due to bending when inserting into the bile duct. However, we are already working on countermeasures for these issues and have made concrete improvements like increasing sheath strength and integrating a guide wire within the device.

From a market perspective, of about 20,000 new bile duct cancer patients per year, roughly 15,000 are estimated to have bile duct strictures or obstructions. Assuming treatment would be done once a month (12 times a year) at a cost of about ¥80,000 per treatment, that's an annual market size of ¥14.4 billion. Furthermore, if we expand to early bile duct cancer, pancreatic cancer, colon cancer, etc., the market could grow to over ¥60 billion.

Steadily increasing the options for cancer treatment. Striving for the optimal therapy for each individual.

Our aim is for this technology to become a new treatment option for bile duct cancer. However, it's not applicable to every case. For example, if the bile duct is completely blocked, there might not be time to wait for the light therapy to take effect. In such high-urgency cases, conventional treatments would need to be chosen.

As such, case selection must be done carefully. We will make judgements based on the patient's condition: for instance, whether a reliable approach to the lesion is possible, and whether there is enough time to wait for the treatment effect. Even in end-stage cases, if a catheter can be inserted into the bile duct, the therapy is possible. We are also considering using it in various scenarios, such as in combination with surgery at an early stage. However, reaching the point where this therapy alone can completely cure cancer is still in the research stage.

On the other hand, this technology has potential applications beyond bile duct cancer. It could possibly be applied broadly to treat pancreatic cancer, colorectal cancer, bladder cancer, cervical cancer, and others. We are currently exploring a variety of directions. The basic concept of the product has been established, but further validation and refinement are needed on the path to practical use. We will continue cautious research, including long-term follow-up after irradiation and studying the relationship between DUV exposure time and therapeutic effect.

This therapy is positioned as one option in cancer treatment. At this stage we can't call it a complete cure, but we want to firmly establish it as one effective treatment choice. We intend to steadily advance the research so that this becomes a reality. The fight against cancer will continue into the future, and we hope that this technology will help alleviate the suffering of patients along the way.

Toshio Kokuryo

Profile

Nagoya University
Toshio Kokuryo

Associate Professor, Nagoya University Graduate School of Medicine

- Ph.D. (Medicine): Completed doctoral program in Functional Construction Medicine, Graduate School of Medicine, Nagoya University.
- COE Postdoctoral Research Fellow. In 2009, became Special Assistant Professor of Surgical Oncology, Graduate School of Medicine, Nagoya University.
- 2020–present: Associate Professor, Genome Medical Center, Nagoya University Hospital (concurrent appointment at Nagoya University Institute for Advanced Research).
- Engaged in R&D of nucleic acid drugs, energy devices, and cell sheets. Patent: JP 2021-053399 (related to this project).

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Research team member portrait
(left) Yoshiko Yamashita

To solve chronic staff shortages and harsh working conditions in healthcare – a work improvement by nurses, for nurses, for the sake of nurses.

Nagoya University / Keiko Yamashita

Visualizing Nurses' Contributions with Digital Technology – A Commercialization Study to Enhance Patient-First Nursing Value, Effectiveness, and Quality

We must improve the working environment for healthcare professionals — not just in words, but through concrete action now.

Even before the term "medical system collapse" was whispered during the COVID-19 outbreak, healthcare workplaces were grappling with chronic staff shortages and extremely harsh working conditions. The media brought attention to it, but it was by no means a sudden problem. Looking to the future, in addition to the shrinking labor force due to low birthrate and aging, the increase in people needing nursing care is expected to accelerate. It's already projected that by 2025 there will be a shortage of 270,000 nurses in Japan, making the situation even more dire.

According to Ministry of Health, Labour and Welfare statistics, as of Dec 31, 2022, there were about 1.31 million working nurses nationwide. Meanwhile, the number of physicians working in medical facilities was about 330,000 – meaning there are four times as many nurses as doctors. Improving nurses' work environment and efficiency will have a huge impact on the entire medical field.

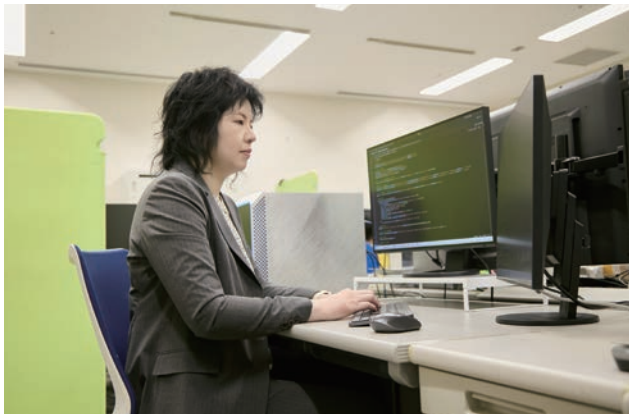
The issue of quantity, such as the shortage of nursing staff, is easy to understand. However, the quality challenges in nursing are less visible and have an even more serious impact. When there is no breathing room in the workplace, it becomes difficult for experienced nurses to adequately pass on their knowledge and skills to the next generation. The challenges to address are numerous—such as the aging of nurses and the accompanying decline in physical stamina, the need to review work styles including long working hours, and improvements in nursing operations—but with limited time, it is difficult to respond to them sufficiently under current conditions.

Even so, nurses feel through their daily duties that the greater the challenges, the more they must face them and push towards solutions. The power to overcome these problems lies within themselves.

So that nurses can work in a way true to their profession – to enrich direct nursing care by streamlining indirect nursing tasks.

A nurse's work can be broadly divided into two types: direct nursing, where they face patients and provide care, and indirect nursing, such as writing nursing records or giving handover reports during shift changes. Ideally, nurses want to devote as much time as possible to direct patient care, but in reality they spend a large portion of their time on indirect nursing tasks.

We wanted to capture the actual situation accurately, rather than relying on impressions. At Nagoya University Hospital, we conducted a survey and found that indirect nursing accounted for 37% of nurses' work. Of that, only 2% was the essential handover communication, while the remaining 35% was almost entirely taken up by documentation. Any nurse would find these results unsurprising. Documenting nursing records is important, but it is a huge burden for nurses. This is deeply tied to the nature of nursing work. For example, suppose you assist a patient to the toilet, then the patient complains of a sore throat so you report it to the doctor, then an alarm on a device sounds and upon checking it turns out to be a false alarm due to a sensor issue. All these events, one by one, have to be recorded with as accurate a timestamp as possible. However, there is virtually no opportunity to write notes in the middle of caring for patients. When you're attending to a patient and another call light goes off, it's a mad scramble and later it's hard to remember exact times to document. Is there a way to solve this? Right now, one answer attracting attention is generative AI.



Using AI to support documentation tasks and free up time for care. The goal is to streamline indirect work and lighten the load.

By having AI take over the task of writing records, we can dramatically reduce the workload of nurses. When we broke down and categorized nurses' duties, we estimated that of the ~35% of time spent on indirect nursing, about half (roughly 17.5%) could be eliminated. We now had a clear target.

For AI to maintain accuracy equal to a human's and to generate even more detailed, real-time records, we need to capture nurses' actions as data. Of course, in an ideal scenario one might consider detailed recordings using audio or video, but from the standpoint of patient privacy that's not realistic. So we turned our attention first to continuously collecting audio data to record communications and activities with patients. In addition, to grasp the nurses' movements and context, we record location information and posture changes over time, so that we can visualize when, where, and what the nurse did in data form.

Leveraging these data, we performed machine learning with AI and built a system that can automatically generate narrative nursing records. We obtained a patent for the core technology, an "activity identification device for healthcare workers and method for generating a decision model".

AI-generated documentation provides real-time records with guaranteed authenticity and no subjective bias or personal quirks. Finally, the nurse reviews and approves the content, and it is shared among the staff.

As a result, we can greatly streamline record-keeping, which is one of the most burdensome indirect nursing tasks. And it's not just about reducing workload. By analyzing the accumulated data, we can visualize the skills of veteran nurses and use that to help transfer nursing techniques to junior staff. Also, leaving more detailed and accurate records means that in the rare event of a malpractice lawsuit, an objective record becomes crucial evidence that protects the nurse. In the beginning, some voices expressed concern that automating records "felt like being watched," but as they came to understand the goal, most nurses became willing to cooperate positively.

If we harness data on nursing tasks, a new path opens for creating a better work environment.

We want to roll out this system to hospitals across the country. We're initially targeting its introduction in advanced hospitals that have ICU/NICU wards. We believe that hospitals of a similar size and nature to ours can adopt it smoothly. In particular, by deploying it in hospitals with large nursing staffs, we can support that many more workplaces. In fact, we've already had requests for adoption from multiple university hospitals, and it's likely to spread further in the future. Ultimately, we plan to adapt it for use in small hospitals as well, so that it can be utilized in a wide range of healthcare settings—from acute care to recovery and chronic care.

We've outlined the business model up to this point, but I believe this initiative holds even more potential. The core of our project is improving efficiency, but it also opens up broad prospects as an education tool and a process improvement tool. By expanding the data obtained at one hospital to multiple hospitals, or even nationwide, we might be able to leverage the valuable know-how accumulated in the medical field. For example, if we make this system cloud-based so it's accessible from anywhere, nurses could hone their skills even while remaining in rural areas, without having to go to a big city. This would become a new foundation supporting regional healthcare, and contribute to the sustainability of local communities—because wherever healthcare is needed, nurses are indispensable. Furthermore, if we extend it to other healthcare professionals like physical therapists, enabling cross-professional data sharing, we can further enhance the quality of team-based medical care. And if we expand into related fields like caregiving, it could contribute to a broad range of healthcare and welfare settings.

By getting this project on track and promoting its adoption in more hospitals, we will create an environment where nurses can devote themselves to their true roles. And beyond that, we hope to contribute to a bright future for both patients and nurses.

Profile

Nagoya University
Keiko Yamashita

Nagoya University Hospital Medical IT Center

- Education: M.S. in Information Science, Nagoya University Graduate School of Information Science. (Currently a doctoral candidate at Nagoya University Graduate School of Informatics.)
- Position: Researcher at Nagoya University Hospital's Medical IT Center.
- Engaged in research on visualizing and improving the efficiency of healthcare workers' tasks using IoT, machine learning, image processing, and activity recognition technologies at the Nagoya University Hospital Medical IT Center.

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A new cancer treatment strategy targeting the root cause of resistant relapse – tracking cancer cells indefinitely to pave the way for a future where cancer is controllable.

Nagoya University / Shinichiro Kato

I Want to Save Patients Suffering from Cancer Recurrence – Drug Development and Clinical Implementation to Cure Cancer

The reality is that 90% of cancer deaths are due to treatment-resistant recurrence. A new treatment strategy is now emerging to address its root cause.

Cancer treatment has continued to advance, and patient survival times have steadily lengthened. Therapies like chemotherapy, molecular targeted drugs, and immunotherapy have been established, but cure rates have hardly improved compared to 10–20 years ago. Of the roughly 9.7 million cancer patients globally each year, 90% end up losing their lives due to treatment-resistant recurrence or metastasis following drug therapy. This is the single biggest issue in cancer treatment.

For example, even with a targeted therapy that zeroes in on a specific molecule, resistant relapse occurs in about one year. Once cancer cells acquire resistance, that drug becomes completely ineffective. Switch to a new drug, and again they eventually become resistant. This cycle of treatment and relapse keeps tormenting cancer patients.

To get at the root of this problem, we focused on cells known as DTPs (Drug-Tolerant Persisters). This is a collective term for the population of resistant cells that remain after treatment – essentially cells that persist through therapy. Typically, during treatment (e.g. with chemotherapy), these cells enter a dormant state to try to ride it out. They eventually acquire resistance, resume growth, and trigger a relapse of the cancer.

If cancer can be found early and treated early, often it can be put into remission, but in most cases cancer is detected at a more advanced stage. With the current treatment paradigm, it's extremely difficult from that point to prevent resistance from developing. So we thought that to break this negative loop of treatment followed by relapse, we need to find the cells that cause resistant relapse and eliminate them before resistance occurs.

Tracking cancer cells and pinpointing the gene key to resistance. By blocking dormancy, we can suppress resistance with 100% success.

First, we began experiments to trace how cancer cells change over the course of treatment and to analyze the mechanism leading to resistance. We used a technology called DNA barcoding. We use an artificial DNA sequence that does not exist in the body as a tag, and attach a unique barcode to each and every cancer cell, making it possible to track them quasi-permanently. If a certain barcode disappears, we can judge that those cells were killed by the treatment. If a barcode continues to be detected after treatment, we can identify that cell as likely a persister that could become resistant.

Further, once we identify those cells, we apply a technique called CRISPR screening for analysis. This method systematically knocks out genes one by one to see which gene's inactivation causes the cancer cell to die. By this means, we can pinpoint which gene is necessary for the cancer cell's survival – in other words, reveal which gene we need to target to kill the cell.

Using this research approach, we investigated DTP cells in melanoma (a type of skin cancer) and discovered that the gene LSD1 is essential for DTP cell survival. It turns out that LSD1 is active both when DTP cells go into dormancy to shield themselves from chemotherapy and when they start proliferating again. If we inhibit this function, the cells can no longer enter dormancy and are instead killed off by the chemotherapy attack.

In other words, administering a drug that blocks LSD1's function can suppress resistance with 100% success. In animal experiments, complete remission was observed in half of the mice. We expect similar effects in other cancer types as well.

"A new strategy to address resistant relapse" – Opening a future where cancer can be managed by tracking cancer cells indefinitely.

With our unique technology to track and identify the DTP cells that lead to resistance and relapse, we aim to connect this to the development of therapeutic drugs. We plan to establish this series of processes as a new platform, making it a foundation for R&D in cancer treatment. By applying it to other cancer types and combining with various anticancer drugs, we can create therapies and drugs that prevent resistance from emerging. By offering this as a pipeline to pharmaceutical companies, we envision linking it to the development of revolutionary new drugs.

To realize this platform, we are currently verifying its expansibility and robustness with support from a GAP Fund. In this model, the university focuses on the basic research of analyzing resistance mechanisms and handles up through the early clinical phase. Subsequent drug development will be carried out in collaboration with pharma, leveraging each party's strengths for efficient R&D in stages. All research findings will be accumulated in a database. By analyzing the traits of DTP cells and the mechanisms of resistance which differ by cancer type, and systematically compiling that knowledge, we will be able to identify treatments suited to each individual patient. With data accumulation and archiving, combined with linking to the "cancer gene panel test" that began in 2019, we believe we can greatly contribute to the realization of personalized medicine, where we propose the optimal drugs and therapies tailored to each case.

Theoretically, this technology holds the potential to be applied to any cancer. While keeping in sight the development of drugs that could be effective for many different cancers in the future, we will build an archive of treatment strategies. By expanding the options in cancer treatment, we aim to become a source of hope for as many patients as possible.

The fight against cancer is entering a new stage. Aiming for a future where it is a "controllable disease."

Interestingly, cancer cells can be compared to queen bees. Even if you eliminate the DTP cells – the "queen" – a sort of next-generation DTP cell arises anew from the remaining cells. It's the same mechanism as how when a queen bee dies, a new queen emerges from among the worker bees. It's a game of endless whack-a-mole. Cancer cells are constantly finding new survival strategies, so trying to eradicate them completely with a single treatment is extremely difficult. We are finding that this phenomenon occurs in other treatments like radiation therapy as well.

However, this is by no means a reason for despair. Our research could provide a solution to the problems – resistant relapse and metastasis – that account for the majority of cancer mortality. Not only might it change cancer treatment dramatically, but cancer could become like tuberculosis once was: even if complete eradication is difficult, it can be made a controllable disease. Cancer would become an illness one can undergo treatment for without fear. Such a future is starting to feel within reach.

In fact, experiments using clinical specimens have shown very good results. At the lab level, we have verified that the current mechanism works well. However, this is still at the in vitro stage – experiments outside the body. It's possible that when we try administering to actual patients, it might not be effective, or unexpected side effects might arise. There are still many hurdles to overcome before real-world implementation. As we advance the research, we may even encounter a critical problem.

But that too is part of the progress of science, and the start of new discoveries. There will be difficulties, but I am certain this research will illuminate some path forward. At the very least, I believe it can make a significant contribution to scientific advancement. The very fact that we found this methodology is itself a big step in cancer therapy.

Shinichiro Kato

Profile

Nagoya University
Shinichiro Kato

Assistant Professor, Nagoya University Graduate School of Medicine

- Ph.D. (Pharmaceutical Sciences), University of Toyama (former Toyama Medical and Pharmaceutical University) Graduate School of Medicine and Pharmaceutical Sciences. JSPS Research Fellow (DC2, then PD).
- 2015–2019: Postdoctoral Fellow at Harvard Medical School (Boston, USA) – also JSPS Overseas Special Research Fellow.
- 2020: Joined Nagoya University Graduate School of Medicine.
- 2023–present: Assistant Professor, Nagoya University Graduate School of Medicine.
- Leads research on spatiotemporal dynamics of cancer therapy resistance, recurrence, and metastasis. Specialty: Tumor biology, epigenetics.
- Currently enrolled at Kyoto University.(as of April, 2025)

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Recent photos of research team members
Third from the left Shoichi Maruyama

Transplant medicine to free patients from burdensome dialysis – liberation from the fate of needing someone else's kidney.

Nagoya University / Shoichi Maruyama

Regenerative Xenotransplantation Therapy Technology – Liberation from Organ Failure and Immunosuppressants

The kidneys perform a wide variety of functions. Dialysis can replace only a fraction of them.

Kidneys remove waste products along with excess water from the blood as urine, but people often assume that is their only role. While that is certainly something only the kidneys can do, their real purpose is to maintain the body's homeostasis. is to maintain the body's homeostasis. Their true function is controlling body fluids, which plays a crucial part in preserving this homeostatic balance.

Broadly classified, the kidneys perform five key functions:

1.Maintaining fluid and electrolyte balance (water and salt equilibrium).
2.Excreting waste products and toxins from the body.
3.Regulating blood pressure.
4.Secreting hormone that stimulates blood production.
5.Activating vitamin D to strengthen bones.

If functions 1 and 2 fail, death follows in short order. That's why, in kidney failure, we perform dialysis to artificially remove waste and maintain proper mineral and fluid levels. In other words, dialysis uses a machine to substitute for those first two functions. It cannot replace all of the kidney's functions. For that reason, at present the only fundamental cure is kidney transplantation.

Of course, that's not to say dialysis is meaningless. In fact, Japan's dialysis outcomes are excellent. According to one study, if we set Japan's relative mortality risk for dialysis patients at 1, the risk is 3.78 times in the US and 2.84 times in Europe. However, the predominant form in Japan, hemodialysis, requires 4–5 hours per session, three times a week, which is an enormous burden. In terms of quality of life, it's obvious that having a transplant is far better.

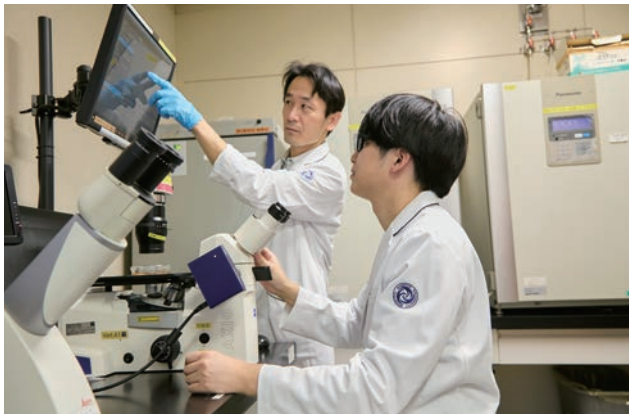
Yet in 2022, only 1,782 kidney transplants were performed in Japan. Meanwhile, 14,080 patients were on the waiting list. There are far, far too few donors.

Is living-donor kidney transplantation truly 'treatment'? The many issues surrounding kidney transplantation.

There are two types of kidney transplantation: living-donor transplant (from a healthy living person) and deceased-donor (cadaveric) transplant, where an organ is donated through someone's goodwill after death. In the 2022 statistics, there were 198 deceased-donor kidney transplants in Japan versus 1,584 living-donor transplants. Living-donor transplants overwhelmingly dominate in Japan. But living-donor transplantation comes with issues.

One issue is physical. Only those who are willing and healthy enough can become donors. Recall a certain study: the risk for a donor to end up in end-stage kidney failure after donating is about one-third that of the general population – which sounds rather favorable. However, compare them to people who qualified as donors (met all health criteria) but did not actually donate, and the risk is nearly seven times higher for those who did. This is only to be expected. The "general population" includes everyone, many with various illnesses, whereas donors are exceptionally healthy individuals. When compared on equal terms, it is clear the donor's risk does increase.

Another issue is ethical. With advances in medical techniques, it is now possible to receive a kidney from a spouse. On the surface this sounds like a beautiful act, but we cannot say that there is never unspoken pressure involved. There are other issues as well. Organ trafficking that targets economically vulnerable people is one example. We've even seen so-called "transplant tourism," where patients unable to find a domestic donor travel overseas to get a transplant. In 2008, the Transplantation Society adopted the Istanbul Declaration to ban this practice. Securing organs for transplant is an international issue. Some have even debated whether taking a kidney from a healthy person can truly be called medicine.



If we could recreate our own kidneys, a new option called regenerative medicine would become possible.

One potential answer to some of the challenges inherent in living-donor kidney transplantation is the concept of xenotransplantation—the idea of using organs from other animals. Although its history is surprisingly long, for many years it was impossible to overcome the barrier of biocompatibility. Xenotransplantation was my main research theme during my studies abroad, and I have continued this research ever since returning to Japan. The shortage of transplantable organs, not only kidneys, has been a longstanding issue. I have always believed it was something that must be achieved, even if it takes time. However, the barriers to be overcome are numerous, high, and formidable, and I was not able to achieve the results I had hoped for. It seemed impossible for me to realize this on my own.

Then an unexpected opportunity arrived. Nagoya University was integrated with Gifu University under the Tokai National Higher Education and Research System, creating a connection with Gifu University's Faculty of Veterinary Medicine. I learned that Gifu Univeristy had gene-editing technology for pigs – which is indispensable to my research. I never imagined such advanced technology was so close at hand. Further luck followed: there was a researcher on campus working on iPS cell-based regenerative medicine. And a program to support the practical implementation of research (this GAP Fund) was ramping up. Before I knew it, the people, the tools (technology), and funding – everything I needed – had come together. If I didn't act, I would regret it. And so I renewed my efforts and launched the research in earnest.

The outline of the technology we aim to develop is as follows. We take cells from a patient with kidney failure and create iPS cells from those patient cells. We then introduce the patient's iPS cells into a genetically modified miniature pig that has been altered so it won't mount an immune attack on human cells, and have the pig grow a kidney for us. That kidney, serving as the donated organ, is then transplanted into the patient. In this way, without relying on a donor, a patient can receive a kidney made from their own cells. There's no long waiting list, and no need for lifelong immunosuppressant drugs after surgery. Dialysis would only be required for the short period until the new kidney is ready.

A groundbreaking method to save patients suffering from organ failure. Establishing an unprecedented technology: regenerative xenotransplantation.

Of course, this is not straightforward. In order to create a human kidney derived from a patient's own cells using a pig as the host, the kidney itself can be made from human cells, but during the process, but they are not 100% human; some parts are formed from pig tissue. This leaves a cause for rejection, and overcoming this remains the current challenge.

If we are undertaking this as a venture, we must also consider the economic side. The cost to generate one regenerated kidney is roughly estimated at ¥10 million (about $70k). Does that sound high? But simply continuing dialysis costs a lot of money too – on the order of ¥400,000 per month, which is ¥4.8 million per year. In just 2 years and 1 month, the expense would break even. Maintaining dialysis for many years ends up costing far more.

Looking at the numbers for Japan's 340,000 dialysis patients, the total reaches an astounding ¥1.7 trillion per year. From that perspective, this could become a concrete national strategy for reducing medical costs. And thinking in terms of sustaining our excellent national health insurance system, it's an issue that affects every one of us.

Some people may feel uneasy about receiving a kidney grown in a pig. But as a reference point: in the U.S., there was one case in 2022 and another in 2023 of transplanting a genetically modified pig's heart into a human. In 2024, a man who received a pig kidney even recovered enough to be discharged from the hospital. He passed away about 2 months after the transplant, but according to the hospital, the cause of death was an unexpected heart attack and they saw no evidence linking the death to the transplant. Since then, two more such surgeries have been reported. What we are aiming for is fundamentally different in approach, but these cases suggest that the concept of xenotransplantation could indeed become a new treatment option. The path has been opened. Believing in the possibilities, I want to dive headlong into this unprecedented grand adventure.

Shoichi Maruyama

Profile

Nagoya University
Shoichi Maruyama

Professor, Nagoya University Graduate School of Medicine, Department of Nephrology

- 1989: Graduated from Nagoya University School of Medicine (M.D.). Worked at Chukyo Hospital and Inazawa Municipal Hospital.
- 1993: Entered Nagoya University Graduate School of Medicine.
- 1996: Research Fellow, Department of Physiology, Columbia University (USA).
- 1999: Served as Technical Official, Nagoya Family Court.
- Subsequently held positions as Assistant Professor, Lecturer, Associate Professor, and Professor of Nephrology at Nagoya University Graduate School of Medicine.
- Apr 2019: Appointed Deputy Director of Nagoya University Hospital.
- Apr 2024: Appointed Hospital Director of Nagoya University Hospital (current position). Degree: M.D., Ph.D.

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Implantable mass production of iPS cells from a single drop of blood — an innovative gene delivery technology from cross-disciplinary collaboration.

Toyohashi University of Technology / Rika Numano

Droplet Electroporation Device for Mass-Producing Implantable, High-Quality iPS Cells

To achieve the dream of integrating regenerative medicine part of mainstream healthcare, a breakthrough in manufacturing technology was imperative.

Regenerative medicine using iPS cells has attracted high expectations as a revolutionary technology that could make it possible to treat diseases once considered incurable. However, its clinical application faces significant hurdles: treatments are extremely expensive, and insurance coverage is not on the horizon, so it remains difficult to widely popularize.

One reason is technical challenges in iPS cell production. The currently predominant viral vector methods introduce virus-derived genes, which raises concerns about oncogenic transformations, thereby limiting their suitability for clinical transplantation. Meanwhile, chemical-based approaches require special reagents and come with the issue of those reagents remaining on cell membranes after transplantation.

So we shifted our focus toward a physical method of gene delivery. We hypothesized that if we could introduce genes by transiently permeabilizing the cell membrane (an electroporation approach), it could present a viable solution for regenerative medicine. However, conventional electroporation has drawbacks: it requires an expensive pulse generator, and it is associated with excessive cytotoxicity.

This challenge is particularly pronounced with blood cells, which are extremely delicate. With conventional methods, result in significant cell mortality, necessitating the use of millions of cells to secure a sufficient quantity for transplantation. The dual burden of expensive equipment and the need for huge quantities of cell samples is a double burden to the broader implementation of iPS cell therapies.

An interdisciplinary fusion of wisdom led to a paradigm shift. Using static electricity discharges to replicate the function of expensive equipment.

We developed an innovative technology to solve this difficult problem. My background is in applied chemistry and biotechnology, and I am also affiliated with a research institute that promotes interdisciplinary collaboration. Through working with a student specializing in electrical engineering, we came up with a new idea that overturns conventional thinking. The result of that collaboration is the "droplet electroporation" method.

The most distinctive feature of our method lies in its use of static electricity discharge. While conventional systems apply a few electrical pulses lasting approximately a millisecond (1/1,000 of a second), our approach generates tens of thousands of pulses within an extraordinarily brief interval—on the order of a nanosecond (1/1,000,000,000 of a second). Although an extremely high voltage is applied instantaneously, the ultra-short pulse duration significantly minimizes cellular damage.

The prototype experimental device embodying this technology was constructed by a student using electronic parts they bought in Akihabara (Tokyo's electronics district). The device was nicknamed "Pachi-Pachi-kun" from the crackling sound ("pachi-pachi") of the discharges, and successfully produced nanosecond pulses without using any expensive specialized machinery. This was a breakthrough that would have been inconceivable using conventional semiconductor-based methods.

In experiments, we found that this method can introduce genes with approximately 50% efficiency. We hypothesize that rather than punching a large hole in the cell membrane, our method likely works by gently relaxes the membrane structure just enough to allow the gene transfer. This gentle, cell-friendly approach is the key that allowed us to achieve both high cell survival and efficient gene delivery.

An additional advantage lies in the reaction's confinement to a droplet measuring only a few microliters, which significantly increases the likelihood of multiple genes being introduced into a single cell simultaneously.

Safely mass-producing iPS cells from just a drop of blood An innovative gene delivery technology born from interdisciplinary fusion.

We are currently engaged in collaborating with Juntendo University, a leader in Parkinson's disease research and treatment. They have verified that iPS cells produced with our technology can differentiate into neural progenitor cells.

What is particularly noteworthy is that compared to existing approaches – although direct comparisons are difficult – under similar conditions our efficiency of iPS cells production is 16 to 100 times higher under comparable conditions. With as few as one thousand cells to start, we can produce on the order of 10 iPS cell colonies. In other words, instead of needing a lot of blood draws, a single drop of blood is sufficient. Furthermore, elderly patients are spared the need for invasive skin biopsies, which would otherwise impose a significant physical burden. We can secure the necessary cells for transplantation while minimizing the donor's burden. —a critical milestone toward the broader implementation of regenerative medicine.

The high efficiency of iPS cell generation with this technology has already been demonstrated, and a patent has been obtained. We are also collaborating with Neppagene Inc. on development toward commercialization and have entered the prototype development stage. An important point is ensuring reproducibility — enabling any user to obtain consistent results s using the device. Moreover, to meet the stringent requirements for medical applications, it is essential to prevent cross-contamination between samples. To that end, we are also developing sterilized, single-use disposable components.

Our vision extends beyond the mere commercialization of a device. We have been systematically testing a wide range of sample types and compiling a comprehensive dataset to determine optimal electric pulse parameters. Based on this, we are considering providing tailored recommendations for each sample type, as part of an integrated post-sales support service. Additionally, taking advantage of being at a university, we can offer users the option to submit their samples for collaborative experimentation and parameter optimization –providing comprehensive technical support.

Establishing iPS cell therapy as a mainstream, universally accessible medical treatment. Innovating fundamental technology to change the future of medicine.

More than a decade has passed since Professor Shinya Yamanaka was awarded the Nobel Prize, and while iPS cells continue to hold immense promise for transforming medical care, numerous challenges remain before their widespread clinical application can be realized. Currently in Japan, regenerative medicine is largely confined to a limited number of cases, such as treatments for retinal disorders, and the prohibitive costs restrict access to only a privileged few. Through the development and dissemination of this transformative manufacturing technology, we aspire to expand these possibilities—however modestly—and contribute to making regenerative therapies more accessible to all.

One tangible vision is to facilitate the safe and cost-effective mass production of iPS cells for the establishment of cellular biobanks. By preserving organ-specific cells while individuals are still in good health, we can ensure timely therapeutic intervention—eliminating delays and enabling immediate transplantation when needed.

Moreover, the technology holds significant promise for other applications. In the field of CAR-T cell therapy, for example, our method could substantially enhance the efficiency of large-scale CAR-T cell production. Unlike conventional treatments such as radiation or chemotherapy, this strategy empowers the body's own immune cells to combat malignancies, offering a more natural and personalized approach to cancer therapy. We are confident that our technology can dramatically improve the scalability of CAR-T cell manufacturing much more efficiently.

We are steadfast in our belief that a world in which anyone, anywhere, can access iPS cell therapies when needed is not a distant aspiration but an achievable goal. The pathway to commercialization is advancing steadily, and we are certain that our technology represents a critical step toward realizing this vision. We are deeply grateful for the funding support that has made this progress possible. As we move into the commercialization phase, we remain fully committed to pursuing this research with unwavering passion, convinced of its immense potential to open a new door for regenerative medicine.

Profile

Toyohashi University of Technology

Rika Numano

Professor, Toyohashi University of Technology Next-Generation Semiconductor & Sensor Science Research Center

- Education: Bachelor and Master degree. in Department of Chemistry and Biotechnology, The Faculty of Engineering, The University of Tokyo, University of Tokyo; Ph.D. in Medicine from the University of Tokyo, Molecular cell Biology, (Ph.D.).
- 2022 - Present Professor, Next-Generation Semiconductor & Sensor Science Research Center, Toyohashi University of Technology
- 2013 - Present Professor,Department of Applied Chemistry and Life Science, Toyohashi University of Technology
- 2010 - 2013 Associate Professor,Electronics-Inspired Interdisciplinary Research Institute(, Toyohashi University of Technology
- 2006 - 2010 Research Fellow ERATO Project, Brain Science Institute, RIKEN
- 2004 - 2006 Department of Molecular and Cell Biology, University of California Berkeley Isacoff Lab.
- 2001 - 2004 Ph.D.Research fellow, Japan Society for the Promotion of Science
- 1997 - Mar, 2001The University of Tokyo, Molecular cell Biology, Medicine, The University of Tokyo
- Apr, 1995 - Mar, 1997The University of Tokyo
- - 1997Chemical and Biological Techonology, Engineering Science, The University of Tokyo
- 1991 - 1995 Department of Chemistry and Biotechnology, The Faculty of Engineering, The University of Tokyo
- - 1995Chemical and Biological Technology, Engineering Science, The University of Tokyo
- Career: JSPS Postdoctoral Fellow (PD) at the Institute of Medical Science, University of Tokyo; JSPS Overseas Research Fellow at University of California, Berkeley; Researcher at RIKEN Brain Science Institute (ERATO project). Associate Professor,Electronics-Inspired Interdisciplinary Research Institute, Toyohashi University of Technology in 2010, and is currently a Professor at the Next-Generation Semiconductor & Sensor Science Research Center and Applied Chemistry and Life Science. Our group developed a new "droplet electroporation" gene introduction method using tiny droplet reaction fields and specialized pulse electric fields, which achieves low toxicity to cells.

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Research team member portrait
(left) Naoki Yamamoto

Escape the 'try until one works' status quo – towards an era of starting treatment with the optimal anticancer drug for each individual from the very beginning.

Fujita Health University / Naoki Yamamoto

Next-Generation Cancer Gene Testing and Drug Development Using High-Efficiency Human Cancer Cell Isolation and Culture

If one drug fails, you move on to the next. And then the next. All the while, the cancer continues to ravage the body — a battle against both time and side effects.

Drug therapy attacks and destroys cancer tissue with medication. Today, in addition to anticancer drugs, there is a wide range of options including molecularly targeted agents and hormone therapies. When the right drug is selected, the effect can be certain — but choosing that right drug is the difficult part. For example, even in the case of lung cancer alone, there are many different drugs, and in reality, determining which one will be effective for a particular patient often comes down to trying them in actual treatment.

At present, drug therapy follows guidelines for each cancer type (e.g. lung cancer, colon cancer), and from those options the attending physician selects a drug based on their experience. Of course this is grounded in clinical evidence to some extent, but that's about as far as it goes. Once a drug is given, it takes roughly 2–3 months to assess its effectiveness. During that period, the patient must endure harsh side effects. If the first chosen drug happens to be effective, the patient is lucky. If its efficacy is low, you move on to try a different drug – but in that interim, the disease progresses further, and the cancer may even acquire drug resistance.

It's not only hard on the patient – it's also inefficient for healthcare. In an effort to slow the cancer's advance as quickly as possible, clinicians often administer a combination of about three drugs in one go. Even if the treatment works, it's very difficult to discern which of those three drugs actually produced the effect. Whether it works or not, a tremendous amount of medical resources are being expended: insurance funds, drug costs, hospital beds, the time of medical staff, and so on. In terms of making the best use of limited healthcare resources, this trial-and-error approach is a big problem.

Verify anticancer drug efficacy using the patient's own cells. We know the theory, yet it's not being done.

It's not that there is no way to test drug effectiveness before administration. There is something called a cancer gene panel test, which analyzes genetic changes in a patient's blood or tumor tissue to reveal the cancer's characteristics. However, currently this test only gets insurance coverage after standard treatments (the best scientifically supported treatments available at the time) have been tried multiple times and found ineffective. And even then, the percentage of patients whose treatment is successfully guided by this test is only 10.9%. It's far from reliably informative.

Anyone with a bit of biology knowledge might ask, "Why not take the patient's cancer cells and try the drugs on them in a dish first?" And that's exactly right. If you could properly harvest and culture the patient's cancer cells and test various drugs on them, you could almost certainly identify which drug is optimal. So why isn't that being done? Because culturing the patient's cancer cells is extremely difficult.

Growing cells taken directly from a patient is called primary culture. The primary cultured cells retain a state that's very close to how they were in the body. Because of that, they have many potential uses and are ideal for things like drug screening. However, historically this technique remained like a kind of artisanal craft, passed down through hands-on experience rather than a standardized protocol – it wasn't something just anyone could do easily. I have been working to break through that situation. Now that a viable approach has come together, I began commercialization efforts with the GAP Fund in 2022. This is my second time being selected for support.

Turning tacit expert know-how into explicit knowledge and shared experience. In modern terms, a method like AI learning that boosted a 10% success rate up to 70–80%.

To describe how we identify the effective chemotherapy, the process is: using the patient's cells to perform genomic analysis and determine the nature of their cancer, and thereby pinpoint a drug that matches it. You can imagine that to analyze the patient's cancer cells properly, it's important to examine them in as close to their in vivo state as possible.

Our approach was to dissect the techniques of primary culture and expand them from being one technician's tacit skill to an organizational level, making it a stable, reproducible technology. If we do that, we can structurally achieve personalized medicine where for each patient we can identify with certainty which anticancer drug will work, and prescribe it.

It's about elevating one person's experience into organizational knowledge. To unravel the techniques I had learned from my mentors by "watch and learn," I started by looking at images of patient-derived cells together with younger team members and explaining in detail what the distinctive features were and where to look. In tissue images of a tumor, of course there are normal cells mixed in with the cancer cells. By explaining how to tell them apart and what points to observe, I turned the technique into words. The juniors, though inexperienced, are trained professionals with knowledge. When they observe while hearing explanations of the why, they indeed say "Aha, I get it." It may seem like an analog approach, but in fact AI image analysis learns in the very same way. If anything, having the reasoning explained makes it far more efficient than AI. In this manner, we organized the "viewpoints for detecting cancer cells" across the team.

At the same time, we clarified the cultivation methods and the details of the materials used (like culture media and preservation solutions). Through repeated trial and error, we developed a new culture medium and storage solution, which raised the success rate of primary culture to 70–80%. When we first received funding in 2022, we were aiming to patent this suite of techniques, and now we have completed the patent filing. We also managed to perform drug efficacy tests using the cultured cancer cells.

Putting a stop to trial-and-error chemotherapy and making healthcare more efficient. Not only that, we want to pursue further possibilities.

We focused our research on lung cancer cells, which are notoriously difficult to culture, and succeeded in raising the primary culture success rate to 70–80%. This implies we can achieve similar results for other top-fatality cancers in Japan, such as colorectal, gastric, and pancreatic cancers. Being able to start treatment with a drug that has been proven effective in advance – in other words, bespoke therapy tailored to each patient – becomes possible. If we can zero in on only the drugs that will work and use them from the outset, side effects can be minimized and the treatment duration can be shortened.

For patients diagnosed at an early stage, this means they could return to society sooner, which also contributes to overall societal productivity. It improves both the cost-effectiveness and the efficiency of medical care. In this way, it not only saves patients, but also boosts the productivity of healthcare and society.

From a business perspective, we plan to start by offering a primary culture service – doing the culture on behalf of clients. Building on this culture technology, we want to optimize cancer panel testing and establish a service that handles everything from cell culture to genetic testing. We have already finished verifying the feasibility of performing panel tests on cultured cancer cells, so the next step is to develop a new kind of cancer panel test. Furthermore, we're considering ventures into selling cultured cancer cells and embarking on drug discovery research using miRNA (microRNA).

Of course, this will also give a boost to research beyond cancer therapy. For example, in the field of regenerative medicine (one of my research themes), having an established primary culture technique is a necessary condition for research. Also, in new drug development, being able to test many aspects in the laboratory at early stages will increase substantially. Improving the precision of cell culture is, I dare say, something that will pave the way for future medicine. As a researcher, using primary cultured cells as a foothold, I want to further expand the possibilities of medicine. That passion remains now as it always has.

Note: Prof. Yamamoto's previous initiative was introduced in the GAP Fund Program promotional booklet STST2022, available here: https://tongali.net/x/stst/ .

Profile

Fujita Health University

Naoki Yamamoto

Specially Appointed Professor, Fujita Health University, Research Promotion Headquarters Center for Industry-Academia Collaboration / International Regenerative Medicine Center

- Ph.D. (Medicine): Earned doctorate at Fujita Health University Graduate School of Medicine.
- Worked at Fujita Health University Hospital and its Emergency & Critical Care Center.
- Served as Assistant, then Lecturer, then Associate Professor at the university's joint research facilities.
- Apr 2020: Appointed Professor of Ophthalmology, Kanazawa Medical University School of Medicine.
- Jun 2021: Joined Fujita Medical University (Fujita Health University). Currently Specially Appointed Professor at the Research Promotion Headquarters (Center for Industry-Academia Collaboration / International Regenerative Medicine Center), Fujita Health University.
- Board member of the Japanese Tissue Culture Association and the Japan Cataract Society. Researches cancer cells, tissue stem cells, iPS cells, and immortalized cells in molecular cell biology and regenerative medicine.

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A CAR-T cell bank that opens a new door to overcoming cancer — enabling treatment "anytime," "anywhere," and for "anyone."

Fujita Health University / Keichiro Mihara

Feasibility study for commercializing allogeneic (donor-derived) CAR-T cell and iPS regenerative "killer" CAR-T cell banking technology

A fourth option emerges in cancer treatment — paving the way for a new therapy that harnesses the power of immune cells.

Surgery, chemotherapy, and radiation therapy have long been established as the three main pillars of cancer treatment. However, each of these methods has limitations in the range of cases it can address, creating the need for new therapeutic approaches. One that has been attracting significant attention is CAR-T cell therapy. In this treatment, immune cells collected from the patient are genetically modified to specifically attack cancer cells. It has shown remarkable results, such as enabling long-term survival in patients with acute lymphoblastic leukemia who were once told they had only a few months to live.

However, current CAR-T cell therapy faces major challenges. Its effectiveness depends heavily on the quality and quantity of the patient's own T cells, and it takes more than one to two months to collect the cells, expand them, and reinfuse them. During this period, some patients may pass away or see their condition worsen to the point where treatment is no longer possible. In addition, the therapy comes with extremely high costs, and manufacturing failures occur at a certain rate, making it difficult to administer the treatment to all patients who might benefit.

Because only a limited number of medical institutions can perform the procedure, the number of patients who can receive the treatment is also restricted. Moreover, when used as a last resort after many rounds of anticancer drug treatments, the patient's T cells are often severely damaged, resulting in highly limited effectiveness. Thus, despite being a groundbreaking therapy, there is a reality in which many patients cannot access it, posing a significant challenge from the perspective of medical equity.

By using donor cells and creating a cell bank, we can develop a treatment that provides exactly what is needed, when it's needed.

To overcome these challenges, we are developing a CAR-T therapy using cells from other people (allogeneic cells) and iPS cells. Instead of relying on each patient's own cells, we take immune cells from healthy donors or derive them from iPS cells, engineer them into CAR-T cells, and bank them for storage. In other words, we prepare CAR-T cells in advance and keep them ready for use when needed.

I have been researching CAR-T cells since around the year 2000, and from that experience I'm focusing on a CAR-T cell construction technique that zeroes in on a particular subset of T-cells. We have already established a method to expand this special type of immune cell. We confirmed that these cells can be cryopreserved in liquid nitrogen and will still retain sufficient function after thawing.

Our research results are steadily accumulating. For example, we developed a CAR-T cell targeting CD38 – a glycoprotein present on the surface of many immune cells – and in experiments, when administered to multiple myeloma cells, the cancer cells almost completely disappeared in just 2–3 days. We have also filed and obtained several patents related to various "cancer-specific markers."

By producing cells in advance and storing them in a cell bank, we can establish a system that allows immediate use whenever needed. This approach can also solve the problem of high manufacturing costs and make it possible to provide treatment to many patients without geographical limitations. We are making great strides toward realizing a therapy that can be used "anytime, anywhere, by anyone."

Networked Research Facilities and Cell Banks to Optimize Supply

Our strength lies in the well-established research infrastructure of Fujita Health University. The Bioresource Center stores tissues and blood and creates a CAR-T cell bank. T cells are produced in the CPC facility (a dedicated cell culture facility), and at the Fujita Health University Haneda Clinic, which opened in October 2023, private (self-funded) treatment is also available. By leveraging these facilities, we aim to optimize the cell supply system.

In Japan, CAR-T cell therapy became available in 2019 and as of now can be administered at 43 hospitals nationwide. The number of eligible diseases is also expanding, and usage of CAR-T is expected to grow even further. Particularly noteworthy is a paradigm shift: rather than positioning CAR-T only as a last-resort treatment, there is a move to establish it as a second-line or salvage therapy – an additional treatment option earlier in the course of care.

In fiscal year 2024, we will use specialized laboratory mice to verify the safety and efficacy of our allogeneic CAR-T cells. From 2025 onwards, we plan to set up a master cell bank (a "parent bank" for long-term storage of high-quality cells) and a working cell bank (a "supply bank" storing cells for actual therapeutic use). In parallel, we will continue refining cell culture and preservation methods. We are also steadily preparing for practical applications by establishing manufacturing and quality control systems, conducting various tests, and compiling final study reports and product summaries.

Our initial target is patients with hematologic (blood) malignancies, who would benefit most from this technology. Looking ahead, we are considering mass production to reduce treatment costs, so that even more patients can receive this therapy. Globally, the CAR-T therapy market was about $5.08 billion in 2023 and is projected to reach $7.15 billion by 2030. Through this treatment – which is gaining worldwide momentum – we hope to deliver hope to as many patients as possible.

Aiming for treatments that can cure cancer, and delivering medical care that brings hope.

Up until now, most cancer treatments have focused on slowing disease progression or extending life expectancy. But I believe that is not enough. If a patient's cancer relapses in six months or a year, then we have merely bought a little time while prolonging their uncertainty and suffering. What truly matters is freeing patients from the fear of cancer's return – that is the goal of the treatment we aim to achieve.

Why do I believe this goal is achievable? Our approach can act not only on cancer cells themselves but also on the tumor microenvironment around them. If cancer cells are like "weeds," our method also treats the "soil" in which they grow, thereby suppressing the chance of regrowth. With this new therapy, we aspire to what previous treatments found difficult – the complete eradication of cancer. That is the key distinguishing feature of our approach.

When I started this research, I never imagined we would come this far. But now I am convinced that we can truly cure cancer. Currently our target is blood cancers, but in reality many people die from solid tumors. Solid tumors present a challenge: their cells are densely packed, making it hard for T-cells to penetrate and attack them. However, by also acting on the surrounding environment of solid tumors, we are working to develop more effective treatments for those cancers as well.

I expect that in the future we might reach an era where this therapy alone can prevent cancer from ever coming back. If we can prepare cells in advance (via banking), costs will come down, allowing more patients to receive treatment. By eliminating inequalities where patients cannot get treated due to geographic or financial constraints, we aim to deliver hope to all patients. That is our ultimate goal. I also feel that our efforts are bringing us ever closer to the day when our approach changes the established norms of cancer treatment and brings new hope to patients and their families.

Keichiro Mihara

Profile

Fujita Health University
Keichiro Mihara

Professor, TR (Translational Research) Division, International Center for Cell and Gene Therapy, Fujita Health University; Professor, Department of Cellular Immunotherapies for Cancer, Graduate School of Medicine, Fujita Health University.

Graduated from the Faculty of Medicine, Tottori University. After completing residency, I earned a Ph.D. in Medicine from the Graduate School of Biomedical and Health Sciences, Hiroshima University. Served as a resident at the National Cancer Center Research Institute, engaging in research on the cell cycle and p53 phosphorylation. Following a position as a medical staff member in the Department of Hematology at Hiroshima University Hospital, worked as a postdoctoral fellow in the Department of Hematology-Oncology at St. Jude Children's Research Hospital in the United States, conducting research on mesenchymal stem cells and CAR-T cells. After returning to Japan in 2003, served as Assistant Professor and later Associate Professor in the Department of Hematology at the Research Institute for Radiation Biology and Medicine, Hiroshima University. Has held the current position since 2020.

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The power of new materials to transform the medical field —significantly reducing the burden of long surgeries.

Meijo University / Atsuhiko Senba

Feasibility study for the commercialization of advanced medical devices made from composite materials.

The challenge in neurosurgical operations lasting up to 10 hours: heavy surgical instruments that continuously exhaust surgeons

In neurosurgery, a bipolar coagulation hemostat—a forceps-like instrument—is indispensable. The tips serve as electrodes, and hemostasis is achieved by applying high-frequency current to bleeding sites. Surgical procedures can last up to 10 hours, and this places an enormous physical burden on surgeons.

Prolonged use of such instruments often leads to occupational health issues for surgeons, including tendonitis and strain on the neck and lower back. Moreover, when made from traditional metals, the design flexibility of these instruments is limited, making it difficult to fully optimize comfort during surgery. In fact, even products currently made from aluminum alloys carry considerable weight, and slimmer stainless steel designs still cannot eliminate the physical strain.

This has become a barrier to women aspiring to enter fields like neurosurgery. Japan has about 10,000 neurosurgeons, but the proportion of women among them is extremely low, and the physical demands of surgery are cited as one contributing factor. Additionally, as the surgeon workforce ages, instrument weight poses an increasing challenge for older doctors. There is a pressing need to develop new surgical instruments that lighten the load on surgeons and enable more precise operations.

In response to these issues, we initiated a new development driven by medical needs. Based on direct requests from surgeons, we began exploring the potential of novel materials to replace traditional metals. Rather than pursuing innovation in basic research for its own sake, our top priority is solving the real-world problem in the operating room.

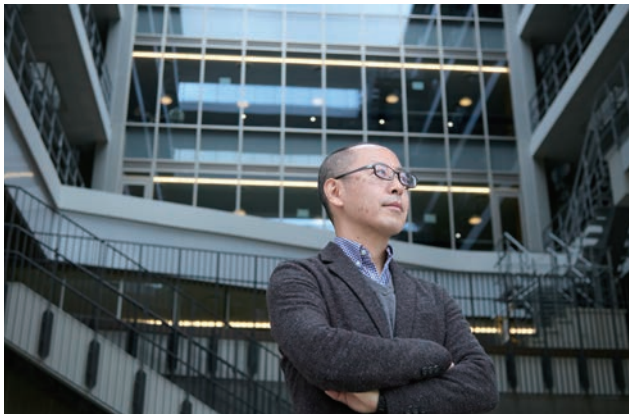
Applying Lightweight Materials from Aircraft to the Medical Field – Expanding Possibilities with Composites

We turned our focus to an advanced composite material called CFRP (Carbon Fiber Reinforced Plastic). CFRP (Carbon Fiber Reinforced Plastic) is up to 40% lighter than aluminum and 80% lighter than stainless steel. It's also X-ray transparent, meaning it won't block the view on CT imaging like metal instruments do. While CFRP is rarely used in the medical field yet, it's a well-established mainstay in the aerospace industry for weight reduction.

Our instrument design uses a plastic called PEEK (polyether ether ketone), long used in medical devices, as the base, and incorporates about 30% carbon fibers of 7 μm diameter. During manufacturing, we melt the material and inject it into a mold, causing the carbon fibers to align along the flow. This molding method allows us to impart strength in specific directions.

There are two manufacturing approaches: laminating sheet materials and baking them in an oven, or a more cost-effective injection molding process. We chose the latter. The device is durable enough to maintain tip precision for a single operation. For longer surgeries, 2–3 instruments may be needed, as it is designed as a single-use device.

Our prototypes use injection molding, which allows us to achieve complex curved shapes that are difficult to make with metalworking. The first prototype focuses primarily on weight reduction, featuring a more ergonomic design than the conventional straight forceps shape. We plan to expand the product lineup with designs that account for surgeon comfort and ease of use.



A New Product to Meet Medical Needs – From Disposable to Custom-Made Instruments

The surgical instrument under development is an extremely precise product, with tips measuring less than 1 mm. It features both hemostatic and cutting functions using high-frequency current, and this level of precision is indispensable. Our goal is to provide the product in a pre-sterilized state at the time of shipment, so that it can be used immediately after opening the package. Conventional products require sterilization before use, but disposable instruments would eliminate this step entirely.

One particular focus is offering product variations tailored to the surgeon's physique. While the delicate precision of the tip must be identical across all models, the grip portion is affected by the user's body size. Therefore, we plan to offer sizes such as L, M, and S. Furthermore, based on feedback, we are considering custom-made options to meet individual surgeons' preferences. In fact, some surgeons carry their own preferred instruments to every operation.

In recent years, there has been growing attention to physician ergonomics and quality of life (QOL). The focus is on creating work environments that enable doctors to maintain good health throughout their careers. Our technology can meet these needs in the medical field. We have already obtained a joint patent for this technology with Meijo University, Nagoya University, and our corporate partner.

In the medical device market, overseas products currently dominate, and the recent depreciation of the yen has further driven up prices, increasing the demand for domestic production. In terms of scale, there are approximately 10,000 neurosurgeons in Japan, with an estimated 100,000 neurosurgical operations per year. Assuming an initial 20% market share, we expect to create a market worth around 1 billion yen. Furthermore, by expanding to neurosurgeons worldwide and into other specialties such as orthopedics and otolaryngology, we believe the market could grow more than 100-fold, reaching as much as 100 billion yen.

Pursuing material innovation in medical devices — for better healthcare environments for both doctors and patients.

In the world of medical devices, few researchers are exploring the use of composite materials. Many think they "don't have the luxury" to venture into such areas, so it's rare to consider applying composites in medicine. However, I believe that by pushing the boundaries of materials and structural design, we can create entirely new value in medical devices.

Ensuring surgeons can work in good health is also crucial for patient care. For instance, if during a nearly 10-hour surgery a surgeon is forced to take breaks because of instrument weight, that is detrimental to the patient's treatment. We are constantly asking, What shapes or designs could enable capabilities that were not possible before? Listening to voices from the field, we will keep refining our device.

Our goal as a venture company is to become a medical device manufacturer, but that cannot be achieved overnight. We hope to grow the company together with passionate collaborators, and contribute to society along the way. First, we are focusing on developing a device that can be processed with existing hospital sterilization equipment, to lower the hurdles for adoption in the medical field. We will leverage the freedom of shape afforded by composite materials to develop products truly designed from the user's perspective.

Looking further ahead, we see potential in fields like disaster and emergency medicine. Lighter equipment can make a huge difference during transport in such situations. For example, when airlifting by helicopter, cutting the weight of equipment in half means you can carry twice as many medical devices. We are also considering incorporating new functions into our instruments to meet various requests from clinicians. By adding such new capabilities, these devices could significantly transform the medical field itself. Through product development, we aim to contribute to improving the quality of healthcare.

Profile

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Atsuhiko Senba

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Completed the Doctoral Program in the Department of Built Environment, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, earning a Ph.D. in Engineering. Served as a Researcher at Tokyo Institute of Technology from 2007, Assistant Professor at the Graduate School of Information Science, Nagoya University, and Assistant Professor at the Nagoya University National Composite Center (NCC), before assuming the current position in 2015.

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Attaching the Essential "Water-Soluble" Trait to Drugs – A Simple, Low-Cost New Idea

Meijo University / Keita Kondo

Validation of a solvent-free amorphous pharmaceutical formulation technology for potential licensing

An active pharmaceutical ingredient must dissolve in water to be absorbed by the body —a dilemma where a hard-won therapeutic effect cannot be realized.

For example, a pain reliever contains an active ingredient that actually relieves pain. This active ingredient is known as the API (active pharmaceutical ingredient). It is the crucial substance that determines the drug's effectiveness. However, you can't simply sell the API by itself as a drug. The API alone may not be readily absorbed into the human body, and it also needs to be in a form that can be easily stored and transported. That's why a process called formulation is indispensable – in which we add inert, safe excipients to the API and create the final drug product.

Whether an API is easily taken up by the body essentially comes down to whether it is water-soluble. About 50–60% of the human body weight is water. Blood, lymph, and digestive fluids all use water as a solvent (the liquid that dissolves other substances). For a drug to exert its effect as a drug, it must first dissolve in water – this is the fundamental premise.

However, over 70% of newly discovered candidate compounds for APIs in recent years are said to be hydrophobic, meaning they do not dissolve in water. In fact, roughly 40% of currently marketed drug APIs have some kind of modification or formulation to help them dissolve in water.

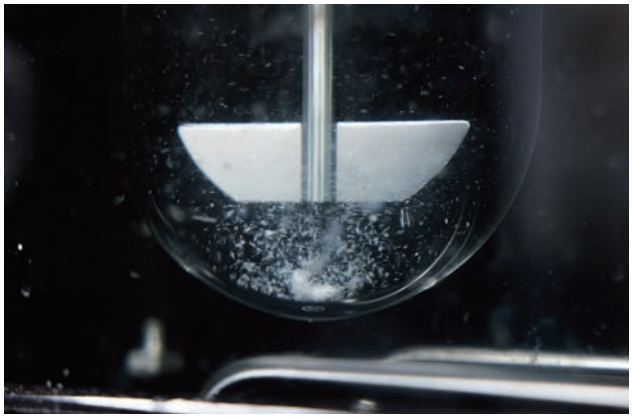
Why is this? As drug development progresses, the chemical structures of APIs tend to become more complex, which often reduces the proportion of hydrophilic (water-attracting) parts or buries them inside the molecule, making the compound less water-soluble. Considering the advances in pharmaceuticals, it's likely that many future APIs will be structurally complex and hence poorly water-soluble. Therefore, techniques to enhance water solubility will become ever more critical in drug development.

Breaking APIs Down to the Molecular Level – The "Achilles' Heel" of Current Processes

When we say an API dissolves in water, we mean that individual molecules of the API become dispersed among the water molecules. But most APIs, as soon as they are synthesized, come out as crystals – solid substances in which molecules are arranged in a regular pattern and held together by strong forces. We need to break this crystal structure apart into individual molecules. To do that, we typically dissolve the API crystals in an organic solvent (a liquid that can dissolve substances which water cannot) to disrupt the crystal lattice. This process of breaking down the crystal structure is called amorphization (making the substance amorphous, i.e. non-crystalline).

However, this step is a serious headache for pharmaceutical manufacturers. Organic solvents include substances like alcohol, acetone, and toluene. Many of them are not only highly flammable but even explosive in some cases. Working with such solvents requires explosion-proof facilities, equipment, and properly certified handlers. Moreover, many organic solvents are toxic to humans, so after dissolving the API and achieving amorphization, the product must be thoroughly dried to ensure no solvent remains. In short, making a drug water-soluble using current methods incurs enormous cost.

These high costs lead to another problem. In Japan, drug prices (reimbursements) are set by the government (Ministry of Health, Labour and Welfare) and are generally revised downward every two years. Meanwhile, manufacturing costs don't decrease accordingly, which means profit margins get squeezed with each price cut. For generic drugs (off-patent drugs), the production cost can be about 70% of the drug price, and repeated price cuts can even drive the price below the cost to make them. In such cases, the more you produce, the more money you lose, potentially forcing manufacturers to cease production, which poses a risk to stable drug supply.



A method for amorphization without relying on organic solvents — a surprisingly simple technology born from a shift in perspective.

Is there a way to make an API dissolve in water without using organic solvents? One method is to melt the API crystals at high temperatures to induce amorphization, but this cannot be used for APIs that are heat-sensitive. Unfortunately, the majority of APIs are sensitive to heat.

The hint came from a device called a ball mill — a cylinder containing hard balls made of metal or ceramics along with the material to be pulverized, which is then rotated. Think of it as an industrial mixer that crushes the material into fine powder. Ball mills are simple in structure and come in a range of sizes, from those used in laboratories to massive ones in cement plants. However, because even a minute amount of the ball material inevitably wears away and mixes into the product, the idea of using them in pharmaceutical manufacturing had never been considered.

A ball mill can grind materials into powder with particles even smaller than potato starch. The powder tends to accumulate at the bottom of the cylinder, but it also coats the surface of the balls themselves. Seeing that gave me an idea: what if we made the "balls" out of cellulose? Then perhaps the balls could just become part of the medicine itself.

Cellulose is the main component of plant cell walls and fibers. It is said to be the most abundant carbohydrate on Earth. It doesn't dissolve in water, so the human body can't digest it. However, it is the primary ingredient in natural dietary fiber found in foods like potatoes and beans, and it's widely used as a safe food additive in products like cheese, ice cream, bread, and condiments. It's also already used in forming pharmaceutical tablets.

Our idea was to form cellulose into tiny spherical granules – essentially small balls – and mix them with the API crystals in a milling process. As expected, the cellulose balls ground down the API crystals into a fine powder (amorphizing them), and the API coated the surface of the cellulose balls. Once we achieve that, we can form the material into tablets, capsules, granules – whatever dosage form we want. No organic solvents or high heat needed. It's a very simple principle.

Safety is paramount, but making drugs more affordable is also crucial, as it directly supports the health of many people.

We are now working to commercialize this technology and implement it in society. We have already filed two patents on the manufacturing method and are testing whether this technique can be practically applied in drug development, with plans to complete verification by the end of FY2024.

We are currently deliberating the best route to commercialization. Pharmaceutical companies used to perform all steps of drug development in-house, but in recent years they outsource many processes as part of business reforms. We are exploring what type of company and in what form this technology can be provided most effectively.

Pharmaceutical companies have a huge social responsibility: once they start selling a drug, they can't easily stop, because patients' treatments depend on it. However, with price revisions every two years forcing prices down, if competing companies quit making a drug, the remaining manufacturers shoulder even more responsibility to continue supplying it – even if they start incurring losses – otherwise patients would suffer. In effect, the more diligently a company tries to continue supplying an important generic drug, the more it risks bankruptcy. Companies are fighting a paradox where doing the right thing threatens their survival.

Therefore, I initially thought our technology could serve as a lifeline to rescue generic drug manufacturers, where raw material costs weigh most heavily on their finances. We are indeed seeking business partners down that avenue. But then another thought struck me: are there any "phantom new drugs" – potentially excellent drugs that were fully developed as effective APIs but never reached manufacturing or market because they couldn't overcome the amorphization hurdle? Could it be that miracle cures that should have been born by now are instead gathering dust in some company or university lab, simply because they couldn't be made water-soluble? As a pharmaceutical scientist, I believe this is entirely possible. That possibility is exciting to contemplate.

I am a researcher in pharmaceutics. My work centers on how to simplify pharmaceutical formulation technology. By supporting drug supply through better formulation techniques, I want to help create a world where many more people can benefit from a wide variety of medications.

Keita Kondo

Profile

Meijo University
Keita Kondo

Associate Professor, Laboratory of Industrial Pharmacy, Department of Pharmacy, Faculty of Pharmacy, Meijo University.

Completed the Doctoral Program in Pharmaceutical Sciences at the Graduate School of Pharmaceutical Sciences, Meijo University, earning a Ph.D. in Pharmacy. In 2013, appointed Assistant Professor in the Laboratory of Industrial Pharmacy, Faculty of Pharmacy, Meijo University. From 2021, conducted a 10-month research stay as a Guest Researcher in the Department of Pharmacy, University of Copenhagen (Denmark). Has held the current position since 2024. Areas of expertise: pharmaceutics and powder engineering. Engaged in the development of pharmaceutical formulation technologies that do not use solvents. Reference information for this project: Japanese Patent Application No. 2023-111045, Japanese Patent Application No. 2024-192291.

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A New Method for Veterinary Surgical Training – Honoring Animal Lives While Ensuring Hands-On Experience

Gifu University / Kazuhiro Watanabe

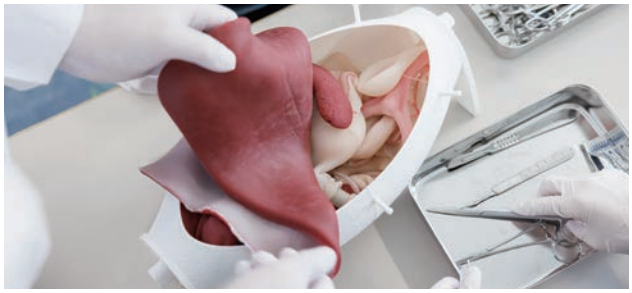
Development of a small-animal surgical training model that does not sacrifice animal lives

The use of live animals in surgical training should be abolished — but the opportunity to practice and experience surgical techniques must be preserved.

In the past, not only at our university but at all veterinary schools, there was a type of training that aspiring veterinarians could not avoid: surgical practice using live animals. To gain hands-on experience of the medical knowledge learned in lectures, students would actually perform incisions on live animals. It was a valuable opportunity to understand the three-dimensional structure of the body and the realities of surgery — aspects that textbooks alone could not fully convey.
In medical schools, there is a system called body donation, in which cadavers are provided with the cooperation of the bereaved families. Furthermore, even after obtaining a medical license, physicians are required to undergo a mandatory clinical training program to acquire practical skills in real medical settings, ensuring that they are never tasked with performing surgery immediately after graduation.
In contrast, veterinary medicine historically had no post-graduation clinical training system. Thus, veterinary students had to make the most of whatever live-animal surgical practice they got during school, so that they could handle surgeries on their own once they graduated. For students who chose veterinary medicine out of a desire to save animal lives, having to perform surgery on a healthy laboratory dog was an extremely painful trial – a heartbreaking hurdle they had to face.
In recent years, animal welfare concepts have gained traction. In 2013, our university made the bold decision to abolish the use of live animals in surgical training. Everyone was secretly relieved by this decision. But at the same time, it meant losing a valuable opportunity for students to learn a living animal's three-dimensional anatomy and experience the realism of surgery beyond flat images in textbooks or videos.

Textbooks and Videos Alone Have Limits – Existing Models Fall Short for Surgical Training

Our stance became "no live animals in surgical practicums." We absolutely did not want to harm animals. We tried everything to simulate surgical realities through other means: surgical videos, anatomical models, mannequins, kits, computer simulations – you name it. We scoured educational materials both domestically and internationally, especially looking for 3D models or kits that could help students understand body structures spatially and experience aspects of surgery. We spared no effort in our search.
For example, for diagnostic practice, we found models for listening to heart and lung sounds, thoracocentesis (chest puncture) models, femoral artery palpation models, etc. For learning anatomy, there were models for neutering/spaying surgeries. We even obtained materials for practicing suturing skin.
However, most commercial products were either overly simplistic (like stuffed-toy level models), focused on specific procedures or diagnostics, or only provided isolated body parts. Some overseas models did strive for realism, but they were prohibitively expensive, making them impractical for student training. We found no model that let students reproduce an actual surgery – for instance, making an incision in an animal's abdomen, ligating blood vessels, and suturing organs like the stomach, intestines, or bladder.
We wondered: what are other universities doing? It turned out they were struggling with the same issue. One school had attempted a crowdfunding campaign for funds, but in the end they could only afford to collect the usual expensive commercial models – which still couldn't be cut open or sutured to simulate real surgery, leading them to conclude it was impossible with existing models.



If we can't find it anywhere in the world, we'll make one ourselves. That is the only solution.

We realized that if such a surgical model doesn't exist, we would have to create one that we're satisfied with, because that's the only solution. The fact that we couldn't find one despite exhaustive search meant every veterinary school in Japan was facing the same problem. So, we decided to design an affordable model that would serve not for anatomy practice, but specifically to simulate surgical training.

Fortunately, I have decades of experience in clinical education. I even authored a textbook that explains the surgeries required in primary care for dogs and cats1. I thought that if we created a surgical model linked to that textbook, students could have a guided simulated surgery experience through the textbook and corresponding videos.

In veterinary medicine, as in human medicine, there is primary care and secondary care. The majority of local animal clinics provide primary care, and most surgeries performed at the primary care level are abdominal surgeries. Therefore, we focused our model on the abdomen, which contains the digestive, urinary, and reproductive organs. This way, the model allows simulation of the surgeries most needed in primary care with a sense of realism. If a model doesn't accurately recreate the 3D relationships of organs in the abdomen, students might panic during real surgery at the sight of internal organs under tension and bleeding. Thus, we put great effort into replicating the shapes, sizes, and positions of the organs. When you cut open the model's abdominal wall, you shouldn't immediately see the target organ. We reproduced the actual incision process: skin incision → separation of subcutaneous tissue → muscle layer incision and ensured that organs positioned toward the back can only be reached by carefully moving aside the organs in front. We paid attention to these surgical points to provide a truly three-dimensional realism in the model. We also struggled with selecting materials that closely mimic the real texture of organs and skin, and that are suitable for surgical manipulation. For example, a material easy to cut is often hard to suture, while one that's hard to cut is easier to suture – finding the right balance was challenging.

On the other hand, in collecting commercial models we painfully realized the issue of cost. Given the purpose and usage, a surgical training model should be considered single-use. To keep costs down even a little, we decided the model's external appearance only needs to be an oval "egg-shaped" case up to the point where it would be covered by surgical drapes (the sterile sheets over a patient during surgery). By covering the model with a drape, students can still get the feel of a real surgery while we keep the model itself as simple as possible externally. We are also considering a business model where after use, the internal organ components can be recycled or replaced with new ones to further reduce costs.

Gaining Not Just Funding but Recognition and a Support Community Through Crowdfunding

After implementing our surgical model in training, we found that students' practical exam performance improved. Also, at our university's annual open campus, high school students got to try out the surgical model, and many said it made them eager to apply to Gifu University – in fact, some applicants in the 2024 admissions cited this initiative as a reason for choosing our school.

To fund the adoption of these surgical models as teaching tools, we ran a crowdfunding campaign in 2022. The campaign garnered a lot of attention, leading to features on TV, radio, and in newspapers, and received an overwhelming response. We raised ¥10.19 million against a ¥5 million goal – more than double the target – which allowed us not only to cover the cost of the initial teaching materials but also to invest in further improving the models. Among the many supportive messages we received, one particularly striking comment was: "I once aspired to become a veterinarian, but I couldn't overcome the trauma of live-animal dissections and gave up." It highlighted how truly compassionate individuals, who cannot bear to see animals suffer, were being lost to the veterinary profession – a great loss for veterinary medicine, in my opinion.

Some argue in response to such comments that "if one lacks the resolve to face life-and-death situations, they aren't fit to be a vet." I acknowledge that point. Veterinarians who have made it through live-animal surgical training are by no means unfeeling or cruel. Yet even those vets would likely have avoided causing harm to animals if an alternative existed. So I firmly believe this project must succeed and become established.

To date, out of the 17 veterinary schools in Japan, we've been contacted by 7 universities about our models. Four have purchased models, and we've sent samples to three others. Several local chapters of the Veterinary Medical Association have also expressed interest in purchasing units. Our initial goal is to introduce the model in all 17 vet schools domestically. Furthermore, with the recent licensing of animal nursing as a profession, we see potential to expand into veterinary nursing schools as well. We are also considering how it could be used for continuing education of young veterinarians after graduation.

We have started exploring international avenues too – for instance, in the US and Europe, where there is strong enthusiasm for animal welfare, our model could find a receptive audience. In Japan, roughly 1,200 veterinary students undergo surgical training each year. Our first aim is to deliver a model into each of their hands. I believe that spreading this initiative at home and abroad will raise the quality of veterinary care and save many animal lives. By changing how we educate future vets, we're not only improving training — we're taking a first step toward a future where animals can live happier, healthier lives.

Illustrated Guide to Canine and Feline Clinical Surgery: Primary Care Procedures You Can Perform Immediately Published by Eduward Press... Winner of the 1st Place Award in the Eduward Press Book Election (2023)

Kazuhiro Watanabe

Profile

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Kazuhiro Watanabe

Professor, Laboratory of Veterinary Surgery, Joint Department of Veterinary Medicine, Faculty of Applied Biological Sciences, Gifu University; Director, Gifu University Animal Medical Center.

Completed the Doctoral Program at the Graduate School of Veterinary Medicine, Hokkaido University, earning a Ph.D. in Veterinary Medicine. Appointed Assistant (later Assistant Professor) at Gifu University in 2002, promoted to Associate Professor in 2007, and has held the current position since 2019. Serving as Director of the University Animal Hospital since 2022. Has been in charge of veterinary surgical training for over 20 years. Major publications include Reading Illustrations! Clinical Surgery of Dogs and Cats and Reading Illustrations! Clinical Dentistry and Oral Surgery of Dogs and Cats (both published by Eduward Press). The surgical model is currently patent pending.

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A formidable threat resistant antibacterial drugs emerges —developing new treatments to kill drug-resistant bacteria

Gifu University / Shoichi Mitsunaka

Commercialization of phage therapy for multidrug-resistant bacterial infections

In reality, the only practical treatment for bacterial infections is the administration of antibiotics —but when infected with drug-resistant bacteria, treatment becomes difficult.

For a long time, bacterial infections were like demons plaguing humanity. In 1928, the discovery of penicillin (the first antibiotic) completely changed that situation. Antibiotics can kill a broad range of bacteria while having minimal effects on human cells. Thanks to antibiotics, humans gained the ability to treat all sorts of bacterial infections, and it seemed we had overcome those diseases. However, today we face a serious problem: bacteria that have become resistant to antibiotics, known as drug-resistant bacteria.

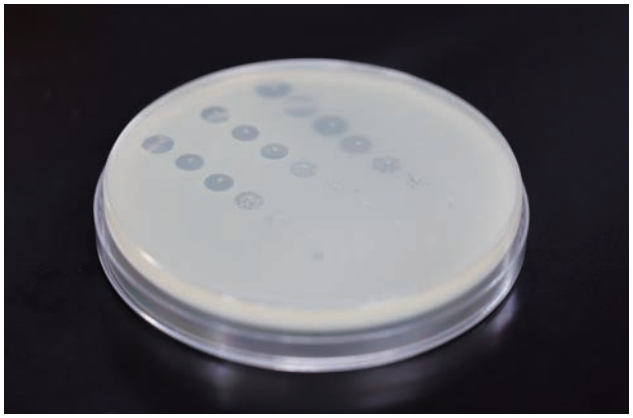
Drug-resistant bacteria are spreading globally. In 2013, about 700,000 deaths worldwide were associated with drug-resistant bacterial infections; by 2019, this increased to 1.27 million deaths. If no effective measures are taken, it's estimated that by 2050 the annual death toll could reach 10 million – exceeding the current number of deaths from cancer. To avert this threat, we need new antibiotics effective against existing drug-resistant bacteria. But developing a new antibiotic requires enormous cost, and history shows that eventually bacteria will emerge that resist any new drug – indeed, antibiotic development has stagnated in recent years.

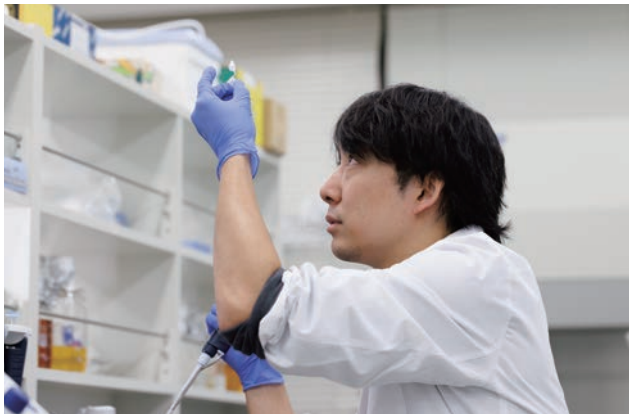
Currently, administering antibiotics is the optimal treatment for bacterial infections, and we have no practical alternative. To fight the intensifying battle against drug-resistant bacteria, we need not only new antibiotics but also entirely new types of antimicrobial therapies.

A "natural enemy" of bacteria that targets only specific strains is drawing attention as a new therapy for multidrug-resistant bacterial infections.

As a potential new treatment, bacteriophages (hereafter "phages"), the natural enemies of bacteria, are attracting worldwide attention. Phages are viruses that infect host bacteria, proliferate within them, and ultimately lyse the host cells. Although the word "virus" may sound alarming, phages are harmless to the human body. A key characteristic of phages is that they rarely infect across bacterial species. Moreover, even within the host bacterial species, not all strains are susceptible — each phage can infect only specific strains. This characteristic is called "host specificity." When a single phage can infect many strains, it is said to have a "broad host range," whereas if it can infect only a few strains, it has a "narrow host range." Because of this host specificity, phages are more difficult to use compared to broad-spectrum antibiotics, which can act on many types of bacteria. As a result, antibiotic research has historically advanced more quickly in the field of infectious diseases.

However, phages kill bacteria through mechanisms entirely different from antibiotics, so they can also kill drug-resistant bacteria. In 2016, the famous "Patterson case" was reported – a success story of phage therapy. In that case, doctors administered a mixture of phages (a phage cocktail) with different host ranges to a patient in a coma from a multidrug-resistant bacterial infection, and the patient made a remarkable recovery. After that, more success stories followed, and it became known that phage cocktails can be effective against drug-resistant bacterial infections. The question we faced was: "How do we efficiently identify phages that can effectively treat infections?".





Finding the suitable Phages and Evaluating Their Therapeutic Potential – Plus, Creating "Designer" Phages

In fact, phages can be easily isolated from the natural environment using their host bacteria. But not all phages are suitable to use as therapeutics. A phage with an overly narrow host range cannot be used for therapy, and one with a broad host range but poor killing efficiency would also be difficult to apply clinically. Additionally, some phages carry genes that are unsuitable for therapy. Therefore, to utilize phages as drugs, we need robust analysis techniques to characterize each phage's traits.

We have, over the years, isolated a great many phages from nature and analyzed their properties. Through this work, we've developed know-how that lets us isolate and characterize phages very rapidly. Using the data from those analyses, we also select candidate phages to include in phage cocktail formulations.

Furthermore, we have established a "phage synthetic engineering" that allows us to freely engineer phages. In this approach, phage DNA is amplified by PCR using chemically synthesized DNA or a phage genome as a template, the fragments are assembled, and then introduced into a host bacterium to create a designer phage. Using this technology, we can load therapeutic genes onto the phage genome, remove unnecessary genes, or alter and expand its host range. This enables us to engineer phages that would otherwise be unsuitable for direct administration to patients, making them usable for phage therapy. In addition, we can endow phages with entirely new functions they do not naturally possess, thereby enhancing their therapeutic effects.

Now, it's not easy to apply phage synthetic engineering to every phage, but we plan to further advance this technology and/or combine it with other engineering methods to establish a "designer phage creation platform" for developing therapeutic phages. This will be a central part of our commercialization effort moving forward.

Phages are not meant to Replace Antibiotics, But to be Used Alongside Them. Having multiple measures allow us to overcome multidrug-resistant bacterial infections

One of our strengths on the path to commercialization is precisely our know-how in rapidly isolating and characterizing phages. There are few groups in Japan studying phages from the perspective of pharmaceutical formulation, and we believe our know-how is at a very high level. However, looking globally, there are already startup companies pursuing phage therapy. These companies have their own proprietary know-how for phage isolation and analysis, which is kept secret, so we can't directly compare ourselves to them. What we do know is that at least a few companies have already advanced phage cocktail products into clinical trials. So no matter how excellent our techniques are, if we simply follow in their footsteps, we will always be chasing those pioneers. How can we catch up? This is where our other major strength – our knowledge in phage engineering becomes crucial.

Our phage synthetic engineering technology can engineer many types of phages. We have already used this technology to create numerous designer phages. By analyzing those designer phages, we are learning which modifications can enhance their infection-fighting effectiveness. We plan to leverage this knowledge: by creating designer phages that have improved therapeutic effects and developing superior phage cocktail formulations, we can close the gap with the leading companies.

I think phage cocktail therapy will not completely replace antibiotics. Many bacterial infections are still well-treated with existing antibiotics, and antibiotics remain a highly effective tool in those cases. Moreover, developing a phage cocktail also requires time and money. That said, given that phages replicate using the host bacteria themselves, the production cost might actually be relatively low compared to some drugs. The key is that even if antibiotics fail, we will have another means to combat the infection. As an optimal option, phage therapy will play a complementary role alongside antibiotics, and having multiple lines of defense is crucial to truly overcome bacterial disease.

Shoichi Mitsunaka

Profile

Gifu University

Shoichi Mitsunaka

Assistant Professor, Graduate School of Medicine, Gifu University.

Completed the Doctoral Program in Life Science at the Graduate School of Science, Rikkyo University, earning a Ph.D. in Science. After working as a postdoctoral researcher at the Graduate School of Medicine, Gifu University, assumed the current position in 2023. Engaged in research on modification technologies for bacteriophages — viruses that are the natural enemies of bacteria.

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Heart disease, the second leading cause of death in Japan, is increasing year by year —what we can do now to prevent a heart failure pandemic

Mie University / Hiromasa Ito

Feasibility study of a health longevity package using a management app for preventing onset and recurrence of heart disease

Clutching the chest in sudden pain and collapsing in agony —in reality, long before that moment, heart failure has already been silently undermining the body.

When you hear the term "heart failure," what kind of image comes to mind? You might picture someone suddenly clutching their chest, collapsing, and being unable to move — but in most cases, such sudden attacks occur only when the condition has already progressed significantly.

Strictly speaking, heart failure is not the name of a single disease. It refers to a state in which an abnormality in the heart causes its pumping function — the ability to send blood throughout the body — to decline, resulting in insufficient blood flow. There is usually an underlying condition or heart abnormality, such as high blood pressure, angina, or myocardial infarction, that causes it. Symptoms such as palpitations, shortness of breath, fatigue, and swelling in the body gradually appear. If left unnoticed and untreated, reduced blood flow can damage organs. Decreased urine output and fluid retention can cause swelling and congestion throughout the body, leading to a vicious cycle that further impairs heart function — making heart failure a dangerous and life-threatening syndrome.

It is not widely known, but like cancer, heart failure also has stages. Stage A refers to individuals who have risk factors that can lead to heart failure, such as high blood pressure or diabetes, but no actual heart disease. Stage B is when heart disease — such as ischemic heart disease — is present. In both of these stages, there are no symptoms of heart failure. Once the disease progresses and symptoms of heart failure appear, it is classified as Stage C. If it worsens further and the symptoms do not sufficiently improve despite treatment, it becomes Stage D, or refractory heart failure. Because the condition tends to progress gradually through repeated cycles of deterioration and recovery, many people fail to notice it after just a few episodes of shortness of breath — and it is not uncommon for someone to collapse suddenly, only to find they are already in Stage C.

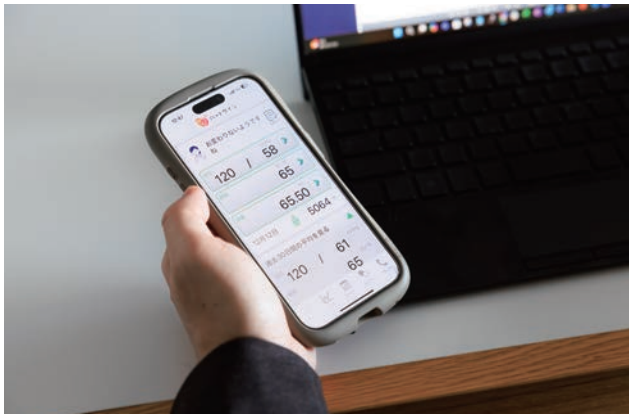
The reason heart disease is on the rise can be summed up in one word: aging. In other words, it is a structural problem of society.

Heart disease became the second leading cause of death among Japanese people in 1985, and that ranking has remained unchanged ever since. Among heart diseases, heart failure (Stage C and D) accounts for the highest proportion of deaths — roughly 40% in recent years, though it fluctuates from year to year.

The primary reason for this consistently high level is the increasing elderly population. Because heart failure worsens and improves in cycles, once someone develops it, repeated hospital admissions and discharges are common. In fact, the number of hospitalized heart failure patients has been increasing annually, now reaching around 280,000 per year. This means that such a number of hospital beds are continuously occupied. With an aging society, the number of patients is expected to keep rising.

Before long, we may face a "heart failure pandemic" in which the number of patients surges dramatically. This is increasingly seen as a serious issue that could lead to medical system collapse and escalating healthcare costs, making it crucial to implement countermeasures.

For many Stage C heart failure patients, it is recommended that they use a "Heart Failure Notebook" — a record diary for tracking daily blood pressure and body weight — during check-ups and when receiving prescriptions from their primary care physician. Stage A and B patients often use a "Hypertension Notebook" for the same purpose. The aim is to help patients notice early signs of heart failure worsening from changes in blood pressure or weight. However, in reality, keeping a consistent record is difficult to make a habit. Since doctors usually review these records only during outpatient visits once every one to two months, any signs of worsening that occur in between can easily be overlooked.



Developing a self-management tool for heart failure as an app. A communication tool that connects patients and doctors

First and foremost, it is important to slow the progression of heart failure. The heart failure notebook requires patients to record blood pressure, pulse, weight, and symptoms by hand, which limits the amount of information that can be retained and makes it difficult to assess the condition.

To address this, we developed Heart Sign, a dedicated app for managing heart disease and heart failure.

With Heart Sign, in addition to what the notebook tracked, patients can log steps walked, medications taken, and more. Data entry is mostly manual, though some inputs are automated. Importantly, Heart Sign is more than just a diary app. It sends reminders and notifications – for example, it pings users to input data at certain times or to take their medication. If the app detects signs of deterioration that the patient might not notice, it issues an alert prompting the patient to seek medical attention. Crucially, the app is designed to share the recorded data with the patient's primary doctor. By creating a platform where the physician can review the patient's data, we enable use in telephone or remote consultations as well.

We started development in 2020 and launched a pilot in 2022. In an observational study across five medical facilities in Mie Prefecture with 56 patients, 90% continued using the app and the effective usage rate at 6 months was 72% – higher than we anticipated. We filed a patent for the app in 2023, and in 2024 we began a clinical trial involving 17 hospitals.

We are also adding new features. One will be educational content to deepen patients' understanding of heart failure and teach how to improve their lifestyle. Proper exercise, diet, and other lifestyle changes are vital to prevent heart failure from worsening. Another crucial feature we're prioritizing is integration with Japan's Mynaportal (the government's personal health record system). By linking, we aim to automatically obtain data on the patient's medications, health checkups, etc., and enrich the information shared between patient and hospital. The fundamental idea is to encourage patient self-management, so they change their behavior from the early stages of disease, while simultaneously sharing data with hospitals in a timely and seamless way. This will allow physicians to more smoothly grasp patients' conditions and respond with prompt, appropriate care. Our app is just a tool; the larger goal is to use it as a lifeline that prevents heart failure from getting worse by linking patients and providers.

Structural Problems Require Structural Solutions – It's About Building a New Healthcare System, Not Just an App

Let me emphasize: Heart Sign is not just a record-keeping app. It's a communication tool connecting patients and healthcare providers, a lifeline to keep heart failure from worsening. To make it truly effective, merely developing the app isn't enough. As mentioned, we need integration with Mynaportal and to establish it as a PHR (Personal Health Record) platform, which requires coordination with local governments and other public agencies.

That's why we plan to partner with municipalities as the implementing entities for this project, and we are designing our business model accordingly. Specifically, we are considering deploying Heart Sign as a PFS (Pay For Success) model project — a performance-based public-private partnership where the local government pays us based on achieved outcomes like healthcare cost savings. In parallel with adding app features, we've been pitching this concept to several local governments, explaining its significance and goals and seeking their understanding and support. Ultimately, the app is just a means; the true essence of our project lies in connecting municipalities, hospitals, and patients to build a new healthcare system that leverages PHR data.

In preliminary talks with government officials, some have suggested expanding our target beyond symptomatic heart failure patients to include, say, people with hypertension. In fact, that broader scope aligns with what I envisioned as a next step. Ideally, we want to help people before they carry major risks – enabling lifestyles that prevent heart disease and heart failure in the first place. Hypertension is a logical condition to target in such a preventative approach. We certainly plan to tackle that in the future. But first and foremost, we need to get our current project firmly on track. That is our top priority right now.

Note: The Heart Sign app is available on Google Play® and the App Store®, but during the trial phase it requires an ID and password for use.

Hiromasa Ito

Profile

Mie University
Hiromasa Ito

Assistant Professor, Department of Cardiology, Mie University Hospital.

Graduated from the Faculty of Medicine, Mie University, earning a Doctor of Medicine (M.D.). After working at Ise Red Cross Hospital and Owase General Hospital, has been serving in the Department of Cardiovascular Medicine at Mie University Hospital since 2019. Since 2024, also working as a researcher in the Department of Healthcare Information Management at the University of Tokyo Hospital, engaging in research on medical information and real-world data, with a focus on studies and social implementation using Personal Health Records (PHR). Core member of the working group for PHR service implementation. Member of the U-40 Young Committee of the Tokai Branch, Japanese Circulation Society.

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Opening the door to safe and environmentally friendly next-generation batteries —an innovative adhesive that uses water to control the bonding of battery materials.

Nagoya University / Norikazu Ishigaki

Feasibility study for commercial development of an ion-conductive adhesive

Tackling the challenges of fire risk, resource supply, and productivity — what kind of next-generation rechargeable batteries will be needed in the future?

Think of the word "battery" – what comes to mind? Perhaps a AA dry cell for your TV remote? Nowadays, many might picture a mobile power bank. Disposable batteries like AAs are called primary batteries, whereas rechargeable ones like power banks are secondary batteries. As you can imagine, we now live in an age where civilization essentially cannot function without batteries – especially secondary batteries.

The most familiar example is the smartphone. But also consider laptops, smartwatches, and the growing demand from large machines like electric vehicles.

Every battery contains an electrolyte that generates electricity. The dominant electrolytes today are liquid. Liquid electrolytes, of course, come with issues like evaporation, leakage, and degradation. But the most serious issue is the risk of fire. Some may recall news of a passenger's mobile battery catching fire on a train – incidents like that underscore the priority of developing batteries that don't burn.

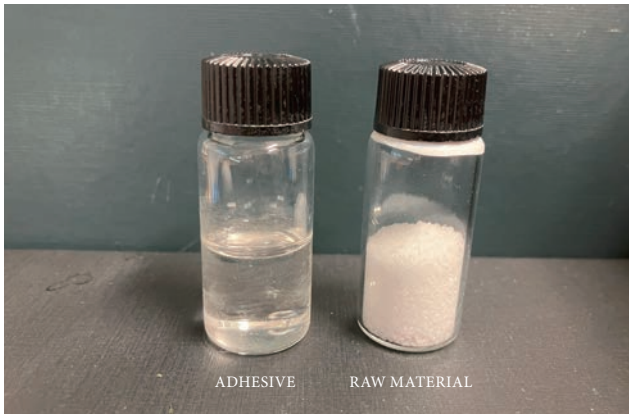
This is why all-solid-state batteries are attracting attention. As the name suggests, they use a solid electrolyte (and a nonflammable one) in place of a liquid. All-solid-state batteries promise not only to eliminate fire risk, but also to dramatically improve performance – faster charging, less degradation, and higher power output. They are considered the next generation of batteries. However, solid-state batteries face their own challenges: one is safety risks, and another is the issue of resource acquisition.

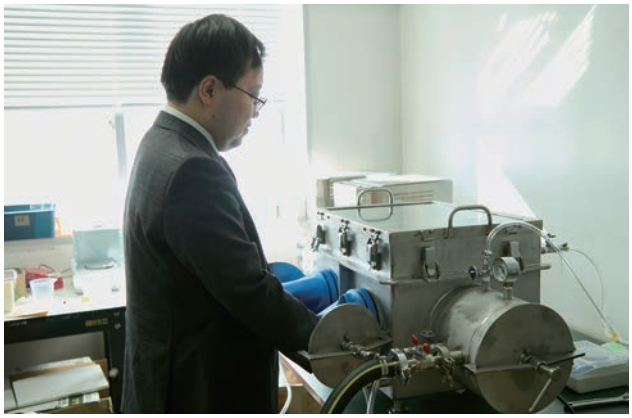
Challenges Facing All-Solid-State Batteries – Ensuring Safety and Stable Resource Supply

First, safety. Solid electrolytes for all-solid-state batteries fall into two broad categories: sulfide-type and oxide-type. Development initially focused on sulfide-type electrolytes since they showed more advantages. But with sulfide electrolytes, if the battery is damaged, there is a possibility – depending on conditions – of generating highly toxic hydrogen sulfide gas. For example, imagine a car accident involving an electric vehicle: the last thing you'd want is poisonous gas leaking when occupants might be trapped. Personally, I find that scenario unacceptable. In recent years, oxide-type solid electrolytes have also reached sufficient performance, and I prefer to focus on those for safety reasons.

Next, regarding resources — and this will take a bit longer to explain. Oxide-based solid electrolytes are, simply put, ceramics: hard powders similar to crushed porcelain. To turn them into batteries, they must be sintered at high temperatures. This process is the bottleneck. In addition to requiring high-temperature treatment, it is prone to contamination by impurities, which limits productivity. Given Japan's current battery production speed of 8,000 units per minute, it is nowhere near sufficient to keep up.

This is where my developed technology comes into play. Instead of sintering, we use an adhesive to bind the material. By using an ion conductor as the adhesive — one that does not compromise the performance of the electrolyte — we can fill the gaps between particles to block impurities, while drastically lowering the forming temperature and dramatically improving productivity. However, this brings us to a resource issue. The adhesive material we use is, technically speaking, an amorphous phosphate. Its raw material, phosphorus (specifically yellow phosphorus), is mined in practice in only one country.





Noticing that sufficient research had not been conducted in this area, we discovered the hidden potential of phosphate-based materials.

Phosphorus itself is not a particularly rare element — it is something we consume in our daily lives when vegetables absorb it from the soil. However, phosphate deposits in large, mineable quantities have been found in only four countries worldwide, and going forward, Japan will be effectively limited to importing it from Kazakhstan. This is why recyclability is crucial — the key point is how effectively the raw material can be reused.

Let me go straight to the conclusion: our adhesive has very high recyclability. This adhesive can be easily decomposed with water. In practice, if you submerge the solidified battery in water, all components – including the adhesive material – break apart and can be recovered. The adhesive is also flame-retardant (the same substance is used in fire extinguishers), so if incorporated into existing secondary batteries, it would automatically extinguish itself in the event of a fire.

Using this property, we can make batteries in any shape we want. The electrolyte itself is a powder, and we solidify it with the adhesive, so even complex shapes – say, a battery shaped like an eyeglass frame – become possible. High safety also means less need for heavy protective casings, enabling thinner battery packs. For example, you could attach a solid-state battery made with our adhesive to the back of a solar panel; it could charge during the day and discharge at night, creating an integrated power system – all safely.

This innovation came from revisiting phosphate chemistry, a field everyone assumed was already well-trodden. In truth, past limitations in measurement technology and the extremely high reactivity of certain phosphate compounds meant that their surfaces would get covered by other substances, so they weren't thoroughly studied. This research became possible precisely because we are doing it now, with modern techniques.

Moreover, the potential of this technology isn't confined to batteries. Fundamentally it's an adhesive, so it could find use in fields like biomedical materials, food additives, or metallurgy – a very wide range of applications. And most importantly, it contributes to building a circular, sustainable society by enabling better resource recycling.

From Personal Curiosity to a Vision 100–200 Years Ahead – Innovating for a Sustainable Future

My research started from pure curiosity. I'm of a generation that grew up with devices from the original Game Boy to mobile phones to smartphones, always surrounded by battery-powered gadgets, so it was natural for me to take an interest in batteries. As I became a researcher, I asked myself: what could I work on that would fascinate me and also make the world more convenient and contribute to society? That line of thinking eventually led me to focus on batteries, something used by countless people.

From a business perspective, we are currently collaborating with a materials manufacturer, and we can start to see the technical feasibility of practical implementation. Personally, I think I should dedicate myself to R&D, so moving forward I plan to secure management personnel (with the help of a GAP Fund for bridging research to enterprise) who can drive the commercial side. Our technology is highly unique and we have patent applications filed, so I'd love to find partners who can help take this from Japan to the world market.

None of us wants a future where "batteries are so expensive that people can't afford smartphones." But our aim isn't just short-term gains like making batteries a bit cheaper. Because batteries are essential for any device that needs charging, our vision is much longer-term – looking 100 or 200 years ahead, we want to contribute to building a sustainable society.

The scope of applications for this technology could broaden even further. Phosphates exist inside living organisms, so our work might even help unravel some biochemical mechanisms. Using it in fertilizers is another important direction – if we have technology that recycles phosphorus, we can cut production and material costs through recycling.

In Japan, some municipalities are already recovering phosphorus from sewage. If Japan, which currently depends almost entirely on imports, can build a system to circulate phosphates domestically, it will secure a stable fertilizer supply – critical for food production. From food and agriculture to information and energy sectors, establishing a broad resource recycling framework for scarce elements like phosphorus is key to a sustainable society. I believe our technology can help make that a reality, and I want to contribute to that future as much as possible.

Norikazu Ishigaki

Profile

Nagoya University
Norikazu Ishigaki

Assistant Professor, Department of Materials Design Innovation Engineering, Graduate School of Engineering, Nagoya University.

Graduated from the Department of Physical Sciences, College of Science and Engineering, Ritsumeikan University, and completed both the Master's and Doctoral Programs in Physics at the Graduate School of Science, Tohoku University, earning a Ph.D. in Science. After serving as a Special Researcher at the National Institute of Advanced Industrial Science and Technology (AIST), assumed the current position in 2021. Engaged in research, development, and societal implementation related to inorganic materials such as ion conductors, phosphorous compounds, and oxides, as well as secondary batteries, with a focus on energy and resource circulation.

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Proteins have a wide range of applications — from producing enzymes and antibodies to petroleum alternatives.Overcoming the trial-and-error, luck-and-perseverance approach to improving productivity with a new technology.

Nagoya University / Teruyo Kato

Validation of a technology to dramatically increase protein production efficiency for “bio-manufacturing”

Proteins have extraordinarily broad utility in fields from medicine and pharmaceuticals to food and beauty – yet there has been an extraordinarily high barrier to producing them in large quantities.

Ask someone “What is a protein?” and most will answer, “One of the three major nutrients.” That’s correct, but it’s only part of the story. A protein is a compound made of amino acids linked together in chains. Proteins are produced by living organisms – not only humans, but all kinds of life forms.

For example, proteins are the building blocks of nearly all body tissues — skin, muscles, organs, blood, hair, and more. They are also responsible for bodily functions such as movement, sensing light, taste, and smell, and protecting the body from pathogens through the immune system. Proteins even play a role in DNA synthesis, which governs genetic information. Moreover, proteins are found not only in plants but also in bacteria and viruses. The type of protein depends on factors such as the number and types of amino acids and the order in which they are bonded, resulting in an almost infinite variety.

As you can imagine, proteins are not only the basis for various substances related to the human body — in medicine, pharmaceuticals, food, and cosmetics — but they also function as catalysts in production. Even photosynthesis in plants is driven by proteins. They are thus extremely valuable substances, with applications in agriculture and biofuel production as well.

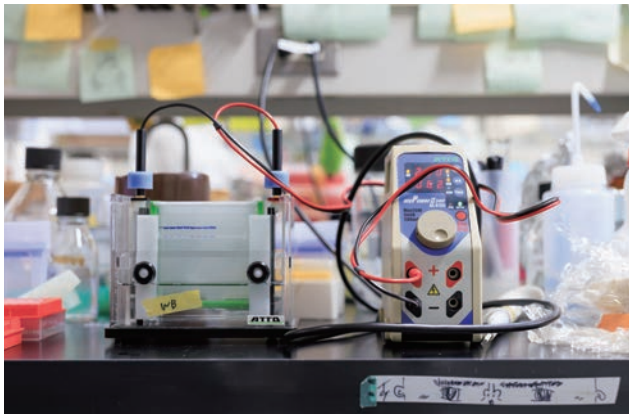
The method for producing proteins is already understood: it involves using the DNA-based mechanism of protein synthesis. However, large-scale production remains difficult. Until now, the only approach was to rely on chance and persistently test countless methods through sheer determination.

Rather than relying on chance, like drawing lots, this method steadily increases efficiency.

The approach is surprisingly simple, yet the results are overwhelming. Proteins can be produced more or less as intended by using the natural mechanism of protein synthesis, which proceeds through the processes of DNA transcription and translation. DNA contains genes — the blueprints for all the proteins an organism needs. Because of this, DNA is extremely long and is folded tightly within the cell nucleus. When a specific protein is needed, only the relevant section is copied and carried out of the nucleus. This copying process is called transcription. The copied blueprint is then used to line up and link amino acids together, assembling the desired protein — a process known as translation. This is the system we utilize.

In practice, this mechanism is carried out inside the cells of living organisms such as microorganisms or insects. However, while it is possible to produce the target protein itself, producing it in large quantities is difficult. Since the regulatory mechanisms of transcription and translation are not yet fully understood, it’s unclear how to maximize output. In reality, production tends to be a matter of trial and error — changing the host organism (the cell type) or altering the culture medium (growth environment) — and then selecting the setups that yield more protein.

Sometimes success comes in three tries, other times not even after a hundred attempts. But it was discovered that by adding a peptide tag (a chain of amino acids) to the beginning of the target protein gene and culturing it, the amount of protein produced increased dramatically. The boost in yield was overwhelming.



Changing the Sequence Without Changing the Function – A Game-Changing Concept

Why does adding a peptide tag have this effect? As we conducted research, we found that the tag doesn't really affect transcription; rather, it improves the efficiency of translation. During translation, the cell assembles amino acids in the order specified by the mRNA from start to finish. If the process stalls mid-way, the protein won't be completed. By adding the tag, it appears we prevent those mid-way stalls and ensure the protein is synthesized all the way to the end.

Moreover, adding a peptide tag causes the resulting protein to have a slightly different amino acid sequence from the original target protein, meaning it is, strictly speaking, a different molecule. However, we do not want to alter the intended function. In the early stages of the research, the tag was added at the beginning of the sequence, where it was known not to affect function. Later, it was found that there are also suitable insertion points within the sequence. Based on earlier research findings, inserting the tag just before a point where bonding tends to stall often increases production efficiency.

A new technology focusing on the protein's own sequence has been developed. By avoiding critical sequences essential for the desired function and inserting a peptide tag just before sequences where bonding tends to stall, production efficiency can be increased. It has also been found that deleting unnecessary sequences or altering sequences prone to stalling can further improve translation efficiency. To preserve the intended function, it is best to change the original protein structure as little as possible. Step by step, the technology has been refined.

Using this method, production of an "antibody against pathogenic bacterium E. coli O157" increased by about 30 times, and production of "lipase," an enzyme that breaks down lipids, increased by about 15 times. Furthermore, the method enabled the synthesis of a "type of carbohydrate-degrading enzyme" that had not been possible before. With promising results achieved, a patent application titled "Protein Production-Enhancing Sequences and Their Uses" (tentative) is planned (as of the November 2024 interview).

As a technology, this is only a small step – but beyond it lies an almost limitless expanse of possibilities.

We have named this approach the "Protein Max Technology," and are making it the central pillar of our efforts — not only producing proteins for research and diagnostic purposes in-house, but also launching a business to accept commissioned projects from companies for protein production design and related services.

This technology improves the efficiency of synthesis and production by focusing on the sequence of the protein itself. It is not limited to a specific protein; rather, it can be applied to a wide variety of proteins across the board. That is why I believe the potential applications of this technology extend far beyond my own imagination.

If productivity for proteins like antibodies — where the protein itself is the end goal — can be increased, more lives can be saved. If productivity for enzymes — proteins essential for making other substances — can be improved, the yields of end products such as petroleum alternatives could be dramatically boosted. This could open the door to an entirely new world.

Higher antibody yields could save more patients; greater enzyme productivity could reduce the cost of certain foods. New biomaterials that do not yet even exist in concept might emerge, giving rise to novel energy sources or products we've never seen before. Just imagining what might happen is exciting.

In truth, this technology began from a sudden idea. But it has since drawn reactions from both Japan and abroad such as, "It's mysterious, but amazing." It is genuinely gratifying when fellow researchers use a technology I've developed — because it proves that the technology is truly useful.

As a business, we are still in the very early stages. The core of "Protein Max Technology," improving translation efficiency through peptide tag insertion, has now been statistically demonstrated. While continuing to investigate the mechanism of this phenomenon as a researcher, I also intend to push forward with its commercialization.

Teruyo Kato

Profile

Nagoya University
Teruyo Kato

Associate Professor, Graduate School of Bioagricultural Sciences, Nagoya University.

Completed the Graduate School of Bioagricultural Sciences, Nagoya University. After working as a researcher at a private company in the food materials sector and as a researcher in an industry-government-academia collaboration project in Aichi Prefecture, earned a Ph.D. in Agriculture. Successfully commercialized antibody discovery technology and founded a Nagoya University-based startup. Joined the current institution as an Assistant Professor in 2022 and has been in the current role since 2024. Currently engaged in developing technologies to improve protein productivity and researching the mechanisms of translation.

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Passing humanity's intellectual assets on to the future — a reusable ultra-long-term DNA storage device.

Nagoya University / Shintaro Itoh —— Development of a DNA data storage device

An explosive crisis is unfolding in digital data preservation. With conventional technology reaching its limits, the world is seeking a solution.

As the information society advances, the volume of digital data worldwide continues to grow by more than 20% annually. Various data that support our daily lives – from AI training data to social media posts – are accumulating every day, and by 2030, it is expected to exceed 600 zettabytes (ZB). This is an astonishing figure, approximately 10 times the volume in 2020.

A serious situation is developing amid this "data explosion." The production of current storage devices, such as SSDs, hard disks, and magnetic tapes, cannot keep up with demand, and securing locations to store all this data is reaching its limit. By 2030, the power consumption of data centers is projected to account for 3–13% of global electricity use, which is becoming a major environmental concern.

Digital data fall into two categories: "hot data," used routinely, and "cold data," which are not accessed frequently but require long-term storage. Cold data, such as medical records, self-driving car logs, and financial transaction records that hold potential future value, account for 50–80% of all data. Indeed, this cold data is poised to be the main driver of the coming "data explosion."

If left unchecked, we will inevitably face shortages of both storage space and power, hindering the development of our digital society. However, simply deleting data is not a fundamental solution. The development of revolutionary storage technology to safeguard data is awaited, which will be of great significance for humanity's future.

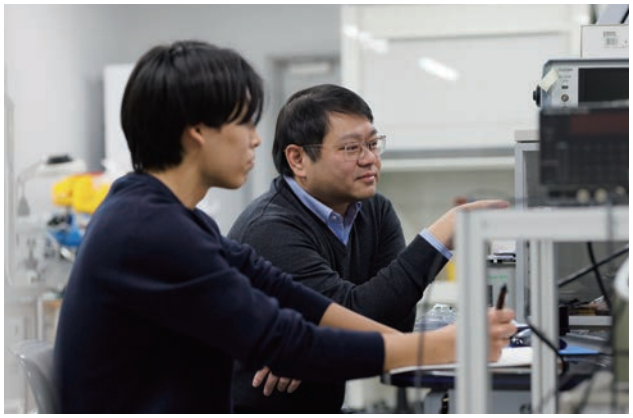
Entrusting humanity's records to the "language of DNA." With astonishing molecular memory, we can now envision the future 500 years from now.

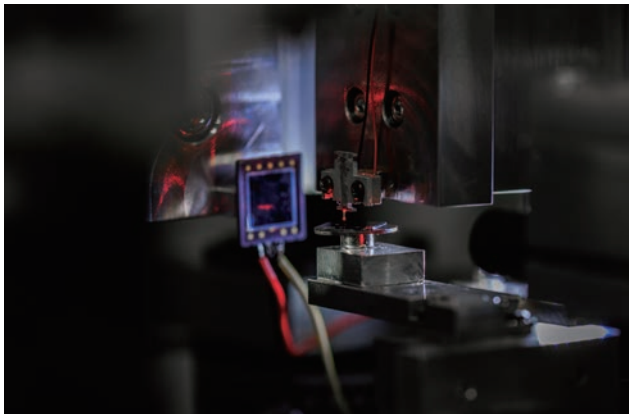
An entirely new way of thinking was required to allow humanity to pass on information 100 or 200 years into the future. The focus has shifted to DNA, which is known as the blueprint of life. The combination of its four bases (A, T, G, and C) serves as a universal language of humanity that can be decoded in any era. The technology that uses DNA as a recording medium is called DNA data storage.

Why DNA? Its greatest advantage lies in ultra-high-density storage at the molecular level. A single DNA base, which is only approximately 2 nm in diameter, can store two bits of data. This enables an overwhelming storage capacity of more than 4,000 times that of the current magnetic tape. For example, data that would require 100 magnetic tapes could theoretically be stored in a single DNA strand.

Another remarkable characteristic of DNA is its high stability. It has been demonstrated that DNA can preserve information for 500 years at room temperature, and even longer under colder conditions. All that is needed for storage is to keep it cool; unlike current technologies, it does not require constant operation. Moreover, DNA does not have compatibility issues that plagued past storage media, such as floppy disks or MO drives.

This technology is not intended for everyday data exchange, such as USB flash drives, but rather specifically aimed at archival use. It can be low-cost and space-saving, and it also reduces the environmental impact. A new door is about to open to ensure that humanity's intellectual assets are securely passed on to the future.





The "Single-Use" Storage Method: A Barrier for DNA Storage. Achieving the World's First Reusable Technology Using Polymer Brushes.

DNA data storage already has established techniques for writing and reading data, some of which are advancing toward commercialization. We took on the challenge of developing the "storage technology" essential for the practical use of DNA storage. The method currently proposed overseas is to encapsulate DNA in microcapsules for storage and then break the capsule to retrieve the DNA when reading it. DNA that has been read once cannot be stored again, making it far from a practical system that allows repeated data retrieval and storage in the long term.

Therefore, we developed a reusable storage device using polymer brush technology. We fabricated microscopic channels called "microfluidic channels" on a substrate and grew special polymer brushes on their surfaces to serve as soft buffer materials. These brushes gently envelop the DNA, preventing it from adhering to the walls or degrading. We also succeeded in freely moving DNA by applying an electric voltage.

When we fluorescently stained the DNA molecules and observed them under a microscope, we could directly verify their movement. Our system employs the principle of electrophoresis, using the negative charge of DNA to move molecules. We have realized a novel technique that "gently immobilizes DNA, and moves it with an applied voltage when needed." By combining microfluidic channels with polymer brushes in this way, we have opened up a new horizon that achieves both the "protection" and "control" of DNA.

Currently, we are using a prototype device approximately 1 cm in size to validate the principle and have succeeded in repeatedly inserting and removing DNA. The next step will be to evaluate various characteristics, such as whether it remains intact after 10,000 cycles of DNA insertion and extraction. We also foresee increasing storage capacity by miniaturizing the "chambers" that hold the DNA and packing 100 or 1,000 of them into the same area. As the world's first reusable DNA storage device, we are taking a new step.

Responding with technology to the dream of "reaching humanity hundreds of thousands of years from now." Toward a ¥1 trillion market by 2030, rewriting the history of data storage.

The DNA data storage we are developing is more than just an improvement in data storage efficiency. Just as ancient libraries supported the advancement of civilization, it serves as a "digital museum" to pass humanity's intellectual assets on to future generations. The stability of DNA has been scientifically demonstrated, and astonishing research results have shown that at −2 °C, it could preserve information for an incredible 160,000 years.

The evolution of technologies, including AI, requires massive data accumulation to achieve high accuracy. For example, autonomous driving technology becomes smarter by leveraging driving data accumulated daily, which also helps reduce accidents. The preservation of digital data plays an important role in all fields.

Market expectations are also on the rise. The magnetic tape storage market is predicted to reach approximately ¥1 trillion by 2030, and DNA data storage is expected to achieve comparable growth. We are already envisioning collaborations with major storage manufacturers in Japan and abroad, and expanding plans such as aiming to implement this technology in data centers. For the time being, as a university-originated startup, we are preparing on both the technical and business fronts, learning as we go in unfamiliar areas like financial planning.

Among the ever-growing troves of data, many remain unread for decades. When your smartphone runs low on storage, you may be tempted to delete old data, but doing so might erase records that are vital to human progress. Just as records from 100 years ago still hold value as historical documents, the digital data of our era should serve as historical archives for future generations.

We want to harness DNA, a universal language decipherable as long as civilization endures, to ensure that humanity's records are passed on to the future. By establishing a long-term preservation technology like none before, we aim to open a new door for civilization.

Shintaro Itoh

Profile

Nagoya University
Shintaro Itoh

Professor, Graduate School of Engineering, Nagoya University

Completed the doctoral program (late stage) in the Department of Mechanical and Electronics Engineering at the Graduate School of Engineering, Nagoya University. Ph.D. (Engineering). After working as a JSPS Special Research Fellow and serving as an Assistant Professor, Lecturer, and Associate Professor at the Graduate School of Engineering, Nagoya University, he assumed his current position. Concurrently served as a JST PRESTO researcher from 2020 to 2024. Engaged in research on nano-fluidic device development and nano-measurement technology.

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Blood pressure and blood sugar — minimizing the burden of daily measurements. A life where you can measure anytime, anywhere, just by wearing a device on your wrist.

Nagoya University / Hedong Zhang

Non-invasive, high-precision wearable device for measuring blood pressure and blood glucose

Having to measure multiple times a day, every day — the reality that devices for managing chronic diseases are inconvenient.

Anyone who's had a health checkup is familiar with blood pressure monitors. They're those devices where you wrap a cuff around your arm to cut off blood flow, with a tube running to a main unit with an LCD screen. Recently, there are wristwatch-style monitors you can wear continuously, but a typical commercial model has a bulky main unit (about 4.8 cm in diameter and 1.4 cm thick, fitting wrists 16–19 cm around), which cannot be used by people with thinner wrists, such as women or children. Also, if blood pressure needs to be measured at set intervals, nighttime measurements can cause sleep disturbances due to the cuff's squeezing.

There is also a device for measuring blood glucose for people with diabetes. Although the number of users is only about one-third to one-half of those with hypertension, it's a vital measuring device for patients, as their life can depend on it. There are portable models that measure blood via a small finger prick around meal times, and a patch-type sensor for the arm for those who need continuous monitoring, but both require inserting a small needle into the body. The result is a significant physical and psychological burden on patients.

Some people with chronic conditions need to measure their blood pressure or blood sugar very frequently. However, the devices for doing so are often inconvenient in daily life. They end up lugging around a bulky blood pressure cuff on every business trip or vacation, or enduring pain each time they check their blood sugar. In particular, Type 1 diabetes, which requires constant blood-glucose monitoring and, unlike lifestyle-related Type 2, affects many children, brings an immeasurable emotional burden: having a device stuck to your arm and constantly being asked by friends "What's that?"

Accurately recording blood pressure and blood sugar with an easy-to-use device —made possible by technology that measures the pulse at the wrist in detail.

We live in an age where the spread of smartwatches allows continuous reading and recording of body information. However, their accuracy is not yet at a level useful for medical purposes. The advantage of smartwatches is that they are non-invasive (do not harm the body). They use a technology called photoplethysmography (PPG) for measurement. This involves shining light on the wrist's blood vessels and recording in real time the attenuation of the reflected light. Because it uses light, it's inherently difficult to accurately read the arterial information that indicates blood pressure, due to influences like skin color and interference from veins and capillaries. In fact, current consumer devices can at best measure heart rate; there are no devices that measure blood pressure accurately, let alone blood glucose. These wearables should be regarded as fitness-oriented products, not medical devices.

We have developed a new technology called the piezoelectric pulse-wave method. Simply put, it "measures the wrist's pulse in extremely fine detail." It involves measuring the pulse with a pressure sensor, and from the pulsations of the radial artery (the artery on the thumb side of the wrist you feel when taking a pulse), it can detect not only blood pressure but also the pressure pulse wave (the wave generated by changes in arterial pressure as the heart pumps blood) and even the reflected wave contained in that pulse wave, with high precision. The reflected wave appears after the first strong pulse corresponding to the heart's contraction, and its timing and strength change with the viscosity of the blood. When blood sugar is high, blood viscosity increases. By modeling the characteristics of this reflected wave and their correlation with blood glucose via machine learning, we can estimate blood glucose levels from the measured pulse wave.

No arm compression, no needles —with continuous monitoring, comfort is paramount.

This sensor, designed to "measure the pulse at the wrist in great detail," directly detects arterial pulsation, allowing it to gather abundant pure data for measuring blood pressure and blood glucose levels. Furthermore, since it works on the principle of converting the pressure detected at the wrist pulse into voltage, the act of measurement itself generates power — making it battery-free for measurement. The battery is used only for signal processing and transmission. This is a major advantage for a wearable device intended for continuous use: it can be made light, compact, and long-lasting on a single charge.

In developing this wearable device, we focused on several innovations: a sensor support method that allows the pressure sensor to flexibly deform without restricting the expansion and contraction of the wrist blood vessels; a housing design that ensures the sensor remains positioned almost directly above the radial artery, even with slight misalignment when worn on the wrist, enabling stable output characteristics regardless of how it is worn; and a structural design that uses the radius bone as a positioning reference.

With this "piezoelectric wearable device," there is no need to compress the arm or insert a needle — you simply wear it like a wristwatch. It allows "anyone, anytime, anywhere" to measure blood pressure and blood glucose without stress. For this reason, we have launched commercialization efforts for a "non-invasive, high-accuracy wearable device for measuring blood pressure and blood glucose" using the GAP Fund program.

As for the method of measuring blood glucose from the sensor's readings — specifically, by detecting reflected waves contained in the pulse wave — there is already prior technology, and its effectiveness has been proven. The core technology of this project, "precise measurement of the pulse wave at the wrist," has already been patented. Development of an app to display the acquired data is complete, and work on an app to convert voltage into blood pressure readings is also well underway. However, because measuring blood glucose is considered a medical act, collecting the necessary sample data for development remains the current challenge.

Developing the blood-glucose measurement app is the immediate hurdle. We are seeking a cardiologist collaborator.

My expertise is in sensing and information processing — I'm a researcher in measurement and analysis. To develop an app that calculates blood glucose from the measured pulse waveform, we need actual patient blood-glucose data as samples. Unlike blood pressure, measuring blood sugar requires blood draws and thus can only be done by a physician. For this reason, we are recruiting cardiologists who can help collect sample blood sugar data. In developing this app, we will use a machine learning process to improve accuracy, so the more samples — i.e. the more collaborators — we have, the higher the precision becomes. It would be immensely helpful to have cardiologists who support this research and are willing to collaborate.

Incidentally, it wasn't mentioned earlier, but existing measurement devices are by no means cheap. For current blood glucose meters, the needles and sensors used are disposable for hygiene reasons, which incurs ongoing cost. In contrast, the device envisioned in this project would cost around ¥30,000 (about $200). Being non-invasive, its only running cost is the electricity it uses. And since our measurement method is battery-free, the device's power consumption can be kept low.

According to WHO statistics, among adults aged 30 to 79, there are approximately 33.1 million people with hypertension in Japan, and 777.4 million when including Europe, the U.S., China, and India. As for adults with diabetes, there are about 11 million in Japan, and 350.4 million including Europe, the U.S., China, and India. Considering that roughly 50% of diabetes patients also suffer from hypertension, there is the potential to free 952.6 million people from the stress of measurement. In the actual business plan, the market size will be defined as "those who are dissatisfied with current measuring devices" within this population. Nevertheless, the benefit of reducing the burden on daily life is immeasurable. By creating new value through sensing and information technology, we can help many people lead better lives. We aim to create such a positive cycle.

Hedong Zhang

Profile

Nagoya University

Hedong Zhang

Professor, Graduate School of Informatics, Nagoya University

Graduated from Zhejiang University (China), Department of Optical Technology & Optoelectronic Instruments. Earned Ph.D. (Engineering) from the Department of Mechanical and Electronic Engineering, Nagoya University Graduate School of Engineering. After serving as Assistant Professor at the Graduate School of Engineering and then at the Graduate School of Informatics, Nagoya University, and later as Associate Professor, he assumed his current position in 2021. Engaged in research on molecular simulations and micro/nano measurement technology.

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Research team members:
(center) Professor Chikara Ohtsuki,
(left) Lecturer Kazumasa Suzuki,
(right) Assistant Professor Yuko Matsukawa

Metals and ceramics are too hard; organic polymers are too weak. The more we study it, the more we realize how remarkable natural bone is — and we strive to develop artificial bone that comes close to matching it.

Nagoya University / Chikara Ohtsuki

Social implementation of strong and flexible artificial bone

Able to work with the knees, hips, back, or legs and withstand the loads of supporting the body. A material that will be increasingly needed in a super-aged society.

Our bones and joints play an essential role in supporting and moving our bodies. When they can no longer fulfill that role, they are repaired or replaced. For instance, in Japan there are over 160,000 hip and knee joint replacement surgeries each year, and this number continues to rise annually. Japan has now become a super-aged society. It is natural that with aging, bones become brittle and the cartilage that cushions bones wears down; therefore, as the elderly population increases, the demand for artificial joints and artificial bone inevitably increases as well.

Existing surgeries to repair joints or bones typically take one of three approaches: (1) Autologous bone grafts — using the patient's own bone from a less critical part of the body. This is an ideal material, but the harvestable sites and quantity are limited, and it injures a healthy site; (2) Artificial joints made of metals and ceramics — metals offer high mechanical strength, but are often too rigid compared to bone and can release metal ions, potentially damaging surrounding tissue and triggering foreign-body reactions; (3) Artificial bones made of ceramics — most of these exhibit high affinity to bone and can even bond to bone tissue, which is crucial for long-term functionality. However, conventional ceramic artificial bone is harder and more brittle than real bone and difficult to process, which remains an issue. Each method has advantages and drawbacks, and in terms of improving post-operative quality of life (QOL), there are still challenges with each.

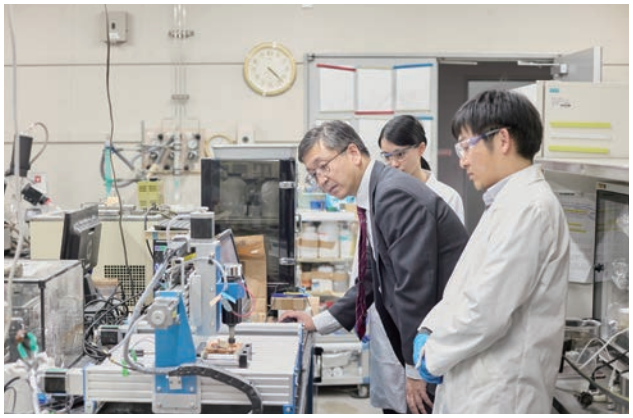
If the patient is younger, their level of physical activity after surgery will be much higher than that of an elderly patient. Thus, creating an artificial bone with properties closer to human bone is extremely meaningful.

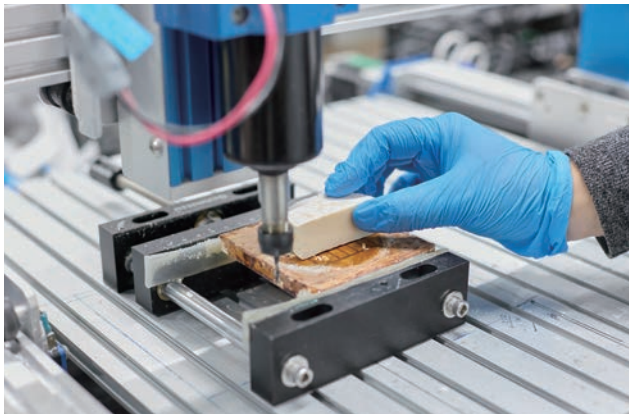
As strong and flexible as human bone, integrating seamlessly with surrounding bone tissue. We also want it to be easily shaped on-site to fit each patient.

When summarizing the physical properties required for "artificial bone similar to human bone," there are three main points: (A) Mechanical strength comparable to real bone—strong enough to fully support the load placed on joints, yet with moderate hardness that does not damage surrounding bone; (B) Affinity with bone—after implantation, it integrates and bonds well with the surrounding bone; and further, (C) Workability on the surgical operation—can be cut or shaped on-site to fit the exact size of the affected area. Both the size of the bone and the shape of the affected area vary from patient to patient. By tailoring the size optimally for each patient, it is possible to achieve a perfect fit while minimizing the amount of bone that needs to be removed from the patient. If it is an autologous bone graft, these properties are inherently present.

To obtain a material with properties similar to autologous bone, we first needed to examine what human bone is made of and the characteristics of those components. Bone is a composite of roughly 30% (by weight) organic material (mainly proteins like collagen) and 70% inorganic material (primarily calcium phosphate). It's a structure where flexible, tensile-resistant organic material and stiff, compression-resistant inorganic material are skillfully combined.

It's tempting to think we could simply make it from exactly the same material, but that's not so easy. In theory, regenerative medicine using iPS cells could create actual bone itself, but at present it would require enormous cost and time, making it impractical. We therefore still need to develop an artificial material that perfectly matches the properties of natural bone.





Attaches easily to bone, is harmless, and simple & inexpensive to produce. Achieving mechanical properties close to bone tissue along with high bone affinity.

How can we achieve this? The approach mentioned earlier — combining an organic and an inorganic component — seems to be the most logical. For the inorganic side, we can't ignore calcium phosphate, the main inorganic component of bone, given its proven track record and ease of use. The tricky part is choosing the organic material. There are countless possibilities for organic polymers with the desired properties, and the options are overwhelming. From those, we chose an acrylate-based resin that is stable in the body, low in toxicity, and highly hydrophilic. In fact, we decided to use an organic polymer material that's used in soft contact lenses which absorb water well and are elastic.

A hint came from another project I'm working on: developing an ivory substitute for shamisen picks. The plectrum (bachi) used to pluck a shamisen's strings – traditionally made of ivory or tortoiseshell – can no longer be sourced due to international regulations. The properties required of this pick, i.e. ivory's properties, are almost identical to bone. Using this shamisen ivory substitute as a reference and tweaking the material blend, we achieved properties very close to human bone. We also found that by not only optimizing the base material but also repeatedly refining the surface treatment, we could further improve affinity with living bone.

This "artificial bone material for hard tissues" is currently being prepped for patent application (as of November 2024). If we can realize a new artificial bone material that is strong yet flexible, has high affinity with living tissue, and is easily machinable, we might be able to apply artificial bone in parts of the body where it couldn't be used before, or extend bone replacement surgeries to patients younger than their 60s. We have launched a commercialization effort to bring this technology into practical use.

Developing a new material typically takes a decade or more. Through biomaterials R&D, we strive for a better society.

This project's core technology — the "artificial bone material for hard tissue" – doesn't identify a single specific material for artificial bone. Rather, it sets the direction and roadmap for selecting composite materials of organic and inorganic components; it's a crucial foundational technology. Building on this, the next step is to choose the optimal material. As a venture, we have now established the core approach and drawn up a blueprint to launch; we've taken the first step.

For now, the surgical sites we envision for this material are those with particularly high need: the knee, spine, and bone cancers. Even just these applications would represent a considerable market. In the future, it could potentially be applied to other large bones like the femur, or in the field of dentistry. Having a wide range of applications and a large market means the technology will be needed by that many more people. We regard it as a project of very significant social importance.

I have continued my research specializing in biomaterials, and I know from experience that even if a new material is proposed at the academic level, it is common for it to take more than ten years before it reaches the market. At the same time, I understand that biomaterials development carries significant social importance, and once begun, there is a responsibility to see it through. In fact, there are a considerable number of healthcare professionals and patients who count on the materials we develop, and I have pursued biomaterials research with a strong belief that "research in biomaterials should ultimately reach the patient." With that in mind, I have involved young staff members who are committed to continuing research steadily and persistently as core members from the very start, so that we can advance together from the research and development stage.

Continuing the business also provides an invaluable opportunity to collect feedback from the clinical field about usability and areas for improvement — something essential to biomaterials research, for which I am truly grateful. Both positive and negative feedback hold great value in ongoing research. For a materials researcher, the real appeal of working in this field is to leverage one's expertise to advance research and, through it, help make human society — beginning with healthcare — better. I believe that is the true reward of engaging in biomaterials research.

Chikara Ohtsuki

Profile

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Chikara Ohtsuki

Professor, Department of Materials Chemistry, Graduate School of Engineering, Nagoya University

Earned a Ph.D. in Science from the Graduate School of Science, Kyoto University. Served as Research Associate at Kyoto University, Lecturer and Associate Professor at Okayama University, and Associate Professor at Nara Institute of Science and Technology (also Director of the university-launched venture PHG Co., Ltd. from April 2005 to May 2010), before assuming the current position in 2006. Specializes in ceramic biomaterials, with research focusing on the evaluation and development of biomaterials using simulated body fluid (SBF), bioactive ceramics, organic–inorganic nanohybrids, and the imparting of bioactivity to metallic materials.

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Tackling energy challenges by harnessing a unique plasma device with an ionization density two orders of magnitude higher — enabling material transformations impossible under normal conditions with ease.

Nagoya University / Hirotaka Toyoda

Advancing a Green Energy Society with High-Density Plasma

It's often talked about but not well understood —what exactly is plasma?

Plasma is a state in which atoms or molecules of a substance absorb energy and split (ionize) into positive ions (+) and electrons (–), becoming highly reactive. Overall, it is electrically neutral, but because it's ionized, it doesn't fit into any of the three classical states of matter (solid, liquid, gas) and is called the fourth state of matter. Still not clear? Well, there are examples of plasma that you encounter in everyday life.

The most familiar example is the flame of a campfire or a candle. Because it's literally burning, you can intuitively sense it's a "highly active state." Other natural examples include lightning, auroras, and the sun's light and heat — all phenomena due to plasma. In technology, examples include plasma TVs, fluorescent lamps, and neon signs. All of these clearly exist and you could touch them if you tried (though you likely wouldn't come away unharmed, so it's not recommended), yet they are neither solid, liquid, nor gas. It seems best to understand plasma simply as a "highly active state" of matter.

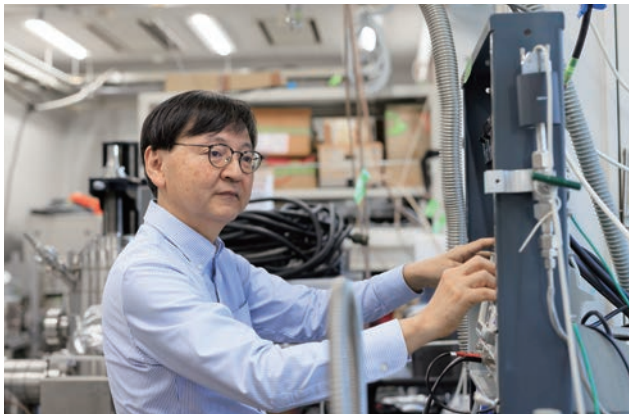
As the fourth state of matter, plasma of course originates from some source material that becomes ionized. Interestingly, even plasma made from the same water molecules will have different characteristics if generated from liquid water versus water vapor. However, as we saw with flames, the properties due to the plasma state itself are far more prominent than differences due to the source material. So for now, it's fine to think of it broadly as plasma without fixating on what material it came from.

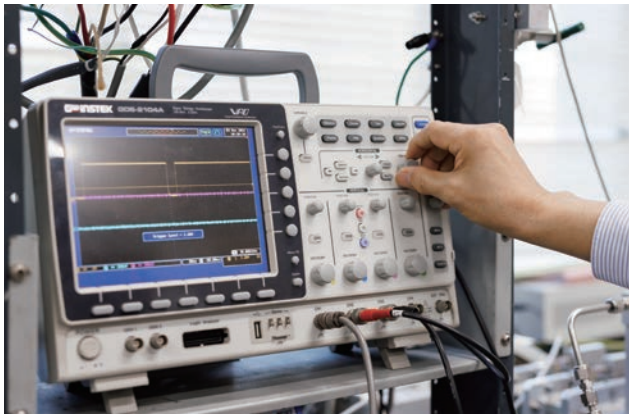
High energy, yet able to induce reactions at room temperature – an original high-density plasma generator.

So, what can we do with plasma? That's like asking, "What can we do with fire?" I won't claim it can do everything, but the possibilities are countless. To highlight some plasma-specific applications: for example, altering a material's surface (surface modification) or depositing a thin film on a surface. Also, leveraging its high energy, you can even ionize matter directly.

The phrase "high energy" might make you imagine that plasma requires high temperatures to generate, but plasma can actually be generated from liquids at low temperatures. In fact, for industrial applications, low-temperature plasmas are more commonly used. Our lab has developed various plasma generation devices tailored to different uses, but let's focus on the ones relevant to this project.

Here we spotlight our liquid plasma device – a device that generates high-density plasma around a liquid. Using this, we can directly and efficiently produce hydrogen (H_2) and hydrogen peroxide (H_2O_2) by ionizing water (H_2O) into H_2 and O_2. Compared to splitting water via electrolysis to get hydrogen and oxygen, our method has the added advantage of being able to collect hydrogen alone as a gas. Meanwhile, hydrogen peroxide is a substance seen as promising as an energy carrier for fuel cells. In short, our approach can highly efficiently generate hydrogen — which is drawing attention as an alternative to petroleum fuels — and at the same time, the by-product hydrogen peroxide can be put to industrial use.





In principle, it emits no carbon dioxide — two methods of hydrogen production using high-density plasma.

As some of you may have already guessed, in short, this business is about producing hydrogen efficiently by utilizing high-density plasma, with the aim of accelerating the transition to a green-energy society.

There are two main methods. The first uses the fluid plasma device mentioned earlier, which directly ionizes water to produce hydrogen and hydrogen peroxide. The conventional mainstream anthraquinone method requires the use of large amounts of organic solvents, raising environmental concerns, but our approach uses only water as the raw material, eliminating this problem. Compared with the environmentally friendly catalyst method, our method offers a much faster reaction rate and higher productivity. We also plan to use the hydrogen peroxide by-product in fuel cells.

The second method is a photocatalytic approach that uses silver nanoparticles to generate hydrogen by ionizing water molecules under sunlight. Simply by placing silver nanoparticles in water and exposing them to sunlight, hydrogen bubbles are generated. We use our fluid plasma device to produce the silver nanoparticles that act as the hydrogen-generation catalyst. Compared with conventional technologies, our method avoids potential deterioration of catalytic performance, enables easy reuse of the precious metal (silver), and has overwhelming productivity — synthesis takes only a few minutes, compared to several days with competing methods.

For the fluid plasma device method, we are also designing production technology development to enable scale-up, aiming to reduce costs through mass production. We are considering low-energy manufacturing by ionizing raw materials, as well as increased efficiency by combining the photocatalytic method with plasma irradiation.

Although still at the conceptual stage, we also aim to work on developing circular carbon-based fuels — such as methane produced from recycled atmospheric CO_2 and other non-fossil fuels — that can serve as alternatives to petroleum and natural gas.

The ultimate climate-change countermeasure is to reuse the excess CO_2 in the atmosphere as a resource.

Hydrogen is an extremely clean fuel that provides energy without releasing CO_2 — the only thing emitted is water. However, one drawback is that our society's infrastructure, optimized for fossil fuels, cannot be directly used for hydrogen. And even if we stop using fossil fuels entirely, that only means we won't increase CO_2 beyond current levels. Unless we reduce the CO_2 already in the atmosphere, it's not a true solution to global warming. Therefore, simply abandoning traditional carbon fuels and converting society wholesale to hydrogen wouldn't be an essential solution in my view.

That said, having multiple options for energy sources is a huge advantage. There is undoubtedly meaning in using hydrogen as one alternative energy. First, we want to equip society with production technologies to expand hydrogen use. In parallel, I'm envisioning developing circulating carbon-based fuels that can use as much of the existing fossil-fuel infrastructure as possible.

I believe plasma's ability to modify materials in large volume and at high speed can contribute to these developments. For example, by slightly customizing the fluid plasma method, we could produce fuels like alcohol or methane gas — essentially by changing the raw input. If we broaden our view, we might discover even more methods. Conceptually, by supplying plasma's energy to chemical processes or materials themselves, we might enable chemical reactions that were difficult before.

"As a plasma specialist, I'm tackling energy problems. I see this project as the very first step in that endeavor," Toyoda says.

Hirotaka Toyoda

Profile

Nagoya University
Hirotaka Toyoda

Professor, Graduate School of Engineering, Nagoya University

After serving as Research Associate, Lecturer, and Associate Professor at Nagoya University, has held the current position since 2007. Engaged in work related to the industrial application of plasma through the development of plasma devices and plasma diagnostic methods, analysis of physicochemical phenomena within plasma, and exploration of new plasma application fields.

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Examining and locating underground resources hidden within the Earth as if seeing through them —a completely non-destructive exploration technology that harnesses subatomic particles raining down from space.

Nagoya University / Kunihiro Morishima

Feasibility study for the commercialization of underground resource exploration using cosmic-ray imaging

Every mine is destined to be depleted eventually. Finding new ore deposits is an exceedingly difficult task.

It goes without saying that mineral resources are essential for industrial development. However, Japan relies on imports for nearly 100% of its underground resources. If resource procurement becomes unstable due to soaring prices or changes in international conditions, it could deal a blow severe enough to shake the nation's economy. And any currently developed mines will eventually run dry. There is a constant need to explore for new ore deposits.

However, detecting the various resources buried underground is an extremely challenging task. Even leveraging all observable clues from the surface – geological surveys and geophysical methods like magnetic and gravity exploration – the precision is far from sufficient.

At present, the best we can do is rely on exploration engineers' experience and intuition to pick a promising spot and then drill ("boring") there to sample deep underground. A boring survey (drilling a narrow vertical hole) can extract soil and rock from depth, but since it only samples along that line, if the target resource is nearby but not intersected by that line, it will be missed. According to resource exploration companies, even after drilling dozens of boreholes (each costing on the order of millions of dollars), it's quite rare to discover the expected resource deposit. The success rate is reportedly a mere 3 in 1000 boreholes. In other words, they're digging on just a 0.3% chance. One can imagine the enormous cost involved.

A technology that "X-ray-visions" objects far larger than the human body: cosmic-ray imaging.

Ideally, we'd like to investigate underground in a way that lets us see through a wide region. The technology that makes what sounds impossible possible is cosmic-ray imaging. The principle is the same as an X-ray. In X-ray imaging, you irradiate the object of interest with X-rays (a type of radiation) and take an image of the "shadow" created as the rays pass through. In place of X-rays, we use muons, which rain down on Earth constantly from cosmic rays.

The Earth is constantly showered by muons – subatomic particles created when cosmic rays from outer space collide with the atmosphere. Muons are akin to electrons but about 200 times heavier, giving them a very strong ability to penetrate matter. They can pass through up to roughly 1 km of rock, and they rain down at a rate of about one muon per square centimeter per minute (roughly one per handprint per second).

In X-ray imaging, because you use artificially generated X-rays, the area and direction you can irradiate are fixed, and you need film as large as the object you're imaging. Muons, however, arrive naturally all the time from all directions, allowing you to survey a wide area even with a small piece of film. By placing this film (a muon detector) underground and capturing the tracks of muons, you can obtain a see-through image similar to an X-ray. If you change the detector placement or viewing angle to get multiple images of the target, you can investigate the underground situation with even greater accuracy. In this way, you can peer through a volume of underground space in three dimensions.

Capturing muons with the analog technology of film, then automatically analyzing them with digital technology to make underground imaging a reality.

The film used for capturing images—nuclear emulsion plates—is made of the same material as traditional analog photographic film. The difference is that it is extremely sensitive, capable of detecting even the tracks left by passing muons. The captured images are then examined piece by piece under a microscope, but doing this by eye takes far too much time. To solve this, Nagoya University independently developed the world's fastest system for automatically analyzing nuclear emulsion plates, and using this device, we have already succeeded in "seeing through" a variety of objects.

Here are some examples. First, the interior of the reactor core of Fukushima Daiichi Nuclear Power Plant's Unit 2. In 2014, our observations revealed for the first time that over 70% of the Unit 2 reactor core fuel had melted. Since 2017, we have also participated in the international survey team investigating the Great Pyramid of Khufu in Giza, Egypt. In this project, we discovered two previously unknown internal spaces, which became major news worldwide. Then, in 2018, in a joint survey with the University of Naples, we investigated underground ruins beneath the city of Naples, Italy, and discovered a Greek-era burial chamber 10 meters underground, successfully achieving detailed visualization of the underground structure.

As these examples show, cosmic-ray imaging—which can see through underground structures—has the potential to dramatically improve the efficiency of underground resource exploration. With this in mind, we have been working toward commercialization, making use of this fund both in FY2022 and again this year. Since December 2023, we have been conducting demonstration experiments by installing detectors at the Kamaishi Mine, and we are currently analyzing the data from the detectors retrieved in April. Underground resource deposits come in many forms, and we have learned, for instance, that thin, vertically spread vein-type deposits—common for gold and silver—are difficult to detect due to large differences in data depending on the viewing angle, while massive deposits—common for copper, zinc, and lead—that spread widely both vertically and horizontally are much better suited for this technology.

Making underground resource exploration more efficient is only the prologue to bringing cosmic-ray imaging into society.

Of course, it's not realistic to think we can find every underground ore body around the world with this technology alone from the start. However, even if we can survey with a few measurements an area that used to require 100 boreholes, that could save tens of billions of yen. We position the value of this project as combining our technique with conventional ones to slash costs. Efforts toward commercialization – such as improving reliability and speeding up measurements when offering this as a service – are still ahead. We plan to interview major trading firms and others as we work to build a viable business model.

A key feature of this technology is that it can examine the interior of an object without destroying it. It can "X-ray" anything from things on the order of kilometers (the inside of a volcano, geological formations, underground resources) to things on the order of meters (like a concrete bridge pier), just by setting up detectors. Since it relies on naturally occurring muons, you can inspect completely non-destructively with zero environmental impact. You can probe the interior of structures that cannot or must not be broken — say, an ancient tree or underground infrastructure like tunnels — from the outside. It does require some time, and conditions like needing to place detectors below the object, but if an object has regions of differing density, there's a potential to see through it.

In fact, when we mentioned that we can examine large infrastructure like dams or tunnels without damaging them, some companies contacted us with interest. If we can get this project on track, feeding the business outcomes back into research will allow us to push the research further. Even the fields where we already sense potential are broad enough, but we expect that with further research, we might encounter applications in areas we can't even imagine yet.

Note: Morishima's previous work was introduced in the GAP Fund Program promotional booklet "STST2022," available at the URL below. → https://tongali.net/x/stst/

Kunihiro Morishima

Profile

Nagoya University
Kunihiro Morishima

Associate Professor, Graduate School of Science, Nagoya University

Completed the doctoral program in Particle and Astrophysical Science at the Graduate School of Science, Nagoya University, earning a Ph.D. in Science. After serving as a Designated Assistant Professor at the Institute for Advanced Research, Nagoya University, and as a JST PRESTO researcher (concurrently), assumed the current position in 2021. Also holds a concurrent position at the Institute of Materials and Systems for Sustainability, Nagoya University. Achievements include the successful visualization of the reactor core meltdown at Fukushima Daiichi Nuclear Power Plant Unit 2 in 2015, and the discovery of a previously unknown large void inside the Great Pyramid of Khufu in Egypt in 2017. Research focuses on the development of cosmic-ray imaging technology using nuclear emulsion plates.

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AI technology that introduces objective evaluation and explanation into sports — capturing hidden brilliant plays and generating artistic performances in abundance.

Nagoya University / Keisuke Fujii

Commercialization of virtual player replication technology for evaluating team sports based on machine learning and game theory.

Objectively explaining what makes a great play great. Science makes sports even more interesting.

In volleyball or baseball games nowadays, you'll see coaches giving instructions with a tablet in hand. In sports broadcasts, you'll see a ball's trajectory overlaid on the screen during replays. We live in an era where introducing data analysis into sports is the norm. Moreover, information technology is being harnessed in game management too – for example, VAR (Video Assistant Referee) has been fully introduced in international matches. Every time there's a close call, debates about AI referees flare up on social media. However, we're still only scratching the surface – there is so much more science can contribute to sports.

From a scientific perspective—such as evaluating and explaining play objectively using data—what are the benefits? One key benefit is that analyzing good plays makes them easier to reproduce. By objectively evaluating an excellent play, we can clearly understand what makes it great. This clarity allows coaches and players to identify exactly what to focus on, ultimately leading to improvements in both tactics and skills. Another benefit is the ability to recognize plays that are outstanding but often go unnoticed. Some players may have little contact with the ball, yet contribute significantly to both offense and defense through their movement. When the entire game is assessed objectively, it becomes possible to highlight valuable plays that might otherwise be overlooked simply because they occur away from the ball.

It not only allows us to notice things humans didn't, but also enables fair evaluations that aren't influenced by a player's past accolades or reputation. I believe one reason this project was able to secure the GAP Fund again (as it did in 2022) is because of this backdrop.

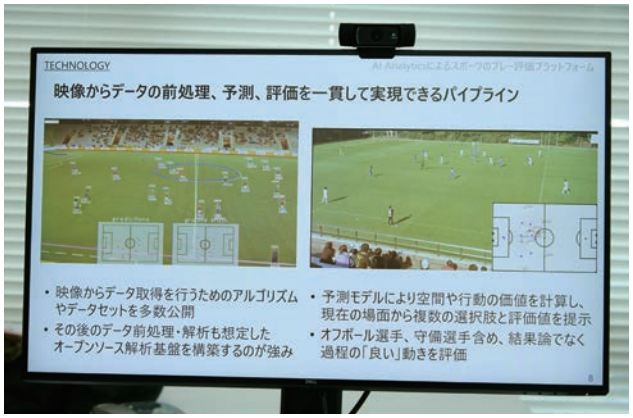
Using AI that fuses image processing, sports science, and game theory to predict outcomes and player trajectories, enabling their evaluation.

Let's briefly look back at our work so far. Focusing on invasion games like soccer and basketball, where players intermingle and offense and defense switch in an instant, we have been developing technology to turn whole plays into data for objective analysis and evaluation. In sports, unlike an exam, there is no single "correct answer," so evaluating play is extremely difficult. We therefore tried two broad approaches to evaluation.

One is "outcome prediction." In this method, we use the situation of each scenario to predict the possible outcomes and use that as a baseline to evaluate the actual play in that scenario. Think of it as applying the approach of predicting the "next move" (as developed in AI shogi chess) to a single scene in soccer or basketball.

The other is a method called "trajectory prediction." We identify plays that led to very good outcomes and, from the starting state of those cases, assign each player a "standard behavior model" of how they would normally move, then simulate the play. Using the resulting standard play as a baseline, we compare it to the actual players' play and quantify the difference.

Both methods rely on building predictive models through machine learning AI. We constructed analytical methods using sports science and game theory, and then integrated them with AI analysis to establish a way to evaluate player movements. We're confident that even now, two years later, this remains a world-unique approach.



In addition to plays that contribute to victory without even touching the ball, the system captures and digitizes every phase of the game — with automated data acquisition as well.

One of the major advancements in the past two years has been further progress in "trajectory prediction" technology. Specifically, we expanded the prediction models beyond just the ball carrier to include off-the-ball movements, such as creating space for teammates and defensive actions. By developing a defensive evaluation method based on counterfactual predictions — "what if a player had been positioned here?" — we made it possible to evaluate defenders. This has led to a framework capable of evaluating the movements of all field players on the pitch.

We also utilized existing open-source reinforcement learning models (a type of machine learning in AI) to evaluate the behavior of actual soccer players. By modeling player decision-making and actions, we calculated — for the first time in the world — the value of every single action taken over an entire match. This enables AI to propose optimal plays and objectively assess how a player should move in any given situation.

Another key advancement is posture estimation technology. The technologies described so far treat players as points moving on the flat surface of the pitch. With this approach alone, a player receiving the ball at the same timing and in the same position would always score (or always miss), which is not realistic — because players differ in their individual skills.

To measure these differences, posture estimation dynamically captures changes in a player's body posture. In reality, video data often comes from only a single, fixed-direction camera, which means posture changes are usually captured only in two dimensions. Our method predicts three-dimensional posture changes from a single camera feed, allowing us to estimate what actions occurred and when. This enables automatic collection of the data needed for analysis from just one camera video.

Realizing that further technological advancement alone is not enough — we are also working on creating systems to raise broader awareness of the technology itself.

Continuing to develop and integrate these technologies is the main thrust of our research, but at the same time we keenly felt how difficult data collection is. Various data owned by teams and leagues – the top teams that collect abundant data tend to keep it private. At the staff level that we can talk to, they understand the importance of this technology, but they're busy with day-to-day work. We haven't been able to convince team management, and data sharing isn't progressing. Even if we get data, every team's data format is different. Converting gathered data into a common format takes an overwhelming amount of time.

To tackle this, we built an analysis platform called OpenSTARLab to solve the conversion problem, and decided to release it to the world as open source. We provide a platform that can perform basic analyses, and we've openly released some of our data and analysis code for free. This way anyone can use it freely and contribute to development. By doing so, we hope to foster mutual understanding of the technology and spark effective discussions on utilizing play data. We want to grow it into a platform that serves that purpose. Advancing the technology is important, but even more, we expect it to function as an educational tool to widely inform people about our technology and the world it aims for.

Incidentally, when we tried crowdfunding to support our reinforcement learning research, we quickly raised about ¥2.85 million, surpassing our ¥2 million goal – which showed us how high expectations are. Also, after the Paris Olympics, I was invited by various media to discuss AI referees, and I've personally felt how high public interest has become. Momentum is building. Our plan now is to implement our system with a soccer team – ideally an entire league – and continue development together on the ground.

Note: Fujii's previous work was introduced in the GAP Fund Program promotional booklet "STST2022," available at the URL below. → https://tongali.net/x/stst/

Keisuke Fujii

Profile

Nagoya University
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Associate Professor, Graduate School of Informatics, Nagoya University

Born in Osaka City in 1986. After earning a Ph.D. from the Graduate School of Human and Environmental Studies at Kyoto University in 2014, served as a researcher at RIKEN Center for Advanced Intelligence Project and elsewhere, before assuming the position of Associate Professor at the Graduate School of Informatics, Nagoya University in 2021. Recipient of the 2023 Nagoya University Akasaki Award. Conducts research on the integration of machine learning and sports analytics, and in recent years has also been engaged in the social implementation of technology in collaboration with various organizations.

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Research team member portrait
(center) Ryohei Fujita

Solving the heat generation problem — the bottleneck of next-generation power semiconductors —with an innovative evaluation technology capable of measuring even heat distribution without contact

Nagoya University / Ryohei Fujita

Commercialization feasibility study of high-speed thermal property mapping technology using lock-in thermography

It is essential to fundamentally resolve the challenges of evaluating heat generation and thermal resistance in semiconductor chips.

Power semiconductors that control high power — in railways, wind turbines, electric vehicles, and even "flying cars" — are now part of our social infrastructure. With next-generation power semiconductors like SiC and GaN, further performance gains are expected, but at the same time, the issue of heat generation in semiconductor chips is becoming critical.

For perspective, a household electric hot plate has a heat flux of about 50 W/cm^2, and a nuclear fuel rod around 100 W/cm^2. By contrast, today's mainstream Si-based power semiconductors have a heat flux around 200 W/cm^2, and the SiC power semiconductors mentioned above reach as high as 500 W/cm^2. If cooling is insufficient, it leads to performance degradation of the chip and damage to nearby components. Indeed, progress in power semiconductors absolutely requires corresponding advances in cooling technology.

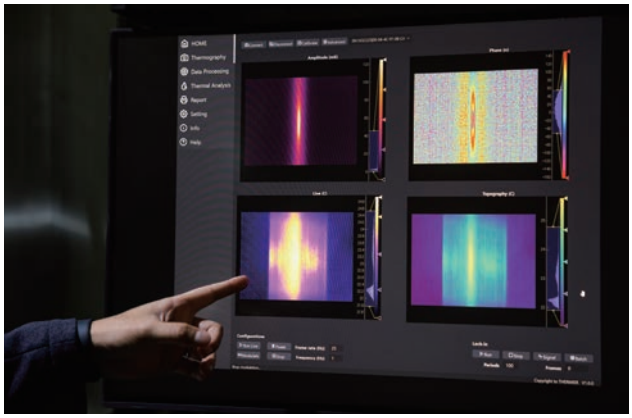
Heat in a semiconductor chip is carried by conduction to a heatsink and dissipated. Between the chip and heatsink lies a metallized substrate composed of insulating and metal layers. A problem is that the thermal resistance between layers (contact thermal resistance) varies with bonding methods and surface roughness, making actual cooling performance hard to predict. Thus, measuring temperatures on a real device becomes essential — but since we use the chip itself as a temperature sensor, you have to mount the chip on a substrate to measure it, which consumes a lot of time and money.

Manufacturers want to know actual measured values, not just theoretical estimates. We developed a technology to "directly measure" interfacial thermal resistance.

Contact thermal resistance can vary greatly if, for example, the material is non-uniform or there are internal delaminations or micro-cracks. Predicting it has not been successful with current techniques.

What if we could evaluate the thermal characteristics using the substrate before assembling the chip? If we could do that, it would save the enormous cost and time of mounting chips, directly boosting competitiveness in the fast-moving semiconductor industry. To achieve this, we have been working on a non-destructive thermal characterization method that combines laser heating and lock-in thermography (LIT) to measure contact and interfacial thermal resistance.

In this method, we use a laser to create a heat source on the sample (substrate), and use LIT to measure how the cross-sectional temperature changes over time and position. From that, we determine the thermal resistance at each interface layer. LIT is a special infrared camera used in semiconductor failure analysis, with a temperature resolution of better than 0.001 °C. The core know-how here is our technique for analyzing the data obtained by LIT and a custom-developed optical system. The thermal response at an interface involves temperature waves reflecting in complex ways, so a mathematical approach is essential to derive a theoretical solution. Thanks to the work of Dr. Ishizaki, a graduate of our lab, we established the basis of this technique.



Making it visible at a glance — non-contact, non-destructive visualization of temperature distribution on and between substrate surfaces.

Thermography, which measures temperature using an infrared camera, captures surface temperature information as an area rather than a point or a line, making it an excellent match for thermal property measurements. Its greatest advantage is the ability to perform imaging. For example, carbon fiber composites and high thermal conductivity resins have distinctive directional properties in heat conduction. If the spread of heat conduction can be imaged, post-processing by a PC can measure thermal properties in all directions. Furthermore, if the back side of the object under investigation is heated uniformly, the distribution of interfacial thermal resistance between layers can also be visualized.

The second advantage is non-contact measurement. Thermography detects infrared radiation emitted from a material to measure temperature. This non-contact nature is especially advantageous for micro-scale samples. For example, it is unrealistic to measure the thermal properties of fibrous fillers with a diameter of 10 μm — used to improve the thermal conductivity of resins — with a contact-type thermometer, but thermography makes it easy. Leveraging this strength, it has also been used for non-destructive measurement of the thermal properties of precious micro-particles returned by JAXA's "Hayabusa2" mission from the asteroid Ryugu.

The third advantage is minimal temperature rise. During measurement, the temperature reaches no higher than human body temperature, minimizing heat loss — the great enemy of thermal property measurement. This is possible because LIT (Lock-in Thermography) has extremely high (fine) temperature resolution.

All of this had already been achieved by the time we were selected for the GAP Fund in FY2022. Since then, we have continued making improvements, and now the new thermal property measurement system, Thermospect, has been completed. It can directly measure interfacial thermal resistance in just a few minutes and display heat conduction behavior as an image. At present, no other technology can do this. In addition, it enables multilayer board thermal resistance imaging, which visualizes how heat spreads across the surfaces of multilayer substrates.

We want to bring the new thermal property measurement system Thermospect to manufacturing sites as soon as possible.

The Thermospect, which can image thermal properties non-contact, has even measured the thermal properties of an aluminum nitride (AlN) whisker — a fibrous filler used to boost a resin's thermal conductivity — which had been very difficult to evaluate before. This further proves how unique our technology is.

When considering commercialization, we initially envisioned two models: one, a contract testing service where we perform thermal measurements for clients (focused on the semiconductor industry); and two, selling our non-contact, non-destructive device as an inline inspection tool in the production line of heat-dissipation materials. However, it turned out each approach has its challenges.

For the contract measurement model, one surprise was how broad the range of potential user companies was. The demand for thermal property measurements has grown far beyond what we anticipated at the planning stage. It's good in the sense of a large, growing market, but it also means the targets of measurement are extremely diverse. We need to enhance our equipment's versatility while scaling up capacity accordingly.

On the other hand, in the inline inspection scenario, discussions with potential users revealed a strong preference to start using it for sample-based inspections rather than integrating it into production lines for 100% product inspection. With that approach, we need to optimize the device for each production environment, and the number of units per customer would be limited compared to full inline adoption. However, the ability to rapidly image thermal properties is our greatest strength, and we feel strong interest from users.

Our device is an all-in-one system that can measure not only overall interfacial thermal resistance, but also thermal resistance distribution at the interface, in-plane thermal conductivity distribution, and the thermal conductivity of fillers. With this device, one can obtain all material property values needed for thermal design in one stop. We are just one step away from turning this technological edge into a successful business.

Note: With this project, Fujita won the Grand Prize at the Forbes JAPAN Academia Entrepreneur Summit 2023 business contest.
Note: Fujita's previous work was introduced in the GAP Fund Program promotional booklet "STST2022," available at the URL below. → https://tongali.net/x/stst/

Ryohei Fujita

Profile

Nagoya University
Ryohei Fujita

Assistant Professor, Graduate School of Engineering, Nagoya University

Completed the doctoral program at the Graduate School of Engineering, Nagoya University, earning a Ph.D. in Engineering. Has practical experience as an aircraft structural engineer at All Nippon Airways Co., Ltd., with a specialization in non-destructive testing (NDT). While enrolled in the doctoral program, won the Grand Prize at the Forbes JAPAN Academia Entrepreneur Summit 2023 business contest. After serving as a JSPS Research Fellow (PD), assumed the current position in 2024. Main research areas include non-destructive inspection of composite materials using quantum-type infrared cameras and thermal property imaging of heat dissipation materials for semiconductors.

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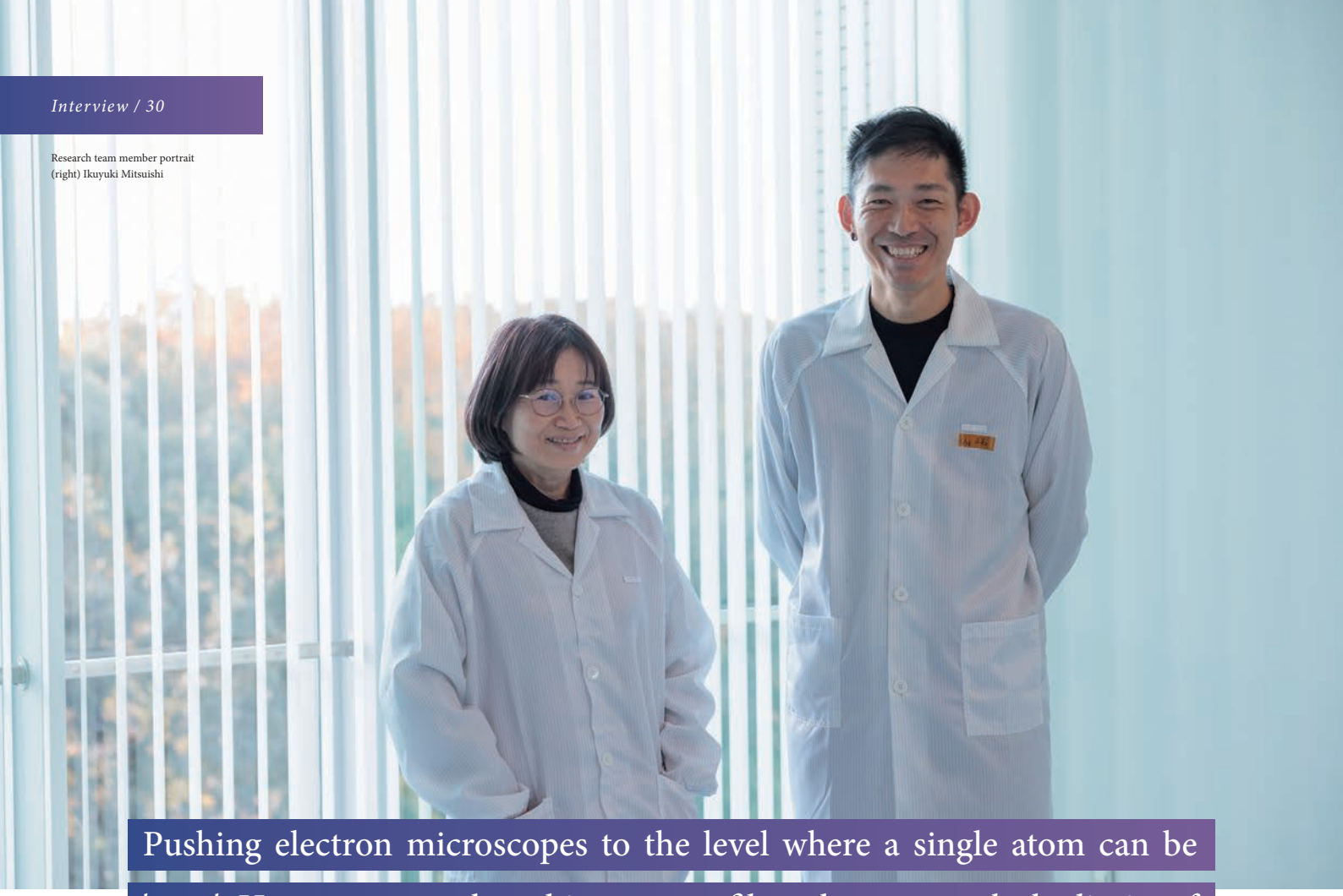


Research team member portrait
(right) Ikuyuki Mitsuishi

Pushing electron microscopes to the level where a single atom can be 'seen': How to create ultra-thin support films that approach the limits of observing matter in the microscopic world.

Nagoya University / Ikuyuki Mitsuishi

Business validation of a manufacturing and sales venture for freestanding ultra-thin membranes to visualize 2.5-dimensional materials

What does it actually mean to 'see' something?

When we see something with our eyes, think of it as receiving visible light—one type of electromagnetic wave—through our eyes, which act as sensors. In this case, visible light serves as the observation tool. As you can tell from the way a classroom microscope shines light from below using a mirror, it also uses visible light as its observation tool.

The observation tool changes depending on the size and nature of what you want to see. The tool must be much smaller than the object of interest. For visible light, the limit is roughly 400 nanometers (nm, one-billionth of a meter). Anything smaller than that cannot be observed with light. This is why, if we want to see cells, viruses, or even the proteins inside them, we use an electron microscope, which employs electrons—a type of subatomic particle—as the observation tool.

Do you remember how, in science class, you placed the object you wanted to observe on a glass slide under the microscope? For visible light, the glass slide is sufficiently transparent, allowing us to see through it. A part that supports the object in this way is called a support material, and it needs to be transparent to the observation tool.

For another example, in X-ray imaging, the "support material" for viewing bones is the human body itself. Since bodily tissues are nearly transparent to X-rays—the observation tool in this case—only the bones appear as white shadows. Incidentally, tumors or inflammations reduce transparency and therefore also show up as white shadows in the image.

The demand for technology capable of observing objects too small to be measured with visible light is higher than ever before.

So, what about when we want to see objects on the nanometer scale? As mentioned earlier, in this case the observation tool is the electron. The higher the transparency of the support material to electrons, the clearer the resulting image will be. To increase transparency, the support material must ideally be thinner than the object being observed. In other words, to closely examine something on the nanometer scale, the support material must also be at the nanometer level—and ideally thinner than the object itself.

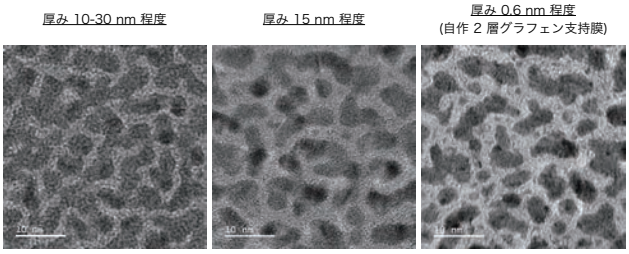
Nanometer-scale materials are now in the spotlight. Special functions of nanomaterials—materials with particle diameters under 100 nanometers—are being reported one after another, making technologies for detailed investigation increasingly important.

Among these tiny substances, quantum dots are attracting particular attention. Their discovery and the invention of methods for synthesizing them earned the 2023 Nobel Prize in Chemistry. Quantum dots are semiconductor crystals about 2–10 nanometers in diameter that emit light when exposed to ultraviolet radiation. The color of this light can be freely tuned according to the particle size.

Electron microscopes are also useful for observing these tiny materials, but their resolution depends greatly on the support material. Because the target is so small, a support material that is even thinner is required to see it clearly.

This is where graphene comes in—a sheet of carbon atoms arranged in a hexagonal lattice, only one atom thick. It has the remarkable property of being physically extremely strong.

異なる厚みの支持材によるプラチナ超微粒子の超高圧電子顕微鏡画像



Tago, Mitsuishi, et al., Proc. of SPIE, 2024

A 2.5-dimensional material—just a few layers stacked from substances as thin as a single atom. Technology for observing this microscopic world.

Materials like graphene, only one atom thick, are called two-dimensional materials because their thickness is so extreme that it can practically be ignored. They possess unique physical properties that stem from their special structure, offering vast potential for applications. When such a distinctive two-dimensional material is stacked in layers—either of the same kind or mixed with impurities from different materials—it exhibits completely different properties from a single sheet. Such layered structures are known as 2.5-dimensional materials. If a support material can clearly visualize materials on this scale, it can also sharply capture quantum dots and nanomaterials of comparable size. And by now, it should be clear that the ideal support material for this purpose is a two-dimensional substance—particularly graphene, prized for its exceptional strength.

I have been working on developing graphene ultra-thin films as viable support materials for analysis. In fiscal year 2022, my work was selected for the GAP Fund Program, and I began a business project to provide graphene support structures that meet the specifications researchers require. A graphene support structure is a composite in which a graphene film is placed on a grid-like support substrate (such as metal). However, during the process of transferring graphene onto the support substrate, the film can tear easily. To solve this, we proposed and demonstrated a new transfer process, for which we have filed a patent. Using this technology, we succeeded in producing very large-diameter free-standing graphene membranes—an order of magnitude larger than existing commercial products. (The larger the diameter, the wider the area that can be observed.)

Using this support material, we observed several types of samples, including nano-island structures made from platinum nanoparticles, nano-island structures made from copper nanoparticles (a lighter element with low density that is especially difficult to observe), and inorganic nanosheets. In all cases, we obtained images far clearer than those achievable with conventional supports—so clear, in fact, that we could detect individual atoms.

Being able to see extremely small things means we can now observe what was previously invisible.

Honestly, I was astonished that we could identify a single atom – and not just once, but repeatedly in multiple observations. In a striking example, we could clearly see atoms arrayed in an orderly lattice and even observe the moment when a single atom peeled away from the structure.

With today's analytical techniques, we can gather images from different angles (like a CT scan) and construct a three-dimensional magnified image of a 2.5D material. In other words, we can greatly magnify various nanomaterials or quantum dots and observe their structures in 3D. What does that lead to?

When you can examine a material in fine detail, fuzzy features snap into clarity and hidden things come into view. Nanomaterials have properties that can vary drastically depending on their structure; until now some of those details have remained unresolved. If we can see them clearly in 3D, we can begin to unravel the mysteries behind their properties.

Compared to our initial project two years ago, our core technology has advanced along its trajectory, but our business focus has sharpened. That's because extremely small materials – especially tiny 2.5D materials – have been garnering increasing attention recently, and the fact that quantum dots won a Nobel Prize made me realize that our technology now has a completely different significance in this new context. By refocusing squarely on ultra-tiny materials (particularly 2.5D ones), we could articulate the superiority of our technology much more clearly. Of course, we didn't ease up on the research itself: we kept improving the support material's performance and managed to file a patent on the fabrication process, among other efforts. It was by diligently continuing the research that we were able to seize this opportunity. I am once again reminded how important it is to persevere without giving up.

Ikuyuki Mitsuishi

Profile

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Completed the Doctoral Program in Physics, Graduate School of Science, The University of Tokyo. Ph.D. (Science). Former JSPS Postdoctoral Fellow (PD) and Assistant Professor at the Graduate School of Science, Nagoya University; currently serving in the present position. An astrophysicist specializing in cosmic X-ray observations and the development of onboard instruments aimed at future high-sensitivity space X-ray observations.

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Technology that enables easy design and evaluation of increasingly severe and complex heat management for factories, data centers, electric vehicles, and more.

Nagoya University / Noriyuki Watanabe

Business validation of loop heat pipe technology with a subscription-based web design platform

For example—the reality of cooling heat in data centers with air conditioners.The dilemma: removing heat requires additional electricity.

From industry and transportation to everyday life, heat is an inevitable byproduct whenever we use energy. Are you aware that we consume even more energy just to handle this unwanted heat?

Take data centers, for example—facilities that house servers for the internet and equipment for data communication (such as mobile, fixed-line, and IP telephony). Around 30% of their total energy consumption goes toward thermal management, including cooling and heat recovery. With the growth of AI, demand is surging for GPUs—chips specialized for image processing—that generate even more heat, making effective thermal management increasingly important. Electric vehicles face a similar challenge. As they operate, their batteries and motors heat up.

The problem is that when these devices get too hot, not only does performance drop, but temperatures can reach dangerously high levels. The heat simply can't be ignored.

Traditionally, heat issues have been addressed in large-scale facilities such as factories that handle high-energy processes. Such facilities cool equipment with water, then circulate the heated water with pumps to release the heat elsewhere. But running these pumps requires energy. Broadly speaking, most of today's thermal management relies on this same principle. This means enormous amounts of energy are spent not only to operate facilities and devices, but also to keep them running. From the perspective of economic efficiency—and in pursuit of a sustainable society—this is a challenge we urgently need to solve.

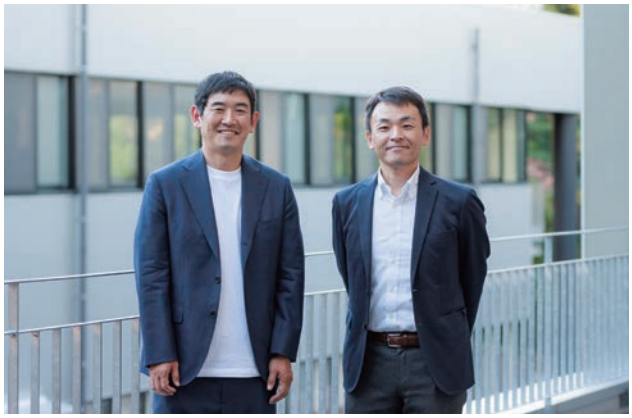
Technology for transferring heat as heat from equipment The "Loop Heat Pipe" born from space development

Managing the heat generated by devices and equipment without consuming extra energy—this was a challenge that NASA tackled head-on. In the 1970s and 1980s, one of the key problems in developing artificial satellites was how to remove heat generated by onboard equipment in a closed environment with limited power supply.

The solution was the Loop Heat Pipe. Instead of pumps, it uses the natural phenomenon of capillary action to move a working fluid—a substance that absorbs and dissipates heat—from the heat source to a remote radiator.

Capillary action is a phenomenon in which liquid inside a narrow tube (capillary) moves naturally through the tube without any external energy input. For example, when you place a sponge on a puddle in the kitchen, it soaks up water, which moves upward against gravity. The same principle is used to move the working fluid.

A cooling unit made from a porous metal—essentially a "metal sponge" full of countless fine pores—is saturated with liquid working fluid and placed in contact with the heat-generating equipment. As the working fluid travels through the metal sponge, it absorbs heat from the equipment and evaporates, causing the sponge to continuously draw in more liquid. Meanwhile, the vaporized fluid is pushed toward a radiator connected by pipes. Once naturally cooled there, it condenses back into liquid form and returns to the cooling unit. In this way, heat can be transferred as heat from one location to another—without relying on electricity or any other external energy source.



Two Challenges to Bringing Loop Heat Pipes into Practical Use
For both solutions, we are the world's front-runner.

To put loop heat pipes into practical use, they must be designed with the appropriate size and performance for the facilities where they will be installed. The first challenge is "achieving a size and performance suitable for actual facilities." We must verify the scale at which this is feasible.

This technology was originally pioneered by NASA. Professor Hosei Nagano, who worked on thermal device development at NASA, is the co-developer of this project. After returning to Japan, he continued his research at Nagoya University and has since developed over 45 different types of loop heat pipes, making him a leading authority in the field. Working together, we have developed various devices, including the world's thinnest at 0.3 mm, the world's longest at 28 meters, and the world's highest-capacity model capable of transferring 10 kW of heat.

The second challenge is "making design and evaluation easy." For example, data centers and electric vehicles have different target temperatures and installation conditions. The choice of working fluid inside the loop heat pipe depends on the desired temperature, the scale of the equipment to be cooled, and the installation environment. Options include water, alcohol, ammonia, and others. The cooling unit must be tailored to the size of the heat-generating device, and the distance to the radiator varies depending on the installation environment. In short, thermal management design is highly complex due to the many interrelated factors involved.

To address this, we have developed design software based on our accumulated research results. By entering key parameters such as the heat source's "heat output, surface area, and allowable temperature," the "distance" between the cooling unit and radiator, and the radiator's "allowable size and target cooling temperature," users can simulate the optimal loop heat pipe configuration.

The loop heat pipe itself has a simple structure, so it can be manufactured without our direct involvement. However, there has been no one capable of handling its complex design—until now. We are making this possible by providing an easy-to-use design software tool.

Toward an era where heat can be used as freely as plugging into an outlet/socket
Realizing a new concept: the "Thermo Socket"

Instead of creating complex designs one by one as custom orders, our approach is to automate the process through software. By offering this as a web-based subscription service, users can easily access it. This will allow various sizes and performance levels of loop heat pipes to be quickly and easily designed and evaluated through software, tailored to specific needs. Now that the technology is ready, we have decided to move forward with commercialization.

In addition to the advantage of requiring no electricity, another remarkable feature is that, because it relies on natural phenomena, it does not need complex and fragile components like those found in electronic devices—making it maintenance-free. Using highly durable stainless steel for the "metal sponge" section mentioned earlier greatly extends its lifespan. This means it can maintain high reliability for extended periods even in closed environments where electronic devices cannot be used, such as nuclear power plants or deep-sea facilities.

What we envision beyond this technology is a new concept we call the Thermo Socket. The idea is to move heat generated in one place to another and use it there—delivering heat as heat, exactly where and when it is needed, just as easily as plugging into an electrical outlet/socket.

From the standpoint of energy efficiency, the potential is immense. At present, we consume extra energy just to dispose of waste heat. This technology not only eliminates that wasted energy but also enables direct use of the vast amounts of heat energy currently being discarded, greatly reducing the burden on the environment.

But beyond efficiency, there may be an entirely new kind of impact. Think about it: if "heat" were added as a new infrastructure service alongside electricity, gas, and water, wouldn't society change in a profound way? We believe our research is paving the way toward a future beyond anything we can currently imagine.

Noriyuki Watanabe

Profile

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Completed the Doctoral Program in Nuclear Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology. Ph.D. (Engineering).
Specializes in reactor engineering, thermal-fluid science, phase change phenomena, and gas–liquid two-phase flow.
Since June 2016, has been engaged in research and development of loop heat pipes at the Nagano Laboratory, Nagoya University.

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A society that can be realized through the pursuit of "making delicious bread": Low-allergen foods, revitalization of local agriculture, and improvement of the food self-sufficiency rate

Meijo University / Masashi Kato

Business development of a bread starter—"Hana-Kobo Pan-no-Moto"—that makes bread fluffy, chewy, and moist

One of the newly isolated wild yeasts from nature— microorganisms found around the nectar of flowers, known as "flower yeast(Hana Kobo)."

Yeasts are single-celled microorganisms. A detailed, technical explanation can get complicated, but for now, you can think of them as microorganisms that cannot move on their own, have a cell wall, and do not photosynthesize but instead absorb nutrients from outside to grow. In nature, many types of yeast exist; they are abundant where fruit juice or tree sap collects, and they are also known to inhabit rivers and seas.

From the perspective of their function, yeasts can be described as microorganisms that break down sugars into alcohol and carbon dioxide. For humans, they are indispensable for making miso, bread, sake, and more. There are many varieties—for example, beer brewing uses beer yeast, wine brewing uses wine yeast, and the flavor of beer or wine changes depending on the yeast used. It's a vast and deep world.

Now, let's talk about flower yeast. This is a rare, natural yeast collected from flowers. In 1998, Professor Emeritus Hisakubo Nakata of Tokyo University of Agriculture, during his tenure there, became the first in the world to isolate sake yeast from flowers. It was initially tested for use in Japanese sake brewing. When I was teaching at Nagoya University, I used flower yeast collected from the campus's double-flowered cherry blossoms to develop and sell the Nagoya University brand junmai sake Nagomi Zakura. After moving to Meijo University, I continued flower yeast research, releasing Hana Shiro, a sake developed mainly by students in my laboratory. This time, the focus is on "flower yeast bread"—using flower yeast in place of conventional baker's yeast for bread making.

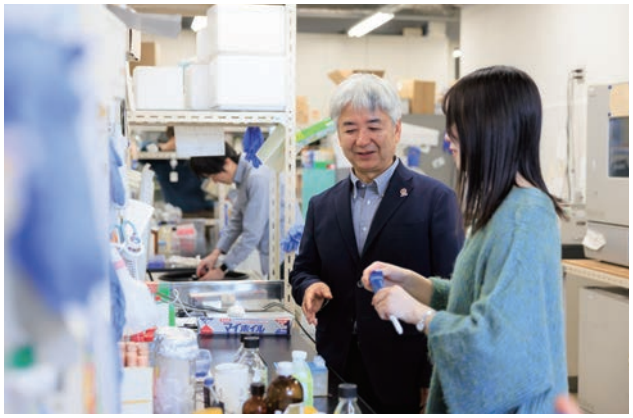
Excellent texture, superior moisture retention, delightful aroma, and perfect rise. The unmatched capabilities of flower yeast—beyond both baker's yeast and natural yeast.

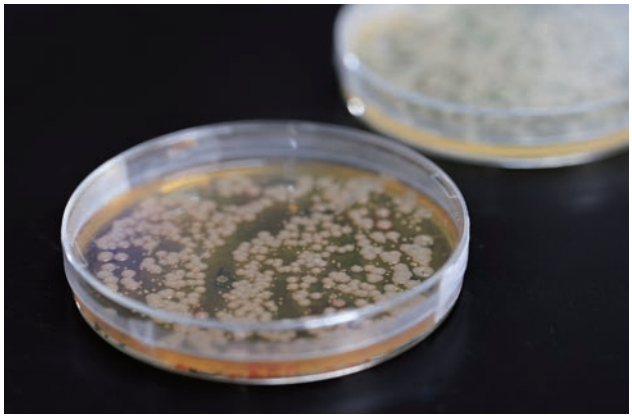
In studying flower yeast, we discovered that it possesses properties ideally suited for bread-making—significantly different from those of common baker's yeast or natural yeast. Let's first talk about making bread with baker's yeast and natural yeast. In English, baker's yeast is simply written as "yeast," but this is actually the direct translation of the word kōbo in Japanese. Generally, however, "yeast" in baking refers not to yeast in general, but specifically to a single strain of yeast, isolated from nature, that is particularly suitable for bread-making and cultivated in pure culture. In this sense, baker's yeast is also a type of natural yeast. When you see "natural yeast bread" in stores, it usually means bread made not with baker's yeast, but with multiple wild yeast strains originally derived from fruits or grains.

Making soft, fluffy bread with baker's yeast alone is surprisingly difficult; to achieve a greater rise, bread improvers known as "yeast food" (food additives) are often added. Baker's yeast has relatively low water-retention capacity and a distinctive "yeasty" smell, with only modest softness and chewiness.

Natural yeast, on the other hand, is yeast cultivated in the traditional way—homemade by fermenting fruits or grains. Because cultivation is challenging, stable production is difficult. Its appeal lies in the unique flavors and aromas that reflect the character of the original yeast strain, but its water-retention and rising ability are generally less than ideal.

By contrast, when we used flower yeast to make bread, it surpassed both baker's yeast and natural yeast in every respect—softness and chewiness of texture, moisture retention, aroma, and rise.





Not just wheat flour—improving the texture of rice-flour bread, too The profound and pressing significance of making this possible

Encouraged by the promising results in our laboratory, we decided to approach bakeries directly to try our product. In 2023, our students themselves visited 40 bakeries to propose trial sales contracts, and 10 agreed to cooperate in test production. Remarkably, 7 of those bakeries went on to sign provisional contracts with us.

We received genuine, positive feedback such as: "The aroma and flavor are excellent," "It has a wonderfully fluffy texture," and "It stays fresh longer after baking, allowing us to extend the shelf life." The response was extremely encouraging. At this point, we began to feel that this could become a viable business. Research showed that among competing products—namely "natural yeast (homemade yeast) bread starters"—the top-selling product earns about 470 million yen annually. Given that every negative point bakeries mentioned about such products was addressed by our flower yeast, we concluded that our product could more than compete. But I have another reason for wanting to commercialize this technology.

One of the 7 bakeries that signed a provisional contract was Bakeshop SolSol, a bakery specializing in rice-flour bread. Its owner, Mr. Yukihiro Katayama, told us: "With natural yeast, gluten-free rice-flour bread doesn't rise well and hardens quickly—but when I use flower yeast, it rises beautifully." Flower yeast has an extraordinary effect on rice-flour bread. Then he shared a deeply moving story.

After opening his rice-flour bakery in Hekinan City, Aichi Prefecture, a parent and child came to visit. They had traveled all the way from Iwate Prefecture. The child had a wheat allergy. Feeling apologetic, Mr. Katayama pointed them to his online shop, but the parent replied: "No—we wanted to give our child the experience of choosing bread at a bakery." Children who cannot eat regular bread can still enjoy rice-flour bread. That is why we want to make delicious rice-flour bread, no less appealing than wheat bread, widely available.

From flower yeast bread starter to a rice-flour bread business—and in the process, a plan to help save local agriculture

In Japan, there are roughly 200,000 people who suffer from wheat allergies. For them, being able to enjoy delicious bread would be life-changing. I won't claim that rice allergies don't exist, but compared to wheat allergies, the number is negligible. We should proactively switch from wheat to rice. Japan's bread could—and perhaps should—be made from rice flour. That may sound extreme, but I have strong reasons for saying so. The issue of food self-sufficiency, and the survival of local agriculture, is closely tied to the decline in rice consumption.

The reality for regional rice farmers is that, unless they produce high-value branded rice, they are often forced to sell at very low prices. By expanding the market for rice through rice-flour bread, we could help stem the decline of rice farming communities. This is not just an idealistic vision—it's a matter of food security for Japan, and at the same time, a path to sustaining local communities.

As one potential avenue for the bread starter business, I am working with farmers in Nanyo-cho, Minato Ward, Nagoya City on a project we call, tentatively, the "Nagoya Gluten-Free Village Initiative." The aim is to cultivate rice varieties suited for rice flour and sell them as bread, thereby increasing the incomes of rice farmers in the area. If successful, similar initiatives could be rolled out nationwide—using local rice and local flower yeast unique to each region.

Let's return to yeast. Yeast means fermentation, and Aichi has a long and rich fermentation culture. In the Edo period, the Tokai region was the second-largest sake-producing area in Japan, thriving in brewing and fermentation. It is even said that Edomae sushi was born because vinegar from Aichi was transported to Edo. I want to reframe fermented foods as a distinctive food culture of Aichi and share its appeal with the world. With that in mind, I joined the "Aichi Fermented Food Culture Promotion Council," established in 2024. From that perspective, "flower yeast bread" also contributes to the development of regional culture. I believe it is a project with tremendous potential.

Masashi Kato

Profile

Meijo University
Masashi Kato

Professor, Faculty of Agriculture, Meijo University

After completing the Doctoral Program at the Graduate School of Agricultural and Life Sciences, The University of Tokyo (Ph.D. in Agriculture), served as Associate Professor at the Graduate School of Bioagricultural Sciences, Nagoya University, among other positions. Since 2010, Professor in the Faculty of Agriculture at Meijo University.From 2019, concurrently serves as Director of the Center for Social Collaboration at Meijo University, and since fiscal year 2023, also as Director of the Information Center. Reference information related to this project: Patent No.6767707, doi: 10.1038/s41598-019-50384-w.

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Revolutionary technology delivering new sensory experiences to humanity through the innovation of monolithic LED integration

Meijo University / Motoaki Iwaya

Development and commercialization of monolithic μLED display panels enabling highly immersive VR/AR head-mounted displays

Put on a pair of glasses, and information dances across the scenery before your eyes. Could sci-fi–like gadgets be just around the corner?

Imagine putting on a pair of glasses and seeing information leap to life across your view. A gadget like something out of a sci-fi movie, right before your eyes. Envision this: you put on glasses and, in front of the building you're looking at, floating text appears, streaming relevant information. Over the person you're speaking with, you see their name and perhaps hobbies displayed above their head. If you could get your hands on a gadget like something out of a futuristic comic or sci-fi film, what would you use it for?

This might sound like pure fantasy, but I'm absolutely serious. In fact, a head-mounted display (HMD) very similar to what I described is already on the market. Despite costing nearly 600,000 yen (around $5,000) per unit, over 200,000 units have been sold. Numerous similar devices that let you experience so-called VR (virtual reality) are also available – many of you might have even tried one.

HMDs have three main display methods. There's the non-see-through type, which completely blocks your view of the outside when worn. There's the video see-through type, which also blocks your direct view but uses cameras to show you the outside scenery on a screen. And there's the optical see-through type, where the display doesn't obstruct your view but overlays images onto the real world. The majority of HMDs you can get today are either non-see-through or video see-through types. Most of those devices are large and bulky, like a pair of snowboard goggles, and they aren't something you can comfortably wear out and about in everyday life.

There are also glasses-type devices that use optical see-through technology, but at present, they are largely geared toward immersive enjoyment of games and videos, and have yet to reach the level of real-time AR that overlays digital information onto the real world."

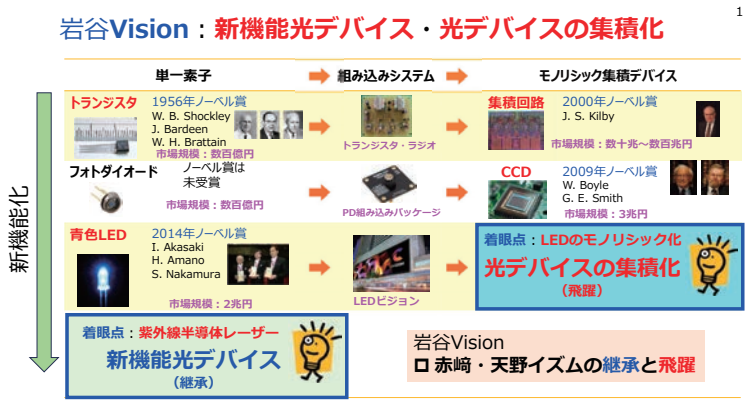
From large displays to private displays—Why they have yet to break past that boundary: insufficient brightness

HMDs certainly seem capable of offering experiences unlike anything before, but at present, they remain essentially gadgets for delivering highly immersive, private viewing experiences in place of large displays. Why is that? With non–see-through systems, the limitation is obvious. Video see-through systems, meanwhile, are too large and heavy, and their image display suffers from time lag, making them suitable for only a limited range of AR applications. This inevitably leads to optical see-through systems, but with current technology, image brightness is insufficient. Outdoors in daylight, when superimposed over real-world visuals, the displayed images become faint and washed out, to the point of disappearing.

Currently, HMDs under development use displays such as liquid crystal, OLED, or surface-emitting lasers. However, due to the principles of these technologies, it is anticipated that they cannot deliver vivid images under natural sunlight.

Now, let's talk about AR—Augmented Reality. This refers to technology that extends a person's perception of the real-world environment using a computer, as well as the augmented environment itself. In medicine, for example, it could be used to display CT scans of a cancerous area during surgery, aiding in tumor removal. For remote medical support, where there's no need to overlay the imagery directly onto the field of view, practical applications using HMDs have already begun.

However, the real essence of AR lies in being usable outdoors. Leading U.S. tech companies have published their desired specifications for AR devices and are seriously seeking the technology to achieve them.



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Technology for producing LED light bright enough to compete with daylight, manufactured as a surface display at glasses scale

Google, Apple, Meta—major tech companies are all desperately seeking the technology that will allow VR/AR systems to maintain sufficient brightness outdoors while delivering imagery in a glasses-sized form factor. But where can we find such a powerful light source? The truth is, we already experience it in daily life. Even with the sun blazing behind us, in intense backlight, we can still clearly see the colors of traffic signals. You've guessed it—it's LED.

Long before the world began clamoring for this kind of technology, I had been exploring the potential of devices integrating LEDs, and in 2013, I succeeded in developing the world's first monolithic micro LED. It was an extremely small LED panel—2.5 mm wide, 0.5 mm tall, single-color display. At the time, no one paid much attention to it—"What use could something so small possibly have?"—but I steadily continued my research toward full-color capability.

Over time, my related patents grew to 20 in number, and in 2023, I finally succeeded in developing the world's first monolithic RGB full-color micro LED array. This marked a technological breakthrough for achieving ultra-bright, ultra-small image displays.

So, what exactly is a monolithic LED? In this context, monolithic integration means taking a single device type and integrating it into an electronic component with entirely new capabilities. A monolithic LED is, therefore, an electronic component that integrates multiple LED elements. When made into a tiny display, it becomes a monolithic micro LED display.

This enables us to meet all the conditions for rendering crisp images even under natural sunlight: maintaining brightness over 30,000 nits, achieving resolutions above 4,000 ppi, reproducing a color space equivalent to the real world, and using highly efficient light-emitting elements. The performance gap compared to existing technologies is overwhelming. At present, it is difficult to imagine any display technology better suited for AR.

A very bright, very small display—Monolithic LED may well be something beyond even that

Looking back at the history of semiconductors, the path of innovation began with maximizing the performance of single devices such as the transistor, the photodiode, and the blue LED. In parallel, there was the development of monolithic integrated devices—integrated circuits (ICs) that combined transistors, and CCDs that combined photodiodes—each revolutionizing technology. Almost all of these inventions won Nobel Prizes and generated markets worth tens of billions to hundreds of trillions of yen, becoming the core technologies that support countless products in modern society, from computers to imaging devices.

In the same way, I have been steadily working on developing a monolithic integrated device built from LEDs as the single element. This is something that has never been achieved before and has the potential to transform the world.

If we can realize a truly practical AR device, the impact will be enormous. The market for VR/AR display panels is projected to grow to 2.3 trillion yen by 2030, with micro LEDs expected to account for more than half. Yet the transformative effect on the world will be even greater than the market impact. Imagine visiting a completely unfamiliar place and having guidance appear showing where everything is. Imagine two people speaking different languages holding a conversation through subtitles displayed unobtrusively at the edge of their vision. This would be a technology that feels like adding an entirely new sense.

It's thanks to the unique environment of the university that I've been able to continue research that initially attracted little attention. By the time this becomes a reality, I expect to have over 100 patents filed for the new technologies developed along the way. In fact, arranging three-color LEDs in ultra-small units within a tiny display has required countless technological innovations. There are still hurdles ahead, but the sense of progress is undeniable. Now, I am working with full confidence in the path forward.

Motoaki Iwaya

Profile

Meijo University
Motoaki Iwaya

Professor, Meijo University School of Science and Technology

After earning his degree in the laboratory of Professors Isamu Akasaki and Hiroshi Amano—recipients of the Nobel Prize for the invention of the blue LED—he has been engaged in the research and development of light-emitting devices such as LEDs and laser diodes based on nitride semiconductors.

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"The Greatest Barrier to Cultured Meat Adoption: Growth Factors Are Far Too Expensive" Unraveling Protein Structures to Unlock a Food Revolution

Gifu University / Yuji O. Kamatari

Proposal for fragmented growth factors that significantly reduce cultured meat production cost

The hope that "cultured meat could solve the food crisis" has been, until now, brought to a standstill by a very real wall of cost.

With the world's population growing, ensuring a stable supply of protein has become an urgent challenge. Traditional livestock farming requires vast expanses of land and huge quantities of water, and it unavoidably produces greenhouse gas emissions. This poses a major obstacle to reconciling food security with environmental conservation.

In response to this problem, research and development of cultured meat – a novel meat production technology that cultures animal cells – has been advancing. Cultured meat requires far less land and water than conventional livestock farming, and its environmental impact can be greatly reduced. It's also drawing attention from an animal welfare perspective. However, the road to practical use is by no means smooth.

The biggest challenge is production cost. When the world's first cultured meat hamburger was unveiled in 2013, its production cost was about 40 million yen (over $300,000). Even now, more than a decade later, there remains a huge gap between the cost of cultured meat and that of ordinary meat. Unless we bridge that gap, cultured meat won't be lining our dinner tables.

Some 98% of the production cost is due to the cell culture medium (the "broth" in which cells grow). And within that, the most expensive components are the growth factors needed for cell proliferation – these account for 99% of the medium cost. If we could achieve a breakthrough that dramatically reduces this expense, making cultured meat a commercial reality would no longer be just a dream. Amazingly, such a potential innovation is now on the horizon, born from advances in protein research.

Breaking through the cost barrier by controlling molecular size. Latest technology draws a roadmap to cultured meat commercialization.

The key idea we pursued was an approach called "fragmentation" – essentially, making the growth factor molecules smaller. Our project is a radical technique that emerged from protein structure research. Proteins are chains of 20 types of amino acids; they fold into specific shapes to function. Leveraging knowledge from structural biochemistry, we found a way to break the cost barrier to cultured meat's practical use.

Currently, growth factors are extremely expensive substances, costing several hundred thousand yen per microgram. The reason lies in the production method. Due to their complex structures, producing growth factors in E. coli is difficult, making it necessary to manufacture them using more costly animal cells. Among these, two growth factors—TGFβ and FGF2—account for 94% of the culture medium cost, making them the primary challenge.

So we set our sights on "fragmenting" the growth factor – reducing the molecular size of the growth factor protein so that it's smaller and simpler. We combined state-of-the-art analytical techniques and data science: atomic-level structural analysis by NMR (nuclear magnetic resonance) and quantitative analysis of molecular interactions by SPR (surface plasmon resonance), coupled with structure prediction via computational methods. By integrating these advanced analytical techniques with data-driven predictions, we achieved a technological innovation that would have been unimaginable 10 years ago.

Through this technology development, we've seen the possibility of reducing the production cost of growth factors to one-tenth or less of current levels. This is literally a step toward overcoming the biggest barrier that has been blocking cultured meat's practical adoption. This innovative technology born from protein research is poised to open the door to a new era of food production.

The challenge of "culture medium development" as the foundation of the cultivated meat industry. Pioneering the future of food through the 'bed' that nurtures cells.

Our goal is to establish a business model centered on "supplying culture media" to the cultivated meat industry. Inside the "bed" of the culture medium, cells absorb the various substances they need to grow, synthesize proteins, and proliferate. For example, pork is produced from pig cells, and chicken from chicken cells. Through the development and supply of this culture medium, it is our mission to contribute to the growth of the cultivated meat industry.

Various research groups are working to reduce the cost of cultivated meat, pursuing diverse approaches such as using plant-derived proteins or producing growth factors in genetically engineered plants. Among these, we specialize in the study of proteins in the "TGFβ superfamily." The production of these proteins is an area with few successful examples from other groups. However, following the publication of our paper, we received inquiries from multiple research institutions, including specialized companies in the United States. Because adjusting growth factors is an extremely challenging technique, this response highlights the potential of our research.

The cultivated meat industry is accelerating its R&D efforts globally, with practical implementation initiatives advancing in various countries. In 2020, the Singapore Food Agency introduced a regulatory framework for cultivated meat. This became a turning point, triggering more serious movements toward approval worldwide. With future food demand projected to outpace supply, the establishment of new production technologies has become an urgent priority.

We are developing culture media suited to a wide range of cells—from mammals and birds to fish and invertebrates. Cultivated meat manufacturers can use these media to develop their own distinctive products. As the "foundation for cultivation" that allows cells to grow healthily, we aim to provide the industry's core technology and help solve the cost challenges facing the cultivated meat sector as a whole.

Protein research indicates the potential of "cell culture." From medical applications to drug discovery, an unforeseen expansive future.

Our technology, building on the common platform of cell culture, is beginning to show potential beyond the cultured meat industry. There is great anticipation for its applications in the medical field in particular. Even now, TGF-β is used in regenerative medicine, but its astronomical cost is a major barrier to practical use. If our technology can lower the production cost, it should open the door to much broader medical applications – for example, using affordable culture medium in the process of expanding iPS cells.

Another noteworthy point is the multifaceted functionality of TGF-β. By unraveling the signaling mechanism through which it promotes cell growth, we have now envisioned developing new therapeutics to suppress the proliferation of cancer cells. Additionally, from an energy metabolism standpoint, we are working on developing a system to elucidate the genetic factors of pathological obesity. One after another, application areas we never imagined are revealing themselves from this single line of research.

Protein research is opening up new horizons far beyond our expectations. In the beginning, our work was centered on uncovering fundamental mechanisms, but as we progressed, a diverse array of possible applications began to sprout. There must still be numerous unknown functions left in the TGF-β superfamily of proteins. I believe that deciphering those will push open the door to further technological innovations.

And now, our challenge to establish cultured meat as a new food production technology is evolving into innovations in broader fields like medicine and drug discovery. No matter what path lies ahead, our mission is to steadily tackle each issue one by one. That steady accumulation of progress is precisely what will yield clues to solving the various challenges humanity faces. I strongly feel that the deepening of basic research can, in ways we never predicted, make real contributions to society in the future.

Yuji O. Kamatari

Profile

Gifu University

Yuji O. Kamatari

Assistant Professor, Tokai National Higher Education and Research System – Gifu University, Glycan Life Research Center

After completing the doctoral program (later stage) at the Graduate School of Science and Technology, Kobe University, in 1996, served as a JSPS Research Fellow, Postdoctoral Researcher at the University of Oxford, HFSP Fellow, Researcher at RIKEN, Assistant Professor at the Center for Emerging Infectious Diseases, Gifu University, and Assistant Professor at the Research Center for Science Systems. Since 2021, has held his current position. Specializes in structural biology, protein science, and biophysics. Aims to elucidate biological phenomena through the structural and interaction analysis of proteins and glycans, and to contribute to solving various challenges in society.

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Toward “sustainable” poultry farming through two innovations: sex-selection technology × resource-circulating new feed

Shizuoka University / Tomohiro Sasanami

Development of innovative feed using sex-selection technology for chickens and quail, and bioconversion with the black soldier fly (Hermetia illucens).

Egg production, once called the “model student of prices,” is at its limit.

Fried eggs, tamago-kake gohan (raw egg on rice), dashimaki tamago (Japanese rolled omelet)… We’ve long enjoyed eggs as an affordable staple, often praising them as “the one item that stays cheap”. But are you aware of the situation facing the poultry farmers who sustain this so-called model student of stable prices? Breeding hens that lay eggs over 360 days a year, cutting labor costs through mechanization, scaling farms ever larger – the poultry industry has worked tirelessly to keep eggs cheap. And yet now it stands at a major crossroads.

For many years, chicken eggs were beloved in Japan as a food with stable prices. However, in recent times, surging feed costs and rising prices for raw materials have been squeezing farmers’ finances. On top of that, there’s the constant risk of avian influenza: a single outbreak can force the culling of hundreds of thousands of birds. While scaling up operations improves efficiency, it also magnifies those risks. Simply put, there is no room left to cut costs further – we’ve hit the limit.

Even more alarming is the issue of chick culling. Because male chicks won’t grow up to lay eggs, they are culled immediately after hatching – over 130 million male chicks are disposed of each year in Japan. From an animal welfare perspective, this is a situation that can no longer be ignored. Meanwhile, small-scale poultry farms are shutting down one after another, and the lack of successors is only getting worse. If this continues, the very foundation of Japan’s egg production could collapse.

To break this crisis, I have been working on two lines of technological development: one is a method to selectively produce only female chicks, and the other is low-cost feed development using food waste. I believe that combining these two innovations can transform the future of the poultry industry. Let me explain each in concrete terms.

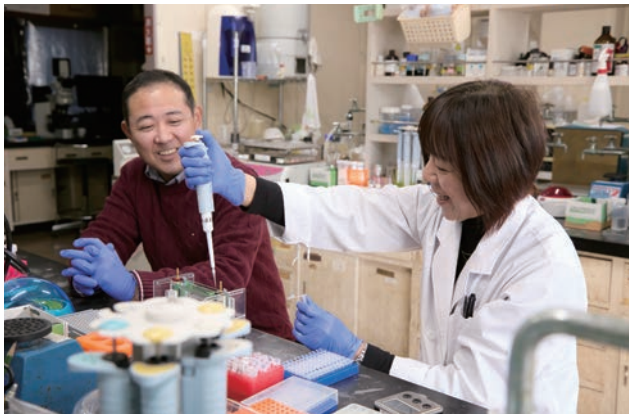
Toward achieving “the same production volume with half the number of breeding birds” Developing feed that creates value from food waste

To fundamentally solve this problem, it is necessary to change the sex ratio. At present, to obtain 100 female chicks, 200 fertilized eggs are required. In nature, the sex ratio is about 1:1, meaning all male chicks must be culled. This inefficient system places a significant burden on poultry farmers.

In our research, we discovered that by feeding mother hens a certain diet, we could get nearly 80% of their chicks to hatch as females. In other words, instead of needing 200 eggs to obtain 100 hens, we could do it with roughly 130 eggs. This means you could halve the number of breeder roosters and hens, yet still produce the needed female chicks. It’s a technology that requires only minimal changes to feed and could be introduced immediately in existing poultry operations, with little new equipment or investment.

The other challenge is the soaring feed cost, especially with global supply instability. Developing a domestic feed source has become urgent. We turned our focus to an unconventional solution: developing a new feed using the black soldier fly (Hermetia illucens). This insect can efficiently convert food waste into protein, and we’ve already established a pilot production system that produces on the order of 5 tons of larvae per year. We’ve confirmed the larvae have very high nutritional value – about 43.6% crude protein. Moreover, an added benefit is that we can earn revenue by accepting food waste (tipping fees), which becomes a baseline income stream for the operation.

By reducing the number of breeder chickens, farmers already save on feed costs; introducing this new insect-derived feed can cut costs even further. Including savings on facility upkeep and labor, we’re looking at the possibility of slashing production costs by 30–40% in total. In short, a path to significantly improving poultry farm economics is coming into view.



High expectations from Japan and abroad Two “ideas” opening up the future of poultry farming

Sex-selection technology has been drawing strong interest from across the poultry industry. From the Japanese branch of a major Dutch breeding company to prefectural research stations and local chicken producers, leading figures in the industry are watching closely. There are high expectations for its potential to fundamentally transform production efficiency.

To live up to those expectations, we’ve been conducting interviews with multiple poultry farmers and preparing for field trials. For instance, a typical mid-sized poultry farm may have feed costs on the order of 4,000 tons per year, at 65,000 yen per ton – an enormous expense. We are confident we can reliably cut that cost. With more efficient housing and our two technologies, the goal of a 30–40% total cost reduction is now within reach. We are currently preparing demonstration experiments with local poultry farms, making use of GAP funding and prefectural grants to get things underway.

Meanwhile, our research on the black soldier fly feed is also bearing fruit. We established a high-efficiency mass-rearing method where in just 11 days, 1 gram of fly eggs yields 4–5 kg of larvae. By utilizing 100% food waste as the input, we succeeded in building a large-scale production system that is very low cost. Of course, there are challenges: regulations for using insects in feed are still being developed, and we need to build an infrastructure for insect farming. We’ll also have to overcome certain cultural perceptions in Japan about using insects. But the times are steadily changing in our favor.

The potential of these technologies is growing even larger. For perspective, China’s egg production is 10 times that of Japan. India and the US each have egg industries about twice the size of Japan’s. In Southeast Asia, countries like the Philippines are big consumers of poultry and eggs. In an era of looming global food crises, our technology can surely offer a new option to the poultry sector worldwide. The combination of “a technology to select the sex of chicks” and “a technology to turn food waste into valuable feed” will, I believe, change the future of poultry farming – and each day we feel more confident in that.

“Re-examining what can be done as a researcher.” From basic research to “social contribution” – a new step forward.

Up to now, I devoted myself to fundamental research in reproductive physiology. I achieved some success with studies like improving in vitro fertilization techniques, and I felt I had done all I could on the basic research front. Then about five years ago, I found myself wanting to give back to society with the knowledge and research skills I’d accumulated, and I decided to make a major change in direction.

Around that time, I was transferred to the Mochimune Coastal Field Station of Shizuoka University’s Faculty of Agriculture. This was a turning point that drastically changed my research style. Previously, I spent my days peering into microscopes and determining protein structures; now my daily work revolves around feeding living creatures and measuring their weights. At first glance it may seem like plain, dull work – but if it’s serving society, I’m perfectly fine with that. In fact, I feel it’s a new stage where I can apply my research experience in a very practical context.

Stepping into the uncharted field of the feed industry has revealed a unique appeal. Through ongoing dialogue with local poultry farmers and encounters with business leaders from various companies, the possibilities for our research are expanding every day. In particular, developing feed using insects has opened the door to worlds I had never known before. It is not only research ability that is tested, but also communication skills and human qualities. To be able to take on new challenges in a place where I can truly test my own value—this is a joy I feel from the bottom of my heart.

Being a university professor is a huge asset in pioneering these unexplored areas. Many people trust us and are willing to collaborate in envisioning a future together. Sometimes I’m made aware of my own shortcomings, but that itself is a valuable learning experience. With the prospect of future food crises becoming ever more real, I want to nurture our technology into a solid solution. By steadily translating the insights gained from basic research into tangible outcomes, step by step, I feel we are grasping something real and impactful each day.

Tomohiro Sasanami

Profile

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Tomohiro Sasanami

Professor, Shizuoka University Faculty of Agriculture (Mochimune Coastal Field)

Withdrew from the Doctoral Program at the United Graduate School of Agricultural Science, Gifu University. Ph.D. (Agriculture). Served as Assistant Professor, Associate Professor, and Professor at the Faculty of Agriculture, Shizuoka University before assuming his current position in 2024. Currently serves as Associate Editor of The Journal of the Japan Poultry Science Association and as Representative of the Avian Endocrinology Research Society. Recipient of the Japan Poultry Science Association Award (2015).

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Selected Tech Seeds For Startup in Tongali

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