

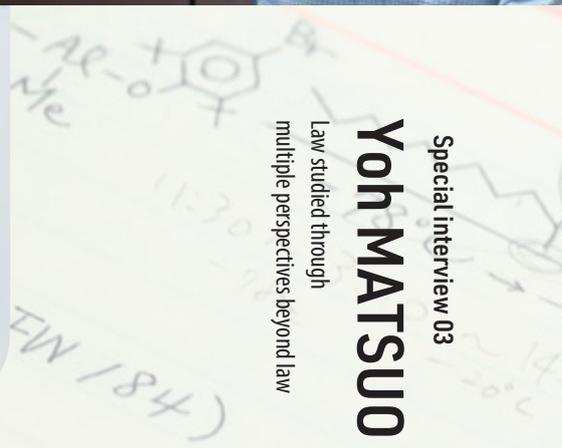
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Advancing Toward a World-Leading Knowledge Creation Hub



Hitoshi Sakakibara

Hitoshi SAKAKIBARA

Director, Institute for Advanced Research,
Nagoya University

The Institute for Advanced Research (IAR) at Nagoya University was established in 2002 as a pioneering initiative among Japanese universities to promote world-leading research and broadly share its outcomes with academia and society. Launched under the leadership of Professor Ryoji Noyori, Nobel Laureate in Chemistry, the IAR has served as a driving force behind the university's research excellence, identifying emerging fields, supporting groundbreaking studies, and nurturing promising researchers across disciplines. The IAR's commitment to intellectual exploration beyond traditional academic frameworks is one of its defining features. We promote cross-disciplinary collaboration, encourage research that challenges established paradigms, and create opportunities for researchers to engage with global peers. Flagship initiatives, such as the "Nagoya University Lecture," which is hosted by the university president, and an array of workshops, seminars, and symposia, form the basis of our efforts to foster dialogue and disseminate new knowledge. Additionally, the IAR participates in global networks of advanced study institutes, University-Based Institutes for Advanced Study (UBIAS), where we exchange insights and strengthen international research ecosystems. Cultivating the next generation of scientific leaders is central to our mission. In particular, the Young Leaders Cultivation (YLC) program provides early-career researchers with a platform to pursue independent and high-impact projects. Furthermore, collaboration with units such as the New Field Research Units, the Tokai Pathways to Global Excellence (T-GEx) initiative, and the Fusion Oriented Research for Disruptive Science and Technology program reinforces our role as a catalyst for innovative research that confronts the complex challenges of today's world. In the future, the IAR will redouble its efforts to function as a nexus for talented individuals and pioneering ideas and to further elevate Nagoya University as a global stage for transformative knowledge creation. We look forward to your continued guidance and encouragement for the IAR.

Institute For Advanced Research

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大井 貴史

Takashi OOI


Professor, Institute of Transformative Bio-Molecules, Graduate School of Engineering, Nagoya University

Prof. Ooi's research, centered on organic ion pair catalysis, is unique in the world. Currently conducting research that combines radical reactions as a KAKENHI* recipient project in the category of Transformative Research Areas (A) Green Catalysis Science for Renovating Transformation of Carbon-Based Resources, he continues to communicate new findings in Chemistry to the world.

*The Japan Society for the Promotion of Science (JSPS) Grants-in-Aid for Scientific Research

名古屋大学 大学院工学研究科/トランスフォーメティブ生命分子研究所 教授

有機イオン対触媒の研究を軸に、世界で唯一無二の研究を展開。現在も学術変革領域研究(A)「炭素資源変換を革新するグリーン触媒科学」において、ラジカル反応を組み合わせた研究に挑戦。新しい化学を世界に発信し続けている。

A researcher's uniqueness—what have I accomplished?
研究者の個性を問う—あなたが積み重ねてきたものは何か

As an undergraduate student, Prof. Ooi wondered whether he should go on to a doctoral course. Until then, he had been working hard, carrying out experiments day and night and gaining some confidence as a young researcher. Yet, his critical mind had some doubts: The world is vast and filled with diverse people. So would he want to spend the rest of his life in the lab?

He considered the option of a corporate job. As he imagined himself lined up with other students from various universities in

an interview room, he wondered why he should be selected and whether he represented something special that would justify a salary. His own answer was, "Not really."

Although he had achieved some research results by then, he himself had never come up with research ideas from scratch. He thought that he had simply been working hard. In such a situation, his mentor, then Associate Prof. Keiji Maruoka (now Designated Professor, Graduate School of Pharmaceutical Sciences, Kyoto

University), suggested that he enter a doctoral program. He felt encouraged, noticing that someone believed, even if only a little, that he should pursue that path.

He imagined himself doing his own research with his own ideas, which he would test in experiments, exploring unknown spheres of Chemistry. He thought about the kind of scientist he wanted to be, someone who would accomplish something unique through teamwork with those with whom he would build a relationship of trust. Yes, I'm

going to do a Ph.D., he decided. Since then, he has been asking himself, "Is there something unique only I can do?"

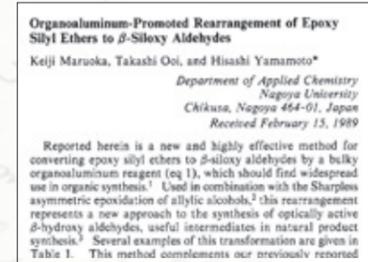
Looking back on his journey so far, Prof. Ooi says: "To put it a little dramatically, I think there's real value in trying something and failing. All the ideas accumulated through each research project that never made it into papers will eventually lead to something, and this is what makes the uniqueness of each researcher."

What appears in research papers is just the tip of the iceberg. A researcher's treasure lies in the vast number of experiments and numerous negative data that are behind published results. Prof. Ooi says that relying on efficacy and good ideas is correct in some ways, but he also believes that research results coming solely from them will not stand the test of time.

Prof. Ooi's experiment-filled life began in his fourth undergraduate year, when he was assigned to a research lab.

Support from mentors during his experiment-filled days

He remembers being "a lazy student." Prof. Hisashi Yamamoto (now Professor Emeritus at Nagoya University) and Prof. Maruoka taught him organic chemistry from scratch and mentored him all along. They played such a major role in his career that he says, "My meeting with them was the starting point for everything." When he was a fourth-year undergraduate, a paper he co-authored with them was published in the prestigious American Chemical Society's journal. It is a memorable paper for him, with his name appearing between his two mentors' names.



"Organoaluminum-Promoted Rearrangement of Epoxy Silyl Ethers to β-Siloxy Aldehydes" Keiji Maruoka, Takashi Ooi, and Hisashi Yamamoto; J. Am. Chem. Soc. 1989, 111, 6431-6432.

「少し極端に言えば、何か試してダメだったことにこそ、本当の価値があると思います。それぞれの研究の過程で積み重なった、目の見なかったアイデアの全てが、何かに繋がります。それが研究者の個性を作っていると思います」

論文として認められたデータは氷山の一角。それを支える膨大な実験の量、そして無数のネガティブデータの厚みこそが宝。効率やアイデアの良さと勝負というのも、「一面では正しいと思う」としつつ、「少なくとも、そうしたアプローチだけの成果は、時の批判に耐えないと思う」と大井さんは話す。

実験を積み重ねる毎日は、研究室に配属された大学4年生のときから始まっていた。大井さんは学生時代の自分を、「不真面目な学生だった」と振り返る。そんな自分にゼロから有機化学を教え、時には叱りつつも信じ続けてくれた恩師2人の存在は大きい。山本尚教授(肩書きは当時。現在、名古屋大学名誉教授)と丸岡啓二助教授(肩書きは当時。現在、京都大学薬学研究科特任教授)だ。「この出会いが何よりも、すべての出発点」と話す。特に丸岡先生とは、キャリアを積む中で多くの現場を共にした。北海道大学では助手、京都大学では助教授としてチャンスを得て、研究室の立ち上げのときも、新しい化学の開拓のときも一緒だった。丸岡先生はそんな大井さんを、もはや学生ではなく、一人の研究メンバーとして尊重してくれた。

「教授として丸岡先生が何を考えているのか、リアルに想像しながら仕事できたのは、幸せなことでした」

いざ、名古屋大学で自身の研究室を立ち上げる時、本当に何も無い状態でも特段焦りは感じなかった。与えてもらったチャンスに対して、やろうと思うことを自然とやる。そんな大井さんのもとに、浦口大輔助手(肩書きは当時。現在、北海道大学触媒科学研究所教授)はじ

め、学生も第一希望で5名も集まった。メンバーに恵まれたことも、何よりの追い風だった。

「新しいことを始めよう」。そうして手掛けたのが、有機イオン対の触媒化学。浦口さんの得意分野も存分に生かした成果の一つに、アミノホスホニウム塩がある。この触媒について、その特徴のごく一部を簡単に説明すると、プラスとマイナスが引き合う力や水素結合の力、触媒の立体構造を利用して、原料となる分子を捕捉、制御し、狙い通りの構造をもった生成物を選択的に化学合成できることだ。

この触媒は学生メンバーの力でさらに発展する。たとえばフェノールを組み合わせた有機イオン対触媒の研究では、担当していた学生の機転で行われたX線構造解析により、驚きの分子構造を明らかにすることができた。最初はアミノホスホニウム一つに対してフェノールが一つ付いた形を想像していた。その予想に反し、三つのフェノールが取り込まれてイオン対となっていたのだ。この構造によって触媒の新たな立体構造が生まれたのに加え、フェノールにClを付けるなど、様々な工夫を施すことが可能になった。偶然に大発見を見出した、まさにセレンディビティを体現した研究成果だった。

大井さんは新しいことへの挑戦に迷いが無い。たとえ勝算が見えなくても、本質にオリジナリティがあると思えば、メンバーと一緒に踏み出す。

「先に希望が見えているかどうかではなくて、やるかやらないかですよ。真っ暗でも、踏み出すことこそが、希望なんです」

多くの人に支えられ、チャンスをもたらしてきた。メンバーと一緒に積み重ねてきた実験の数々を土台に、「自分にしかできないこと」を自然と紡ぐ。

「論文を出したときに、著者名と所属機関を隠しても、『これたぶん大井研からじゃないの』と、世界の人に思ってもらえるような化学をこれからも発信しようと思っています」



Compounds, although made of the same material, can be made completely different if shaped differently, even only slightly. As an example, let us take a look at some steps of the experiment that the three researchers conducted in the process of producing results that led to the paper mentioned above. Do you notice in Fig. ① and ② the difference in the shape of the starting materials and in the shape and number of the resulting compounds?

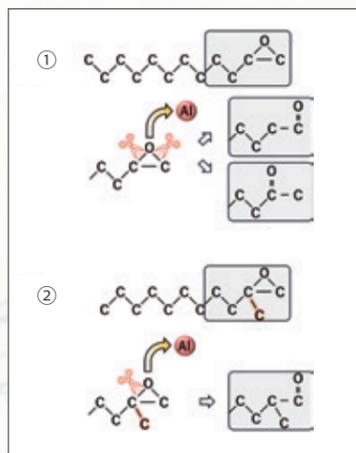


Illustration of a part of an epoxide ring-opening reaction (For clarity, the atomic symbols for hydrogen and the hydrogen atoms in the formyl group in the product are omitted.)

In both ① and ②, the starting material contains 12 carbon atoms (C), 24 hydrogen atoms (H), and one oxygen atom (O), but their configurations differ slightly. Aluminum (Al) in the catalyst coordinates with O. In ①, it is unclear which of the two carbon bonds will break, but in ②, only the bond on the left carbon is selectively broken.

エポキシド開環反応の一部を表したイメージ図(わかりやすさのため水素の元素記号は省略。生成物中ホルミル基の水素の元素記号も省略)。出発原料は、①、②どちらもC(炭素)が12個、H(水素)が24個、O(酸素)が1個だが、一部形が異なる。触媒中のAl(アルミニウム)がOに配位し、①では2つの炭素との結合のうちどちらが切れるかわからないが、②では左側の炭素との結合のみ選択的に切れる。

In the very early stage of the experiment, a jumble of many different compounds with seemingly similar yet essentially different structures came about. Then, suddenly one day, it became possible to selectively obtain just one compound. He did not immediately understand how this worked. He was simply surprised by the results and thought, "Something's different."

At first, Prof. Yamamoto advised a young Mr. Ooi to change his attitude. Prof. Maruoka often gave him an earful as they spent all their time in the lab. Gradually, however, he began to find experiments more interesting. Preparation for the graduate school entrance exam was the first time he studied seriously since entering university. His hard work to stay in the lab as a graduate student resulted in excellent grades. Prof. Maruoka was pleasantly surprised. Prof. Yamamoto also sensed the change in Mr. Ooi. When he was in his second year of graduate school, Prof. Yamamoto personally assigned him to tutoring some younger students. He still treasures the moment he was given this task.

"For Prof. Yamamoto, it may have been nothing special, but it made me very happy," says Prof. Ooi.

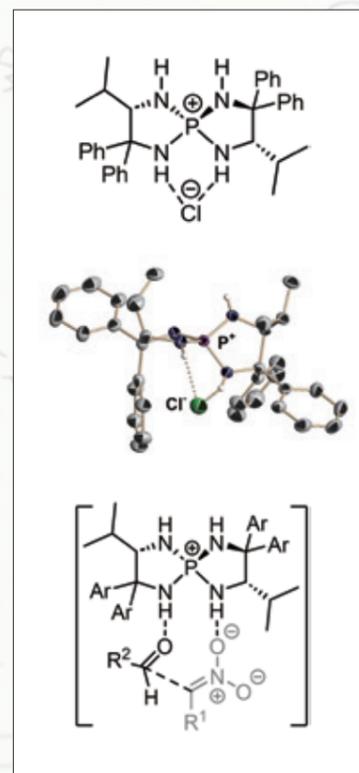
Capturing opportunities while working with lab members

Prof. Ooi continued to work on many research projects with Prof. Maruoka, who provided him with the opportunity to work as an assistant professor at Hokkaido University and an associate professor at Kyoto University. They also worked together in opening new laboratories and exploring new research topics of chemistry. By that time, Prof. Maruoka had come to treat his mentee as a fellow researcher.

"I was fortunate to be able to work while imagining what Prof. Maruoka was thinking in real-life situations as a scientist," says Prof. Ooi.

When Prof. Ooi opened his own laboratory at Nagoya University, he started with absolutely nothing but was at ease. His policy was to take advantage of the opportunity he was given and simply do what he wanted to do. He was joined by Dr. Daisuke Uruguchi (then assistant professor, now Professor at Hokkaido University Institute for Catalysis) and five students who chose the laboratory as their first choice. Having such good members was the best driving force for Prof. Ooi and the laboratory.

One day, Prof. Ooi decided to start "something new," and he began working on catalytic chemistry of organic ion pairs. One of the lab's research achievements, which fully utilized Prof. Uruguchi's area of expertise, was aminophosphonium salt. To briefly explain just a few of the characteristics of this catalyst, it uses the attractive forces between positive and negative charges, the power of hydrogen bonds, and the three-dimensional structure of the catalyst to capture and control starting-material molecules, realizing the selective chemical synthesis of products with a desired structure.



Prof. Ooi's lab notebook from that time in university student: The details of the experiment are recorded carefully on each page; the first neat synthesis of the compound is described on the page on the right in the photo.

大学生当時の実験ノート。一ページずつ実験の内容が丁寧に記録されている。写真中、見開きの右ページが、はじめて化合物がきれいに合成されたときの実験結果



(Top) A form of aminophosphonium salt, which takes on various shapes; positively charged catalyst molecule attracts negatively charged molecules and captures them at the site of hydrogen bonding. In this form, a Cl⁻ (chloride ion) is attached.

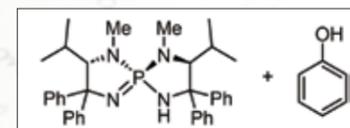
(Middle) A three-dimensional structure determined by X-ray structural analysis; it has a compact structure, but it wraps around and fixes the molecule.

(Bottom) An example of how a catalyst works; reaction is controlled where Cl⁻ was attached. For greater detail, refer to the paper below: Chiral Tetraaminophosphonium Salt-Mediated Asymmetric Direct Henry Reaction; Daisuke Uruguchi, Sawako Sakaki, and Takashi Ooi; J. Am. Chem. Soc. 2007, 129, 12392-12393.

(上) 様々な形をとるアミノホスホニウム塩の一形態。プラスのカでマイナスの電荷を帯びた分子を引き付け、水素結合の部位で分子を捕捉する。この形態ではCl⁻(塩化物イオン)が付いている。(中) X線構造解析で決定した立体構造。コンパクトな構造であっても、分子を包み込むように固定する。(下) 触媒が働くようすの例。Cl⁻が付いていた場所で合成を制御する。詳細は以下論文参照。

Chiral Tetraaminophosphonium Salt-Mediated Asymmetric Direct Henry Reaction; Daisuke Uruguchi, Sawako Sakaki, and Takashi Ooi; J. Am. Chem. Soc. 2007, 129, 12392-12393.

This catalyst was further developed thanks to great efforts by the lab's student. He explored the possibility of replacing the Cl⁻ site with another interesting molecule and, starting from scratch, chose phenol, which is readily available in a wide variety of commercial forms.

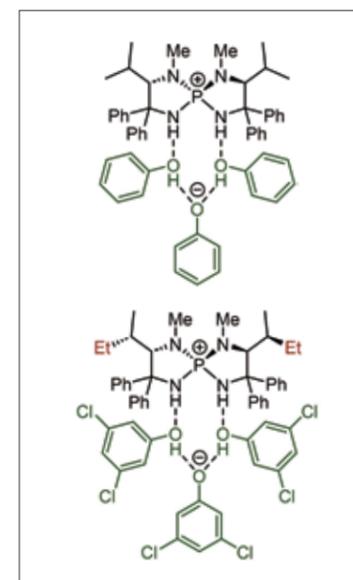


Iminophosphorane, the conjugate base of aminophosphonium and phenol

アミノホスホニウムの共役塩基であるイミノホスホランとフェノール

At first, they imagined a structure in which one aminophosphonium was attached to one phenol. The synthesis reaction went reasonably well. However, they were not able to explain why replacement with

phenol was necessary. Then one day, the student in charge of this experiment came up with the idea of trying X-ray structural analysis, which revealed a surprising molecular structure. It turned out that there was not just one phenol but two more in between. This gave birth to new three-dimensional structures and made it possible to add various other ingenuities, such as attaching Cl to the phenol.



(Top) Aminophosphonium with three phenol molecules attached

(Bottom) Rearrangements with substituents on aminophosphonium and phenol molecules enabling further improvement on catalyst

(上) アミノホスホニウムにフェノール分子が3つ付いた形をとっている。(下) アミノホスホニウムやフェノール分子の置換基を工夫することで、さらなる触媒の改良に成功した

The scientists often made a breakthrough by accident. It was serendipity in action. Their paper was published in Science, where the student's name appeared between the names of his two supervisors. The story of young Mr. Ooi was repeated.

Chiral Organic Ion Pair Catalysts Assembled Through a Hydrogen-Bonding Network

Daisuke Uruguchi, Yusuke Ueki, Takashi Ooi
Research to develop structurally diverse, chiral supramolecular catalysts for asymmetric organic transformations has met with limited success. Here, we report that a chiral tetraaminophosphonium cation, two phenols, and a phenoxide anion appear to self-assemble into a catalytically active supramolecular architecture through intermolecular hydrogen bonding. The structure of the resulting molecular assembly was determined in the solid state by means of x-ray diffraction analysis. Furthermore, in solution the complex generates a highly enantioselective catalytic activity of equal enantioselectivity to *trans*-unsaturated ester complexes with a broad substrate scope. All structural components of the catalyst independently participate in the stereoselective event.

Chiral Organic Ion Pair Catalysts Assembled Through a Hydrogen-Bonding Network; Daisuke Uruguchi, Yusuke Ueki, Takashi Ooi; Science. 2009, 326, 120-123.

Encounters with people and repeated experiments leading to new chemistry

When Prof. Ooi takes on a new challenge, there is no hesitation. Even if successful outcomes seem unlikely, he forges ahead with his teammates on a project, as long as it has inherent originality.

"It's not about whether there's hope ahead. It's about whether you do it or not. In the dark, taking a step forward brings about a ray of hope."

Prof. Ooi has been supported by many people and given opportunities. Building on the foundation of numerous experiments he has conducted with the lab members, he simply continues in pursuit of something unique that only he can do.

"I am hoping to do the kind of research in chemistry that makes people around the world think and say, 'Isn't this from Ooi's lab?' even if the findings are published without the authors' names or university name."



川口由紀

YUKIKAWAGUCHI



Professor, Condensed Matter Engineering Group, Department of Applied Physics, Graduate School of Engineering, Nagoya University

Prof. Kawaguchi conducts research in theoretical physics, focusing on topics such as ultracold atomic gases, topological magnetic structures, and superfluidity and superconductivity. In particular, she has received several awards for her theoretical research on ultracold atomic gases with internal degrees of freedom, including the Award for Science and Technology (Research Category), conferred by the Minister for Education, Culture, Sports, Science and Technology.

名古屋大学 大学院工学研究科 応用物理学専攻 量子物理工学 教授

冷却原子気体、トポロジカル磁気構造、超流動や超伝導といったキーワードのもと、理論物理学の研究を進める。中でも、内部自由度を持つ冷却原子気体の理論研究では、科学技術分野の文部科学大臣表彰をはじめとし、数多くの受賞歴を持つ。

Predicting new physical phenomena, theorizing unknown behavior in ultracold atomic gases

新たな物理現象を予言せよ！ 理論研究で挑む、極低温原子の未知のふるまい

Temperatures cannot fall below absolute zero, -273.15 degrees Celsius, a realm of complete stillness. As temperatures approach it, strange things occur that defy our everyday intuition. For example, helium is a light and stable gas commonly used in balloons: no matter how much pressure is applied, it will never become a liquid at room temperature. However, it becomes a liquid at -269 °C, and when cooled further by about two degrees Celsius, it exhibits new properties, such as the ability to “climb” the walls of the container and to pass through gaps only a

few atoms wide. These are manifestations of superfluidity—the ultimate free-flowing state with zero friction.

“I found this fascinating. It’s one of the reasons I chose this research area,” says Prof. Kawaguchi.

How do atoms behave at extremely low temperatures? Exploring this question is fascinating in itself, and demonstrating it experimentally is equally compelling. On the other hand, as an undergraduate, she often struggled with setting up

experiments and found it difficult to carry them far enough to analyze the underlying physics. “In those days, I was eager to enjoy the core mystery that physics had to offer,” says Prof. Kawaguchi. Her decision to pursue theoretical physics stemmed from the pleasure she found in deep reflection. Theoretical physicists, such as Albert Einstein, use established laws, working hypotheses, and experimental data to predict new phenomena and to explain experimental results beyond the scope of existing theories.

Attractive research in atomic gases at the crossroads of theory and experiment

Theoretical physics and experimental physics are inseparable. New theories guide the direction of subsequent experiments, whose results in turn lay the foundation for future theories. When Prof. Kawaguchi entered university, the development of techniques for trapping and cooling atoms made it possible to reach temperatures as low as one ten-millionth of a degree Celsius above absolute zero. This technological advance led to the experimental realization of a Bose-Einstein condensate (BEC), which had been theoretically predicted by Einstein in 1925 based on the quantum statistics formulated by Satyendra Nath Bose—some 70 years earlier.

To gain an intuitive understanding of BEC, let us take rubidium as an example. Rubidium is a solid at room temperature and produces vapor when heated to about 100 °C. Under ordinary cooling, gaseous rubidium first condenses into a liquid and then solidifies again. However, when the gas density is reduced to about one hundred-thousandth of that of air, the gas can remain in the gaseous phase even at temperatures very close to absolute zero. Such a low density is achieved by trapping atoms in a vacuum using magnetic fields, preventing them from sticking to the container walls. At extremely low temperatures, even more striking phenomena occur; one such phenomenon is Bose-Einstein condensation. Gaseous rubidium atoms move independently yet exhibit coherent behavior through quantum statistics. As the temperature decreases, these quantum correlations extend over long distances and become more pronounced. As a result, the atoms behave not only as particles but also as waves—one of the defining features of quantum physics. In BEC experiments, which are conducted in carefully controlled and isolated environments, it is possible to observe the quantum nature of atoms in a state close to their fundamental form.

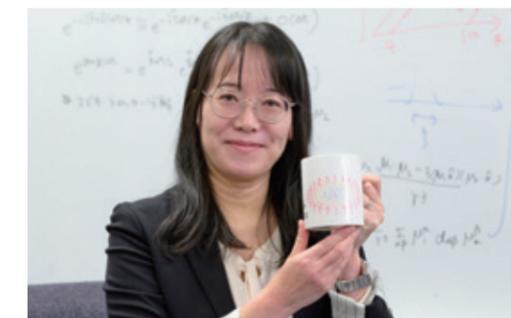
1915年、アルベルト・アインシュタインとワンダー・ド・ハースにより、両者の名をとったアインシュタイン＝ド・ハース効果という現象が発見された。磁気回転効果ともいい、現象はシンプル。鉄の棒にコイルを巻いて電磁石を作り、そのコイルの電流の向きを反転させて電磁石のS極N極をひっくり返すと、鉄の棒が回転し始めるというものだ。磁石の磁力方向の変化が回転運動の力に変換されることを示している。では、このアインシュタイン＝ド・ハース効果を、量子性の強い極低温の気体で実現したらどうなるだろうか？

この問いに対して理論を確立したのが、川口さんの2005年の論文⁽¹⁾である。研究の舞台は冷却原子気体を使った量子の世界。絶対零度、マイナス273.15°Cに程近い極低温で実現される、ボース＝アインシュタイン凝縮という現象がある。気体状態でバラバラのまま冷やされた原子一粒ひとつぶが好き勝手に動き回る。なのに、スカスカな空間で遠く離れた原子同士が、同じ原子という理由だけで波のように響き合い、エネルギーの低い場所を教えあう等のやり取りが、温度が低いほど遠くまで行われる。“粒であり、波である”という、“量子”の特徴が表れるのだ。「一つひとつの動きが全体としてはどのような面白い構造を作るのか。何が重要なのか以前に、個人的にとっても楽しいと感じるんですね」このときシミュレーションと数値計算に使用したのが、ステンレス鋼の含有物としても身近な元素・クロムだ。前提としてどの元素でも、原子一つひとつは小さな磁石としての性質を持っている。クロムは、それまで実験に使われてきた元素よりもその性質が強い。論文では、クロムの原子気体に同じ方向の磁場をかけておき、急にその磁場を切ったときに、原子それぞれと原子気体全体がどのように振る舞うかを精密に記述した。アインシュタイン＝ド・ハース効果と同じように回転の効果がかり、それが量子の世界では渦となる計算結果が示された。競争が激しかった理論研究を見事に駆け抜けて着地させた川口さんは、当時を振り返って次のように話す。「数値計算をするときに、起こっている物理現

象を想像しながら、必ずこうなるはずだと信じて進めていました。信念が無いと、続けられないんですよ。絶対に正しい方向に進んでいるはずだから頑張ろう、というふうに」

ここで確立した理論がもしも実験的に再現できるならば、その量子の渦の中心には特徴的な穴が確認されるはずだ。

「実は最近、実験でその穴が確認されました」



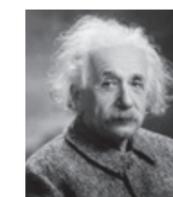
発表から約20年。川口さんの論文で示した理論予想が、なんと実験で示されたのだ⁽²⁾。決して簡単な実験ではない。クロム原子よりもさらに磁力の強いユウロピウム原子が使われたものの、気体全体での磁力は地磁気のわずか1万分の1。ただでさえ難しい原子気体の制御に加え、あらゆるパーツを磁性の無い樹脂で作成し、高い精度で外部環境の磁場を遮断する空間を作り出す必要があった。これには長い年月と大きな労力を要する。ここまでして実験を行う価値があると、川口さんの論文が認められた証拠でもあったのだ。

不思議なことが、いつか常識になる。その瞬間を目指して、川口さんの研究は続く。「原子気体の中での話にとどまらず、他の分野にも還元できるような新しい現象の予言をしてみたいですね。たとえば、普通の固体結晶では、熱の出入りや電流、あるいは光や電場・磁場を使った制御など、さまざまな要素が極めて複雑に影響しあっています。でも、原子気体の実験のように、これらの要素を精密に制御しながら、個々の仕組みがどのように働き、互いに作用するかを丁寧に調べていけば、まったく新しい現象をみいだせるんじゃないかなと思っています」



A droplet attached to the bottom of the container shows that superfluid helium has climbed up and out of the container. (Photo courtesy: Cryogenic Research Center, The University of Tokyo)

容器の外側底面に液滴が付いていることから、超流動ヘリウムが壁をよじ登り、容器の外に出たことがわかる。(画像提供: 東京大学低温科学研究センター)



(L) Satyendra Nath Bose (R) Albert Einstein
(左) サティエンドラ・ナート・ボース、(右) アルベルト・アインシュタイン

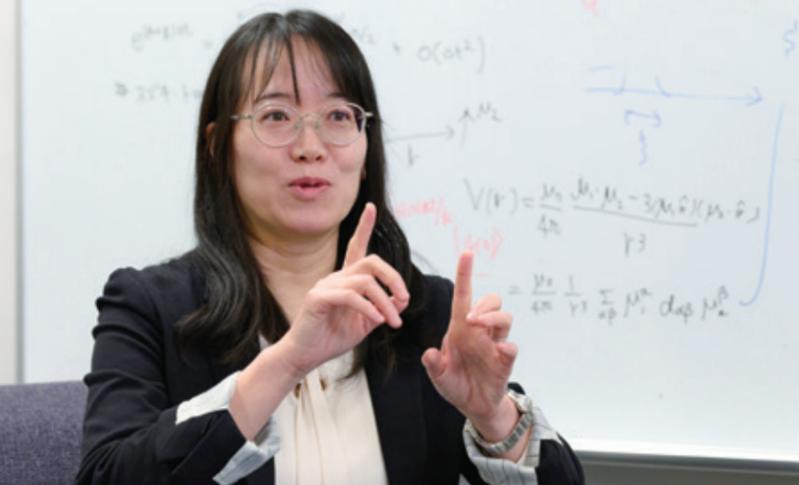


Illustration of atoms that exhibit both particle-like and wave-like behavior—moving independently while their wave nature enables synchronized motion.

“粒であり、波である”状態のイメージ図。“粒”の性質としてバラバラに動いているのに、“波”の性質として重なり合う

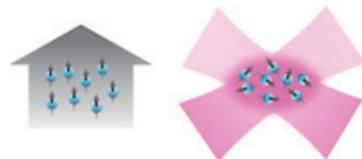
Prof. Kawaguchi says: “Atomic gases are amazing. One fascinating aspect is that they allow us to explore parameter regimes that are inaccessible in conventional experimental settings.”

Let us briefly turn to another area of research related to superconductivity. Generally, superconductivity requires a metal or compound to be maintained at an extremely low temperature. For example, in maglev trains, niobium-titanium alloy used as a superconductor must be cooled to -269°C to create powerful electromagnets that levitate the vehicles. If superconductivity could be realized at higher temperatures, much closer to those of daily human activity, it would have an enormous impact. High-temperature superconductivity has long been a scientific dream, yet it remains unrealized. This naturally raises a fundamental question: how high-temperature superconductivity can be realized under ideal conditions. An experiment using atomic gases demonstrated that a state analogous to superconductivity can emerge at relatively high temperatures by tuning interatomic interactions. In electronic systems, this would correspond to temperatures of around 1,000°C. Needless to say, such results do not directly lead to high-temperature superconductivity because real materials involve many additional constraints and complexities. Nevertheless, the experiment provides valuable insight into the fundamental physics and allows researchers to develop new theoretical frameworks, thereby guiding future experimental studies.

Prof. Kawaguchi: “Atomic gases contain no impurities. In a clean environment, they allow us to design experiments exactly as in theoretical models. It’s quite exciting when you can perfectly align experiments with theories.”

Tackling new theoretical challenges

In 2005, a paper was published reporting the successful creation of a BEC using chromium, an element previously considered difficult for BEC experiments. Chromium is a familiar element, commonly found in stainless steel. It possesses an unusually strong magnetic property—each atom behaves like a tiny magnet. This pronounced property made chromium particularly attractive for exploring new quantum phenomena. Meanwhile, a new method had been developed to capture gaseous atoms at extremely low temperatures. In earlier experiments, magnetic traps forced the tiny magnets of atoms to align in the same direction. The new optical trapping method uses laser beams to trap atoms, removing the constraint imposed by magnetic fields. Freed from magnetic constraints, the tiny magnets of chromium atoms can now orient themselves, governed by their intrinsic interactions. What new quantum phenomena could ultracold atoms reveal?



(L) Gaseous atoms captured by a magnetic trap: arrows indicate the direction of the tiny atomic magnets. (R) Atoms captured by an optical trap: lasers are shone from two directions, capturing atoms at their intersection. Free from magnetic constraints, the tiny atomic magnets can orient in any direction.

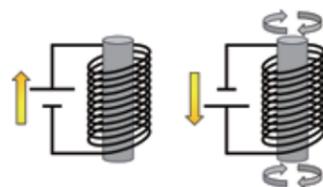
(左) 磁場で原子気体を捕獲しよう。矢印は原子のもつ微小磁石の向きを表す。(右) 光で原子を捕獲しよう。二方向からレーザーを照射し、交差する中心部で原子気体を捕獲する。光で捕獲した場合、原子は磁気的な自由度を持つことが可能

Prof. Kawaguchi: “What kinds of structures emerge from the collective motion of individual particles? I find that it’s great fun to ask such questions, regardless of their immediate scientific importance.”

While discussing these ideas with her colleagues, Prof. Kawaguchi began theoretically investigating the phenomena that might emerge when a chromium BEC was combined with optical trapping. She focused on the Einstein-de Haas effect, a gyromagnetic phenomenon first reported in 1915 by Einstein and Wander de Haas, which was demonstrated experimentally at the time, albeit only approximately. To put it simply, the effect can be understood by imagining an electromagnet made of an iron rod with a coil wound around it. When the direction of the electric current is reversed, the north and south poles of the electromagnet flip, causing the rod to rotate. This phenomenon shows that changes in the direction of iron’s tiny atomic magnets can be converted into mechanical rotation. Then, what would happen if the same principle were realized not in a solid piece of iron, but in a quantum gas composed of freely moving atoms?



Wander de Haas
ワンダー・ド・ハース



Einstein-de Haas effect illustrated: When the direction of current is reversed and the magnet’s north and south poles flip, the iron rod begins to rotate.

アインシュタイン=ド・ハース効果のイメージ図。電流の向きが変わり、電磁石のS極N極が入れ替わると、鉄心が自転するように回転する

When she revisited the role of magnetism in theoretical studies of atomic gases, she encountered unexpected obstacles, beyond the already complex mathematics, requiring approaches far more ingenious than originally anticipated.

Prof. Kawaguchi: “I carried out the calculation while mentally visualizing the

physical phenomena that must be occurring. Without this kind of conviction, it would have been impossible to continue. I encouraged myself, telling myself that I was definitely moving in the right direction.”

After about six months, Prof. Kawaguchi finally completed her theoretical calculations and simulations. Just then, she faced an unforeseen challenge. A paper presenting an idea similar to hers appeared as a preprint before undergoing formal peer review. Reading it, she realized that, although it pursued a similar idea, its content was less rigorously structured than hers. Yet, she knew that if she fell behind, her work might be seen as derivative—something she could not accept. She had only one week to complete her paper and establish the originality of her idea. After a whirlwind week, on November 2, 2005, she submitted her paper to *Physical Review Letters*, an American Physical Society journal. The paper, “Einstein-de Haas Effect in Dipolar Bose-Einstein Condensates (1),” was published on March 3, 2006, an unforgettable milestone in her research career.

In summary, her paper describes how individual chromium atoms behave collectively when a uniformly applied magnetic field is suddenly turned off. The mathematical analysis shows that the gas begins to circulate, representing the Einstein-de Haas effect, and that, as a consequence of its quantum nature, it forms a quantized vortex. The formation of such a vortex should be accompanied by a distinctive hole at its center.

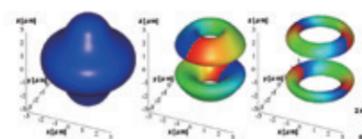
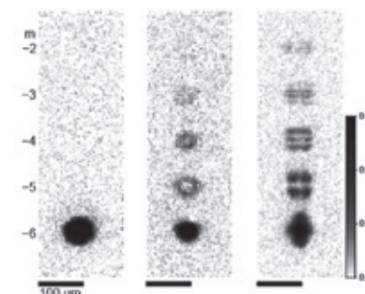


Fig. 1 (b)-(d) from Prof. Kawaguchi’s paper, “Einstein-de Haas Effect in Dipolar Bose-Einstein Condensates (1)” shows the atomic gas forming a vortex structure after a uniform magnetic field is turned off. The figure presents the density distribution of the gas separated by the direction of each atom’s tiny magnet, with holes appearing at the center in panels (C) and (R), revealing the presence of quantized vortices.

論文「Einstein-de Haas Effect in Dipolar Bose-Einstein Condensates」(1)よりFIG. 1 (b)-(d)を引用。磁場を切った後、原子気体が量子渦を形成する様子を表す。図は各原子の微小磁石の方向によって分離された原子気体の密度分布を示しており、(中)および(右)では中心部に穴が現れ、量子渦の存在が顕わになっている

“In fact, it has now been confirmed experimentally,” says Prof. Kawaguchi.

Almost 20 years after its publication, her prediction was experimentally demonstrated (2). The experiment was by no means easy to carry out. To enhance the magnetic effects, the researchers used europium atoms, which are more magnetic than chromium atoms. Even so, the magnetic field generated by the gas as a whole was only about one ten-thousandth as strong as the Earth’s magnetic field. The experiment required extraordinarily demanding measures, including constructing all components from non-magnetic materials and creating a space shielded with extreme precision from external magnetic fields—on top of the already formidable challenge of controlling an ultracold atomic gas. These efforts required years of work and enormous dedication, clear evidence that Prof. Kawaguchi’s paper was recognized as being worthy of such commitment.



Experimental results showing a europium quantum gas after being separated by the direction of each atom’s tiny magnet. The grayscale represents atomic density. Darker regions indicate higher densities, as shown by the bar on the right. Panel (L) shows the initial uniformly magnetized state. In panels (C) and (R), the three images at the bottom correspond to panels (L), (C), and (R) in the previous figure, arranged from bottom to top, with panels (C) and (R) showing the view from above and from the side, respectively. (Image courtesy: Dr. Hiroki Matsui, Assistant Professor, Institute of Science Tokyo. Explanation of this figure is provided in the Institute of Science Tokyo press release (3) and Fig. 1 of the paper “Observation of the Einstein-de Haas effect in a Bose-Einstein condensate (2).”)

ユウロピニウムの原子気体を、各原子がもつ微小磁石の方向によって分類した様子。暗いほど原子密度が高いことを表す。(左)の図は磁場を均一にかけている初期状態。(中)と(右)の図はそれぞれ上から見た図、横から見た図で、輪切り映像となっている。それぞれ前掲した図(Fig. 1 (b)-(d)(1))の(左)、(中)、(右)と対応している。(画像提供: 松井宏樹特任助教(東京科学大学)。東京科学大学プレスリリース(3)および、論文「Observation of the Einstein-de Haas effect in a Bose-Einstein condensate」(2)の図1と同図の説明がある)

- (1) Einstein-de Haas Effect in Dipolar Bose-Einstein Condensates; Yuki Kawaguchi, Hiroki Saito, and Masahito Ueda; *Physical Review Letters*. 2006, 96, 080405
- (2) Observation of the Einstein-de Haas effect in a Bose-Einstein condensate; Hiroki Matsui, Yuki Miyazawa, Ryoto Goto, Chihiro Nakano, Yuki Kawaguchi, Masahito Ueda, Mikio Kozuma; *Science*. 2026, 391, 384-388.
- (3) “Atomic spins set quantum fluid in motion” (Institute of SCIENCE TOKYO; <https://www.isct.ac.jp/en/news/y4riu9qihv5b>)

Working toward predictions beyond the realm of atomic gases

What abilities are required of theoretical physicists?

Prof. Kawaguchi says: “I believe researchers must be able to visualize the physical phenomena they are concerned with, especially in three dimensions. Mathematical formulas alone are merely symbols and lines of code. One must be careful not to lose sight of the underlying physics. If you can explain what is really happening—and why—behind the mathematical expressions, then you can be confident with your results.”

Prof. Kawaguchi continues her research, hoping to turn what is now considered mysterious into established understanding.

“I would like to make predictions beyond atomic gases that can contribute to other fields as well. For example, in ordinary solid crystals, electrons and atoms are affected by various factors such as heat transport, electric currents, and control by light, electric fields, or magnetic fields in extremely complex ways. However, I believe that by carefully investigating how individual mechanisms operate and work together—through experiments in which these factors can be controlled as precisely as we do with atomic gases—we may uncover entirely new phenomena.”



松尾陽

Yoh MATSUO


**Professor, Graduate School of Law/
Director, Research and Education Center for Japanese Law, Nagoya University**

Prof. Matsuo specializes in philosophy of law, but his range of activity is much broader than legal research. He serves as a member of the Ministry of Economy, Trade and Industry's Study Group on a New Governance Models in Society 5.0 and the Study Group on Ethical Guidelines for Autonomous Vehicles of the Science Council of Japan; is an active communicator, writing a regular column for the Asahi Shimbun titled "Kempo Kihyo (Seasonal Reviews of the Constitution)"; and is an author/editor of several publications, including *Akitekuchâ to Hô (Architecture and Law)* (Kobundo, 2017).

名古屋大学 大学院法学研究科/日本法教育研究センター 教授

法哲学を専門としつつ、経済産業省「Society5.0における新たなガバナンスモデル検討会」の委員や「自動運転倫理ガイドライン研究会」のメンバー他、幅広い研究対象をもつ。主な編著書に、『アーキテクチャと法』(弘文堂)がある。朝日新聞コラム「憲法季評」に連載を持つなど、積極的な発信活動も行っている。

Law studied through multiple perspectives beyond law

法だけでは、法は見えない—研究テーマの幅広さで法哲学を深める

What is law? How should law be? Great thinkers around the world have asked these questions, from Socrates, Plato, and Aristotle in ancient times to Kant, John Rawls, and others in modern times. Based on such knowledge in philosophy and legal theories accumulated throughout history, The endless pursuit of philosophy of law continues while taking into account changes in society.

There is a research method that involves proposing new interpretations of great works of the past. This is still mainstream today, but Prof. Matsuo sought out a

different approach. When examining what law is, wouldn't it be necessary to identify conditions for good functioning of law in the first place? Isn't there something important outside the realm of law that could be applied to understand what has not been fully grasped in legal studies to date? One of the things Prof. Matsuo arrived at after exploring these questions is "architecture," one of his current research themes. This term originally denoted buildings and constructing buildings, but is now used in a broader sense, referring to such things as physical

technology in general, the framework or structure of something intangible, and even computer software.

How an architecture surreptitiously guides and controls human behavior

"Do you know what a piano staircase is?" asks Prof. Matsuo, citing it as one of his favorite examples of "architecture." It is a staircase that is structured like a piano keyboard, and you can play the notes "Do, Re, Mi..." by walking on the steps one by

one. People who would normally use the escalator next to it are enticed to walk up the stairs to make the sounds, out of curiosity. Believed to be effective in town revitalization and physical health promotion, the installation has become popular in many parts of the world. In Japan, piano staircases are found at train stations in Gifu and Fukuoka. It started as part of the Fun Theory project, led by the automaker Volkswagen. The piano staircase installed in 2009 at Odenplan Station in Stockholm, Sweden, resulted in a 66% increase in the number of people who chose the stairs over the escalator as compared to the days before the installation.

There is no need to post a signboard encouraging people to use the stairs for their health. Nevertheless, people are naturally drawn to try the piano staircase for fun. In some cases, what amounts to "architecture" can be expressed as "design" or "suggestion." Frequent users of the social media X find it relatively easy to compose a message within the limit of 280 characters, and those accustomed to barcode-based payment do not mind going out without carrying cash. These are also examples of architecture, which guides and controls people's behavior without their becoming aware of it.



At Odenplan Station, clearly more people were seen walking up the piano staircase, as compared to when there was no piano staircase.

* Images taken from the video titled "The Volkswagen Fun Theory 1 - Piano Staircase Initiative Drive" of the YouTube channel Ingram Volkswagen Ayr at 01:23 (upper image) and 00:03 (lower image)
<https://www.youtube.com/watch?v=QU8Rms94C5c>.

オーデンプラン駅に設置されたピアノ階段のようす(上写真)。設置されていないとき(下写真)と比べ、人々が階段の方へ誘導されている様子が一目瞭然(引用源: YouTube「The Volkswagen Fun Theory 1 - Piano Staircase Initiative Drive Ingram Volkswagen」(<https://www.youtube.com/watch?v=QU8Rms94C5c>); YouTubeチャンネル名「Ingram Volkswagen Ayr」;上写真は動画内01:23、下写真は動画内00:03のタイミングのものを用)

そもそも法が機能するための条件とは何だろうか。これまでの法が捉えきれていない非法的なところに大切なものはないか。

この問いから始まった松尾さんの研究対象は幅広い。一例として、経済産業省「Society5.0における新たなガバナンスモデル検討会」の委員や「自動運転倫理ガイドライン研究会」のメンバーとしてガバナンスの研究を行い、さらには日本法教育研究センター長としてアジア各国への法整備支援まで手掛けてきた。

こうした中、松尾さんの研究対象として中核をなすものに「アーキテクチャ」がある。本来は「建築」や「建築物」を意味する言葉だが、現在では広い意味で使われるようになり、物理的な技術一般、物事を構成する枠組みや構造一般、さらにはコンピューターソフトウェアを指すこともある。「デザイン」や、「暗示」と表現されることもあり、アーキテクチャは人々の行動を無意識に誘導・制御する。たとえばSNSのXをよく利用する人は140字の字数制限内で可能な文章表現を容易に思い浮かべ、バーコード決済を当たり前にする人は現金を持ち歩かないことに不安を感じない。

松尾さんがアーキテクチャの研究に興味をもったきっかけの一つは、1999年に公開された書籍、『Code: And Other Laws Of Cyberspace』⁽¹⁾にある。憲法学者およびインターネット法学者のローレンス・レッシングが著したもので、インターネットが急激に発達、普及した1990年代の議論を反映している。松尾さんの編著書、『アーキテクチャと法』⁽²⁾を参照しながら、当時の議論の一端を見てみよう。「インターネットをめぐる言説では、国家による規制が及ばないインターネット『空間』においては真に自由な社会が広がるのだというユートピア思想があふれていた(p.5)」という。「インターネット空間のアーキテクチャは、様々な行為を可能にしてくれる新技術として捉えられたのである(p.6)」。インターネットには変更不可能な自由さがあり、国境すらも超え、国家を超えた存在であるという考え方すらあった。こうした論説を批判する形で登場したのが、ローレンス・レッシングの著書だった。一見、自由で取り締まりが不可能に思われたインターネット空間も、結局はプログラムコードの書き換えによって規制可能な空間であった。その上で、「そのコードを利用して大企業が自己に有利な規制を形成しつつあり、そのコードが既存の法に取って代わる危険がある(p.7)」と主張したのだ。

「こうしてアーキテクチャは、様々な行動を

可能にしてくれる技術というよりも、行動の制約を促進する技術として捉えられる。インターネットがその本性上自由な空間であるとはできないことが『コード』で示されたのである(p.7;ここでの『コード』は、ローレンス・レッシングの著書『Code: And Other Laws Of Cyberspace』を指す)。

また、このとき松尾さんはインターネットにのみ関心があったわけではなく、アーキテクチャ全般に興味を広げていくことになった。



「レッシングは、インターネットのプログラムコード以外にも市場や社会規範、アーキテクチャといったものの動きを見たらうで、あくまでワンオペゼムとして法規制を見るべきだという言い方をしました。ここに私はものすごく惹かれて出発しました」

今やインターネットは私たちの生活に深く根差したアーキテクチャであり、多くの場面でインターネットの存在を無意識的に前提とした生活が営まれている。便利である一方、どのように規制していくのか、法との関係性はどうかといった検討がここから始まった。

現在、私たちは目まぐるしい速度で発展する技術と、その社会実装の流れの中で生活している。ここで生まれるアーキテクチャと、それによる新しい考え方、行動のすべてを法規制だけで制御することはもはや不可能だ。法、市場、社会規範、そしてアーキテクチャのそれぞれと、その関係性を包括的に扱ってこそ、より良い規制の在り方が見えてくる。

法自体の研究に加え、法が見据える社会全般の行く末を見通す松尾さんの試みが続く。

「人と社会への興味が根底にあります。究極的には、人と社会をいろいろな角度からずっと見ていく。自分としてはこれを貫いていますね」



Why does a legal philosophy researcher study architecture?

One trigger for Prof. Matsuo's interest in architecture was the book *Code: And Other Laws of Cyberspace*,⁽¹⁾ published in 1999 and written by Lawrence Lessig, a researcher in constitutional and Internet law. The book reflects well the debates in the 1990s concerning the Internet, when it was rapidly developing and spreading. Let us look back on some aspects of those debates by referring to *Architecture and Law*⁽²⁾, co-authored and edited by Prof. Matsuo. "At that time, the discourse surrounding the Internet was full of utopian ideas echoing the belief that a truly free society would emerge in cyberspace, unbound by state control" (p. 5), "The architecture of cyberspace was viewed as a new technology that would enable a variety of actions" (p. 6), and there were those who believed that the Internet had unalterable freedom as an entity transcending national borders and nation-states. Lessig's book appeared as a critical opposition to these ideas. He argued that the Internet, a seemingly free space impossible to be policed, was, at the end of the day, a space that can be regulated simply through the rewriting of program codes. The author further stated that, "major corporations were already using codes to establish regulations advantageous to them, and there was a danger that these codes might replace the existing laws" (p. 7).

"Thus, architecture was now viewed as a technology that facilitates constraints on behavior, rather than one that enables a variety of behaviors. Lessig demonstrated in his book that the Internet cannot be a free space for what it inherently is" (p. 7).

Today, the Internet is an architecture deeply rooted in our lives, and we pursue many of our daily activities, taking the existence of the Internet for granted. While the Internet is convenient, it poses many questions with regard to regulation and how it should be understood in legal terms, thereby setting in motion deeper reflection.

At that time, Prof. Matsuo was not interested in the Internet alone and broadened his focus to architecture in general.

"Lessig said that we should study law as one of many things, paying close attention to the movements of markets, social norms, and architecture, in addition to the Internet program code. This impressed me deeply and became a new starting point for me."

Today, we live in a world where new technology is developing and being applied in society at a dizzying pace. It is no longer possible to control architectures that emerge in such a world and new ways of thinking and behavior resulting there from solely through legal systems. Only by comprehensively addressing law, markets, social norms, and architecture, individually and as a whole, can we find better ways of regulating them. In this context, *Architecture and Law* examines how architecture interacts with law, which is another interesting point of this book. It poses some intriguing questions: Are there cases in which architecture replaces law (question of substitutability)? What kind of architecture is desirable (question of legitimacy)? Who builds architecture and how (question of orthodoxy)? Since it is impossible to cover the whole book

here, the best thing to do is to read it for yourself!

(1): *Code: And Other Laws Of Cyberspace* by Lawrence Lessig, (Basic Books, 1999)
(2): *Architecture and Law* (Kobundo, 2017) by Tatsuhiro Inatani et al. / Yoh Matsuo (ed.)

Governance: regulation as designed within organizations and society

"I think 'governance' will be a major keyword from now on," says Prof. Matsuo.

Legal regulations are designed on the assumption that negative situations are more likely to occur than not. This does not mean that lawmakers cut corners, but because laws designed to be too restrictive can deprive people of their freedom. As freedom is thus secured, various architectures come into being every day. To ensure that they function effectively in society in such a way as to contribute to people's happiness, it is important to exercise governance, that is, voluntary control and management within organizations such as private companies.

The risks of new technologies are not always easily detected and addressed. For example, self-driving cars are currently being actively developed and put to trial use. However, even if they are called self-driving, literally fully autonomous cars, which function flawlessly on public roads with no human intervention, have not yet been realized. There are still various obstacles to be overcome, including not only technical issues but also the development of roads and traffic signs and the formulation of rules in anticipation of accidents. In sum, there is still a long way to go. For engineers working in the field, the idea of fully autonomous cars being put to practical use and becoming an architecture taken for granted may seem like a dream to be realized in the distant future. On the other hand, PR personnel working for automakers may be tempted to present self-driving cars as realistically usable as possible in order to win gradual societal acceptance and secure funding for ongoing development. Such an attitude may be natural in a way. Indeed, autonomous cars in promotional videos move so smoothly and attractively that it seems as though they do not require human intervention or attention at all. However, the intense conflict between engineers, PR personnel, and company management could one day tip the balance and lead to serious accidents. Prof. Matsuo, who is a member of the Study Group on Ethical Guidelines for

Autonomous Vehicles⁽³⁾, has had the opportunity to meet in person engineers directly involved in the development of self-driving cars. Talking with them, he felt a strong need to improve the decision-making processes at car manufacturers and in other related organizations.

Prof. Matsuo also points out the need to focus on governance from a broader perspective, not just within the organizational framework. This is because, in the process of a new architecture being adopted in society, society itself influences how it is adopted and operated. To take the example of self-driving cars once again, while it is naturally necessary to improve their safety, their earliest possible adoption may be equally important in some areas in Japan marked with a declining and aging population and desperate for new means of transportation in their underserved zones. Moreover, in the future, carmakers will probably want to export their vehicles. This would normally require the cars to be designed to conform to local regulations. Then, a question would emerge as to whether transnational regulations would satisfy domestic needs in Japan. In this way, it will be important to examine governance from broad and varied perspectives that go beyond the scope of a single company or organization.

(3): Study Group on Ethical Guidelines for Autonomous Vehicles (representative: Takashi HIKASA, Associate Professor, School of Management and Information Sciences, Tama University; established in September 2021)



Asian legal issues for the future of Japanese law

Prof. Matsuo currently serves as Director of the Research and Education Center for Japanese Law (CJL). The Center has opened bases at universities in Asian

countries such as Uzbekistan, Mongolia, Vietnam, and Cambodia, as part of the Center's initiative to support the development of local legal systems. One of its distinctive activities is an educational program conducted in respective countries. The participating students study not only local law but also Japanese language and law. The program is complex and strenuous, and many of the students who successfully complete it in four to five years go on to graduate school in Japan. In another activity, the center also studies cases in which the application of current laws hindered court proceedings in each country, with an eye to making concrete improvements in the local legal systems.

There is an important concept in international assistance for legal system development: supporting through accompanying assisted parties, rather than simply teaching as if to "enlighten" recipients from top down.

Prof. Matsuo says: "We are not forcing Japanese values on them. In the past, we in Japan struggled to adapt the laws we had imported from the West to our domestic situations. We share our past experience with our Asian partners as well."

The Center's efforts to support legal reform in other Asian countries also has great significance for improvement of Japanese laws.

"Even if we can point to positive results from abstract laws and policy measures, there are usually hidden third elements. To see them, we need to look closely at local situations in many countries."

For example, in Germany, labor unions are industry-specific in that they are formed by employees of multiple companies of the same industry, whereas in Japan, labor unions are company-specific in that employees of the same company often form a labor union. In Germany, it is easier for a labor union as a whole to assert its position without being influenced by a single company's circumstances. On the other hand, in Japan, labor unions are more likely to be influenced by their companies' situations. To check on the good functioning of labor unions, it is impossible to really know without examining situations on the ground other than the legal system. As this example shows, simply looking at one's own country does not necessarily lead to the construction of a robust mechanism. Moreover, Japan being an

Asian country, its culture has been largely shaped by the geography and history of the region. Therefore, addressing legal issues in other Asian countries can be a valuable learning tool.



Prof. Matsuo also says that it is very important for Japan's future to help train professionals in other Asian countries who are well versed in local and Japanese laws. This is obvious with regard to immigration. While there is room for debate concerning specific future policies, given Japan's declining birthrate and aging population, it is possible that the country will opt to accept more immigrants. Then, lawyers familiar with Japanese and concerned foreign cultures will definitely become necessary to handle legal issues that may arise from cross-cultural contact and conflict, bound to occur in a multicultural society.

Prof. Matsuo says: "Asian law is outside my original specialization. When the post of Director was proposed to me, I thought it'd be extremely challenging. But I accepted it in the end because I share these motivations."

Consistency in wide-ranging research themes

— What conditions would be required for good functioning of law? Isn't there something important outside the realm of law that has not been fully grasped in legal studies to date? Starting with these questions, Prof. Matsuo's research has evolved to cover wide-ranging themes. In addition to legal research, he continues to look into the future of society as a whole as revealed through legal affairs.

"Fundamentally, I am interested in people and society. I hope to continue examining people and society from various angles. I have always done so, and I think I will continue to the end."

Interviews with IAR faculty members

The Institute for Advanced Research serves as the center of Nagoya University's intellectual life through promoting scholarship, supporting outstanding research, nurturing the next generation of researchers, and coordinating international research exchange. The Institute also functions as an academic hub that is open to the rest of Nagoya University and beyond. This role is notably fulfilled through planning and implementing various initiatives, including the organization of the Nagoya University Lecture, considered as the university's most important academic lecture series, and the IAR Symposium, a forum designed to create a highly transparent research environment by presenting cutting-edge research conducted at Nagoya University. Essential to these activities are the Institute's faculty members who, in addition to their advanced research, conduct administrative and operational tasks for the Institute's major activities. We spoke with four of them.



Satomi KANNO, Ph.D.

Full-time IAR faculty member (in charge of Life Sciences)/Associate Professor
Area of specialization: Plant physiology



Tsutomu FUKUDA, Ph.D.

Full-time IAR faculty member (in charge of Science and Engineering)/Specially Appointed Senior Lecturer
Area of specialization: Elementary particle physics



Masumi KAMEDA, Ph.D.

Full-time IAR faculty member (in charge of Humanities and Social Sciences)/ Associate Professor
Area of specialization: History of emotion



Yukinori KAWAE, Ph.D.

Professor, Center for Digital Humanities and Social Sciences
Area of specialization: Egyptian archaeology

IAR Information

Satomi KANNO

Full-time IAR faculty member (in charge of Life Sciences)/Associate Professor
Area of specialization: Plant physiology

Dr. Kanno is conducting research using uniquely developed imaging equipment targeting plant cells to whole plant, all for the objective of elucidating the mechanisms of nutrient absorption in plants. She has successfully analyzed nutrient absorption dynamics in live plants by developing a method to insert isotopes of nutrient elements into plants and image the beta rays emitted from them as visible light. This technology is expected to unlock unresolved mysteries of plant physiology and lead to practical applications such as efficiency increase in fertilizer utilization. Dr. Kanno is actively involved in interdisciplinary research, wherein she compares different proteins that absorb phosphate in various organisms such as bacteria and archaea, thus studying their coevolution with the environment.



Could you give us a general idea of how full-time IAR faculty members engage in administrative tasks?

All full-time faculty members at the Institute have their respective area of specialization, be it in humanities and social sciences, science and engineering, or life sciences. To organize lectures within the framework of a major academic event, such as the Nagoya University Lecture or the IAR Symposium, full-time IAR faculty members draw on their knowledge and expertise to select speakers and work out details of the event. Each year, the full-time faculty members take turns in organizing events in their respective fields. I am in charge of events related to life sciences. In the 2023 Nagoya University Lecture, we had the honor of inviting Prof. Aaron Ciechanover, laureate of the 2004 Nobel Prize in chemistry, who delivered a lecture on medicine in the new era.



Could you tell us what you do concretely as part of your administrative duties?

One of my main duties is running a joint research program with the University of Freiburg in Germany to nurture young researchers. The two universities each select two of their young researchers and send them to the other university for one month. We cover their travel and living expenses. What is unique about this program is that a one-month stay is repeated the next

year with the same researchers, one month in Year 1 and another month in Year 2.

That's unique indeed, supporting the same researchers' overseas stay for two consecutive years. Tell us more about this program's virtues.

In this program arranged like this, even if the participant researchers stay at the partner university only for a relatively short period, when they know that they will return the next year, they usually maintain ties with their colleagues at the host university over an extended period, ideally leading to future joint research efforts. Also, from my own experience, I think it's very important for young researchers to see firsthand as many sites of actual research and experiments as possible. There is a world of difference between reading other researchers' papers while knowing what goes on behind the scenes and reading them without that kind of knowledge. So I believe it's highly significant that young researchers have this kind of experience, which trains them in their sensibility and discernment as well.

What about your other responsibilities?

I have diverse responsibilities, but overall, for some reason, I have frequently been involved in launching new programs. The FRIAS (Freiburg Institute for Advanced Studies)-Nagoya Joint Fellowship Program, which I just talked about is one of them. I also launched the New Year IAR networking event last year to promote interaction among young researchers. This is intended as a forum where young researchers, who don't usually have many opportunities to meet other researchers in different areas, get together at the beginning of the new year. We also operate a kids' room as a way to support parenting by young researchers. They can come to work on the campus with their children and look after and stay close to them. I'm also a parenting researcher, and so I understand the value of initiatives like the kids' room. I think it's very important to have frequent and casual conversations with different people to generate ideas to improve the workplace environment.



(Interview conducted by Haruka Kamiguchi and compiled by Tatsuro Ayatsuka)

Satomi KANNO

IAR Information

Tsutomu FUKUDA

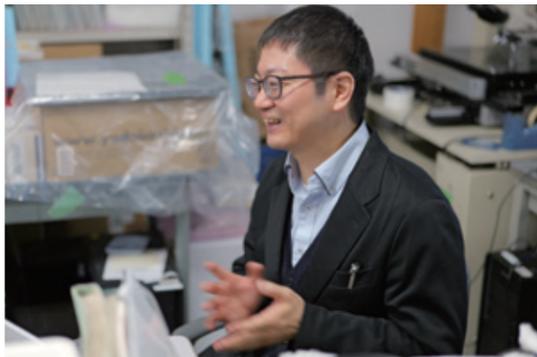
Full-time IAR faculty member (in charge of Science and Engineering)/ Specially Appointed Senior Lecturer
Area of specialization: Elementary particle physics

Dr. Fukuda researches the elementary particle neutrino and the origin of the universe, making full use of nuclear emulsion plates that record charged particles with the world's highest precision of less than one micron. He is the representative of the international joint research project Neutrino Interaction Research with Nuclear Emulsion and J-PARC Accelerator, nicknamed "NINJA," aiming at the discovery of new neutrinos and unknown neutrino interactions. In this project, an artificial neutrino beam is generated at J-PARC, a high-intensity proton accelerator facility located in Tokai Village, Ibaraki Prefecture, and used to irradiate specialized detectors based on nuclear emulsion and water target for high-precision measurement in an attempt to uncover mysteries surrounding the neutrino.



Could you tell us about your administrative responsibilities at the Institute?

First of all, I am in charge of running the lecture series called "Appreciate the Fun of Research," aimed at first- and second-year undergraduates, and the Nagoya University Lecture, which is considered the most important academic lecture series at Nagoya University. I handle YLC program faculty open call, organizing information meetings, checking recruitment guidelines, and registering applicants. I have handled international exchange events such as the UBIAS Working Group Meeting and a lecture by Prof. Oron Catts, Director of the Institute of Advanced Studies at the University of Western Australia. I also look after IT-related matters, including the management of the Institute's official website and email servers and IP addresses.



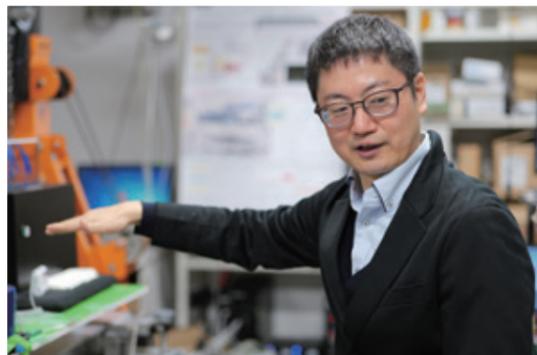
Tell us more about the Institute's unique lecture series "Appreciate the Fun of Research."

One of the Institute's missions is, "As an academy within the University, the Institute introducing excellent research to

members of the University" to promote scholarship. We are doing just that through the "Appreciate the Fun of Research" lectures. This is designed for first- and second-year undergraduates who are still new to university life. Each year, we invite about 15 researchers who represent Nagoya University with their outstanding research achievements in a wide variety of fields as lecturers. The purpose of the lecture is to introduce students to the appeal of scholarship and help them discover the fun of research, which is different from the kind of "study" they experienced up until high school. In organizing this lecture series, I have selected lecturers and provided support on the day of the lecture to ensure its smooth running.

What is impressive about this lecture series is the lineup of speakers. So far, President Naoshi Sugiyama and prominent researchers from Nagoya University, and distinguished researchers from outside the University with close ties with the university, have served as lecturers, including Dr. Sumio Iijima, famous for his discovery of carbon nanotubes. Tell us about the challenges and rewards involved in organizing this lecture.

To be sure, it is not easy to select lecturers and coordinate lectures, but personally, I don't regard my tasks negatively, and I actually enjoy them. I have the experience of serving as the representative or section leader of international joint research projects, leading groups of varying sizes from 50 to several hundred members. Perhaps the coordinating and communication skills that I cultivated through those projects are now proving useful. Most of all, I really appreciate the opportunity to speak directly with renowned researchers who are otherwise normally difficult to invite. I also find the contents of the lectures edifying. I'd be pleased if the students were inspired by the lectures so that they spend their university life with high aspirations. I hope that this exceptionally rich and valuable lecture series will continue to attract many students.



(Interview conducted by Haruka Kamiguchi and compiled by Tatsuro Ayatsuka)

IAR Information

Masumi KAMEDA

Full-time IAR faculty member (in charge of Humanities and Social Sciences)/ Associate Professor
Area of specialization: History of emotion

Dr. Kameda researches the influence of propaganda on the formation of people's sense of belonging to a nation. This research interest was inspired by her two-year stay in Croatia, where she met and talked with local residents who had undergone change of nationality multiple times during the region's turbulent years. In her research, she has unraveled how propaganda penetrates deep into people's emotions. Currently, she is studying the process by which people's emotions are shaped by advertising and cultural industry by comparing the United States and the Soviet Union. Her representative publications (in Japanese) include *Iconography of Nation Building: Propaganda of the Five-Year Plans in the Soviet Union and Yugoslavia* (Tokyo: Seibunsha, 2014) and *A Cultural History of Mass Empathy: Emotion and Politics in the 1930s in the U.S. and the Soviet* (Tokyo: University of Tokyo Press, 2023).



Since you assumed your post at the Institute in September 2025, you have already handled many important projects. Could you tell us what you are working on at the moment?

My main focus is managing international academic exchange. One project of international collaboration that is attracting attention from the whole of Nagoya University is the University Based Institute for Advanced Study (UBIAS). It is a network of more than 40 advanced research institutes all over the world. It is a great privilege for me to be able to interact, through this project, with researchers from different parts of the world who are active at the forefront of their respective fields. Incidentally, many researchers affiliated with the UBIAS are in humanities and social sciences. So perhaps for this reason, I find it relatively easy to work in this environment while drawing on my expertise. As a UBIAS activity, we have a Directors' Meeting every two years, which gathers together the representatives of all member universities. In early November 2025, the University of Ghana hosted the meeting, which I attended along with Prof. Sakakibara, the Institute's Director, and Prof. Kawae.

Was there anything particularly impressive about the Directors' Meeting at the University of Ghana?

Before attending, I had imagined it to be a meeting where the heads of the member universities meet and make formal agreements, as the name suggested. In reality, I was surprised to find that it was carefully programmed and organized like an academic conference. We covered a wide range of topics, many serious ones we discussed in depth, including AI utilization and the relationship between academic research and the State and politics. Moreover, all the attendees had a positive critical spirit, and so the discussions became quite heated at times. It was incredibly passionate. I was impressed by the democratic atmosphere where everyone was able to freely voice their

opinion. For example, even on the seemingly simple topic of the use of English as the official language of international meetings, our discussion developed into various directions, touching on the past colonial rule in some countries, the difficulty experienced in the meeting organization and participation by those from non-English-speaking countries, and so on. Overall, the hospitality of the people at the University of Ghana was also impressive. I was able to enjoy Ghanaian culture through local tours and dance parties. It was a valuable opportunity to go and observe in person how the UBIAS was run by those people.



Could you tell us how you personally view your responsibilities at the Institute?

My dream is to be someone who is called a "thinker," someone whose opinions on society and the world matter, beyond the arena of her area of research. For this, it is not enough to just read the news; I believe there are many things I can truly understand only by becoming involved as a stakeholder myself. My responsibilities at the Institute positively impact me and my research. I hope to learn more about contemporary society from a broader perspective.



(Interview conducted by Haruka Kamiguchi and compiled by Tatsuro Ayatsuka)

IAR Information

Yukinori KAWAE

Professor, Center for Digital Humanities and Social Sciences
Area of specialization: Egyptian archaeology

Dr. Kawae was a full-time IAR faculty member from October 2018 to December 2024. Since January 2025, he has been a Professor at the Center for Digital Humanities and Social Sciences, in addition to his part-time IAR role. As an Egyptologist, he has conducted research that includes excavations in the Pyramid Town in Giza, Egypt, and structural analysis of the three great pyramids of Giza. He realized three-dimensional measurement of the pyramids using laser scanners and drone-aided aerial photography. Following the on-site recording, he is currently analyzing the data, whose extreme precision should enable him to examine even the shape of every single stone. As part of his outreach activities, he has made numerous media appearances and runs his own YouTube channel, "Ancient Egypt by Yukinori Kawae" (mainly in Japanese), which has over 300,000 subscribers.



You used to be a leading full-time IAR faculty member, starting from October 2018. Could you tell us about your activities during that period?

Up until September 2025, when I fully handed over my role to Dr. Kameda, I was mainly in charge of international academic exchange, especially within the framework of the University Based Institute for Advanced Study (UBIAS). I was also in charge of managing the Nagoya University Lecture and the IAR Symposium in the areas of humanities and social sciences, as well as the launch of online events.



Could you tell us more about your activities relating to the UBIAIS?

From 2021 to last year, Nagoya University's IAR was one of the three IARs called the "Coordination Trio," which handles practical operations within the Steering Committee. As part of this responsibility, we hosted the 2023 Directors' Meeting at Nagoya University. This meeting assembles the representatives from around the world every two years. I looked after roughly

everything, from coordination with all representatives to organization of the program of the day. Today, when I see researchers who were at the meeting, they all say things like "Yuki, the Nagoya meeting was great!" to me, which makes me really happy. It really drives home the importance of holding an in-person meeting. The meeting agenda itself is important, but you can't forget the close ties that we form with people by eating together and introducing Japanese culture to them. As anyone involved in international exchange on the ground should know, the benefits of personal encounters are not easily definable, but as with research, you repeat trial and error, and you eventually arrive at something positive. I think despite the ambiguity, interpersonal ties are important in maintaining organizational relationships. Last year, I had Director Sakakibara and Dr. Kameda attend with me the Directors' Meeting hosted by the University of Ghana, which was one of the Coordination Trio along with Nagoya. It was great that I was able to personally introduce Dr. Kameda as my successor to the UBIAIS members on that occasion and see her warmly received, which I suppose was largely due to her personality.

What do you find particularly interesting about international exchange, and what do you expect from the Institute in the future?

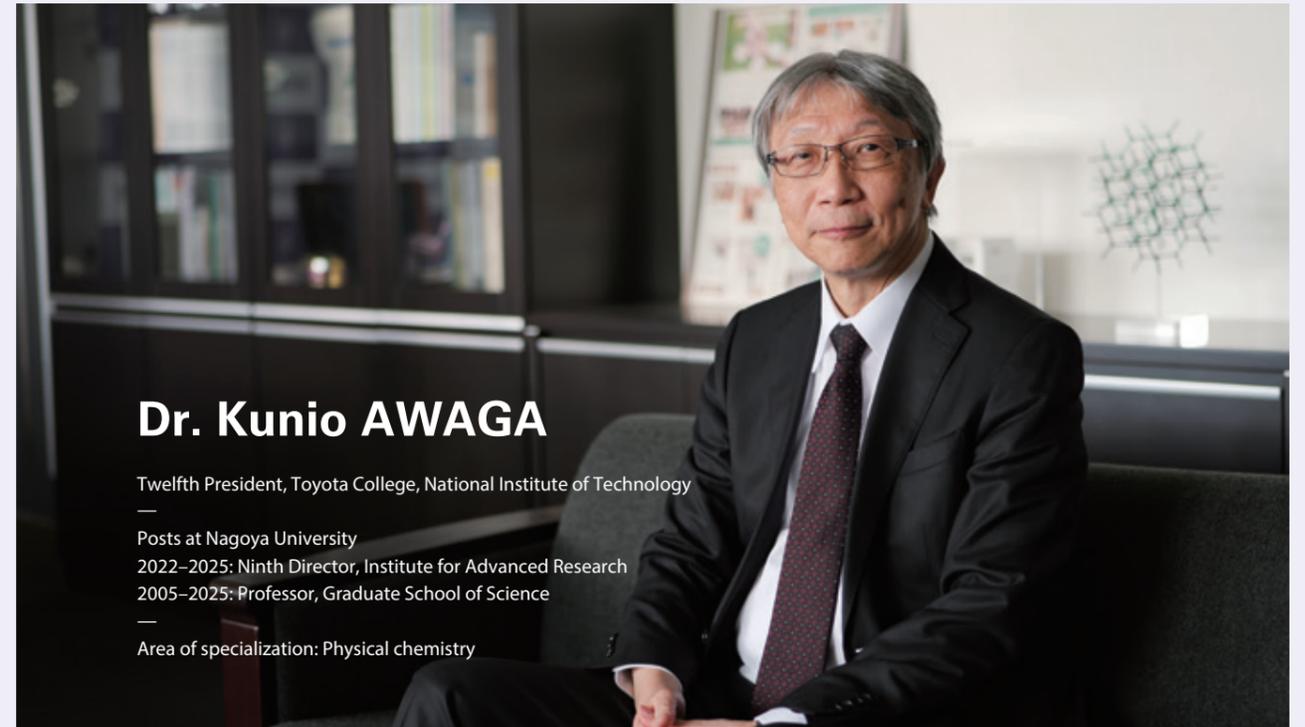
Being involved in international exchange, I was able to observe firsthand how ideas and ways of thinking differ from one country to another, or one culture to another, on many topics. For example, AI is a hot topic right now, and different countries show different approaches and attitudes to AI, depending on their situations. For some, expenses related to AI use are a huge burden, whereas others are more concerned about data leakage to other countries. AI is bound to remain relevant to academic research in many ways. So I think the Institute should determine how to deal with it through repeated discussions with people representing various domains and values.



(Interview conducted by Haruka Kamiguchi and compiled by Tatsuro Ayatsuka)

IAR Connection

In "IAR Connection," we introduce people who have contributed as part of the Institute for Advanced Research (IAR). For this edition, we talked with Dr. Kunio Awaga, who served as the Ninth IAR Director. Dr. Awaga is currently the 12th President of Toyota College of the National Institute of Technology, popularly known as "Toyota Kosen." One of the higher education institutions of the "Kosen" system, Toyota Kosen established in 1963 to train future engineers and other specialists, it celebrated its 60th anniversary in 2023. The college's substantial five-year program of education and research (seven years for students in advanced courses) continues to produce excellent specialists trusted by society.



Dr. Kunio AWAGA

Twelfth President, Toyota College, National Institute of Technology

Posts at Nagoya University

2022–2025: Ninth Director, Institute for Advanced Research

2005–2025: Professor, Graduate School of Science

Area of specialization: Physical chemistry

Could you tell me what your work consists of today?

As Toyota Kosen's President, I lead the college at the helm while adhering to its philosophy and principles steadfastly, ensure an environment in which all personnel can perform their duties in the best possible manner, and promote Toyota Kosen externally, among other responsibilities... such is my work.

What was your first impression of Toyota Kosen when you first arrived at your post?

I was made vividly aware of the power of Toyota Kosen's characteristics. First of all, the students are incredibly talented. They're quite hands-on and great team players. For example, at the 6th National Institute of Technology Deep Learning Contest (DCON2025) held last year, Toyota Kosen's "Nagara" Team won the top prize. They developed an AI-aided system with a small microphone that allows nursing facility personnel to automatically generate reports and other documents to reduce paperwork, which often gets in the way of actual nursing care on the ground. The system uses already existing technologies, but it is readily applicable in actual nursing settings. The proactive way the students visited the facilities to identify problems firsthand and took steps to ensure collaboration from the local community typifies Kosen's characteristics. Needless to say, you can't overlook the presence of teachers who support the students in their endeavors. They pursue their own research while teaching classes and providing students with guidance on student life, which is no easy task. What comes into play here is the Kosen spirit. In fact, many of our teachers are also Kosen graduates, and many of them have chosen this career

path because they wanted to transmit something to future generations at the college. We also have many Kosen graduates among the parents. Overall, the ties among people who love Kosen provide strong support to college life.

What would be your message to the IAR?

I think it would be great if the IAR proudly emphasized its unique qualities and, by extension, Nagoya University's unique qualities in its activities. Regarding Toyota Kosen, I spoke about the Kosen spirit and the graduates' love for Kosen. It would be great if, in a similar way, there were a well-established system that allows NU alumni to stay connected with the university long after their graduation. Finally, Toyota Kosen really has many truly excellent students. I would be most pleased if some collaborative system were put in place that would allow such students to engage in interesting projects at Nagoya University.



(Interview conducted and compiled by Tatsuro Ayatsuka)



Hao WEN

Designated Assistant Professor of Young Leaders Cultivation Program
Graduate School of Humanities / Institute for Advanced Research, Nagoya University
E-mail: wen.hao.n7@f.mail.nagoya-u.ac.jp

Reconsidering Cinema’s Potential as Urban Infrastructure

INTRODUCTION

My research investigates the history of how cinema materially configured the urban setting and aesthetically shaped the urban imaginary of Tokyo as a global city in the 1980s and 90s and further explores cinema’s potential in shaping and transforming urban and local societies in contemporary Japan. While cinema’s role in facilitating transnational flows and cultural exchanges has been widely discussed, there has been insufficient emphasis on its material formation on the local ground. Considering the material aspect of cinema involves recognizing visual media’s capacity to designate, occupy, and transform local spaces and places. In other words, it becomes crucial to understand cinema as a specific media infrastructure of the city, which proactively shapes and reshapes our everyday life and culture in contemporary urban society. This approach echoes the recent infrastructural turn in Anglophone academia across urban studies, anthropology, media studies, and science and technology studies (STS) disciplines (Larkin 2013, Mattern 2018). Dialoguing with anthropologist Brian Larkin’s call to examine the ‘politics and poetics of infrastructure,’ my research investigates how the presence of cinema in material forms (e.g., film venues, film festivals, cultural institutions, and sites of filmmaking and screening) shapes the politics and culture of Japanese cities. Through the infrastructural approach, this research renegotiates the dynamics of local and global in the context of contemporary Japan, allowing a complex local scenario to emerge.

INSTITUTIONALIZATION OF CINEMA IN URBAN PLANNING

In the 1980s, cinema was practiced by the Tokyo Metropolitan Government (TMG) to tackle various domestic and international issues. It was an urgency for the Tokyo officials to administer cultural policies in order to ease tensions led by the rise of regionalism and to establish the city’s international status within an increasingly permeable and free-flowing globalized world. The TMG held its cultural roundtables as an experiment to conceive and address the city’s unique local culture, with cinema played an imperative part of the campaign. On the one hand, cinema’s capacity to visualize an ‘authentic’ past was exploited to reinvent Tokyo’s local essence. On the other hand, cinema’s capability of facilitating capital and human exchanges across the border was maximized through the deployment of film festivals of various scales—such as the Tokyo International Film Festival (Figure 1) and the Japan Foundation Film Series. While it was conducted to maintain the official’s developmentalist blueprint of the city, the unfolding of different temporalities problematized the city’s economic-centered history and reality. Furthermore, these newly institutionalized urban spaces for cinema also enabled grassroots actors to realize their own agendas and provided opportunities for unexpected encounters and assemblages in a newly reconfigured globalized network. The deployment of cinema as a specific cultural form to facilitate Tokyo’s global city

agendas by government officials and their business partners and its overspill for subversive practices and actions is worth meticulous examination from a materialist perspective.



Figure 1. Streets of Shibuya during the 1st TIFF. Retrieved from www.nippon.com/ja/features/h00327/ (2023, October, 2).

FILM COMMISSION FOR MACHIZUKURI

Machizukuri, originally rooted in post-war anti-establishment movements across various Japanese regions, where local residents autonomously opposed industrial constructions to protect their living environments, has metamorphosed as an umbrella term to facilitate the state and local government’s goals of regional development and the capitalist desire for urban renovation. In the 21st century, two types of film commissions have emerged alongside the *machizukuri* campaign, with the official intention of promoting local culture and eventually creating spaces for alternative collective formation and actions through cinema. The first type represents grounded practices of organizing local imaginary through location scouting and on-site production. The second type operates through collaborating with others, who are not necessarily from the local, to open spaces for problematizing and elaborating on the existing ideas and ideals of the local. The two types of film commissions are deeply interwoven with each other in actual practices and are important forces that shape the material and aesthetic conditions of contemporary Japanese local regions.

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“The double-edged sword of Gorilla Tourism over species conservation and public education”

INTRODUCTION

People are increasingly turning to animal interactions as a way to connect with nature. However, such encounters can pose risks, including physical injury and the transmission of zoonotic diseases. Our research, focusing on the well-known and economically significant practice of Gorilla Tourism, highlighted the dangers of animal aggression and disease transmission through close human-animal interactions (HAIs)—a topic that gained heightened public and scientific attention during the pandemic. This prompted us to examine the human side of these interactions, particularly tourists’ willingness to approach large animals at dangerously close distances. To better understand this dynamic in a more controlled environment, we shifted our focus to zoos, which play an important role in shaping public perceptions of species conservation.

GORILLA TOURISM

Mountain gorillas (*Gorilla beringei beringei*) are critically endangered and exist only in their wild habitat. As they do not thrive in captivity, Gorilla Tourism —where tourists visit habituated wild groups—is the primary means of funding their conservation. However, human presence can negatively affect the animals, raising concerns about the long-term sustainability of Gorilla Tourism. In Bwindi Impenetrable National Park, Uganda, we studied how tourist visits impact gorilla stress levels, coping behaviors, and social dynamics. Contrary to the recommended 7-meter viewing distance, tourists often stayed within 3 meters for 60% of their visit. At this proximity, gorillas showed increased stress indicators, physical interactions, and agonistic behavior towards visitors, raising disease transmission risks. Using frequentist and social network analyses [1-3], we found that close human contact led to heightened stress responses and altered gorillas’ social cohesion, which may reflect a form of social buffering in response to disturbance. We discussed with local authorities the dangers of the imminent risk of pathogenic spill during these close interactions with tourists, which we advised may be exacerbated by the fact that animals under stress may have compromised immunity.



Figure 1. Infant mountain gorilla in Bwindi Impenetrable National Park, Uganda.

ROLE OF ZOOS

The previous project raised further questions about the human side of these interactions, particularly the willingness of tourists to approach large animals at dangerously close distances. To explore this in a controlled environment, we shifted our focus to zoos. Our findings suggest that visitors who form stronger emotional attachments to specific animals are more motivated to learn from them (4). However, visit frequency or duration did not significantly influence this connection, pointing to the interaction quality itself as a key factor. Together, these results highlight the potential of zoos to educate the public on responsible wildlife engagement and sustainable tourism. Our current research focuses on understanding what makes these HAIs meaningful. By combining insights from both wild and captive settings, we aim to uncover how tourism, conservation, and animal welfare intersect - and how they can be better balanced in practice.

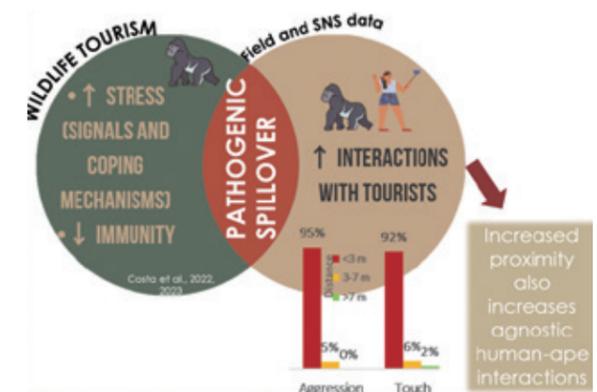


Figure 2. Summary of the dangers of uncontrolled HAI in Gorilla Tourism.

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Interpersonal Body Synchrony: Past Insights and Future Paths

Elements of our bodies, such as body movement and heart rate, tend to synchronize unintentionally with those of others, a phenomenon known as interpersonal body synchronization (Schmidt et al., 1990; Richardson et al., 2006). The significance of interpersonal body synchronization has been acknowledged implicitly since ancient times, as evidenced by cave paintings that depict groups of people dancing together, indicating its historical integration into social life. This spontaneous alignment of individuals who are neither physically nor neurologically connected has long fascinated cognitive scientists and psychologists.

Previous research has revealed that interpersonal body synchronization is closely linked to social activity. For example, moving in sync with others induces cooperative behavior toward others and facilitates the development of rapport (Bernieri, 1988; Kirschner et al., 2010). In addition, when someone makes a good impression, it becomes easier to synchronize with them (Cheng et al., 2020). Thus, interpersonal body synchronization and social cognition influence each other.

I have investigated factors that influence interpersonal body synchronization, such as personal space and social relationships, and have shown that interpersonal body synchronization can vary contingent on these factors. Personal space surrounding our body as a boundary between others' and ours is particularly related to interpersonal body synchronization. For example, the shorter the interpersonal distance, the greater the interpersonal postural synchronization (Okazaki et al., 2015). In addition, our position relative to others affects interpersonal body synchronization. My previous study found that our heart rate tends to decrease in synchrony with others' when they are facing us or to our right (Mukai et al., 2024). Furthermore, the occurrence of such synchrony was associated with increased parasympathetic nervous system activity. Notably, such physiological synchrony might occur in intimate individuals, such as family members and close friends. Other studies have demonstrated that increased sympathetic nervous system activity was observed when a stranger approached (Candini et al., 2021). However, under such circumstances, it remains unclear whether physiological responses related to sympathetic nervous system activity, such as heart rate and electrodermal activity, change in synchrony between two individuals. Further investigations may provide deeper insights into how interpersonal social relationships modulate the association between interpersonal body synchronization and personal space.

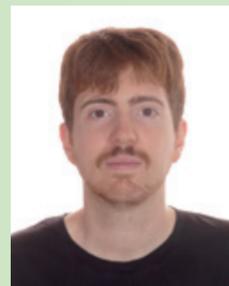
In addition to exploring the relationship between social factors and interpersonal body synchronization, I have studied developmental and age-related changes in interpersonal body synchronization. Although several previous studies indicate that interpersonal body synchronization may vary with age, empirical evidence examining its evolution across a wide age range remains limited. In my previous study, I examined changes in interpersonal body synchronization in children aged 5–12 using experimental psychological methods and showed that the tendency to synchronize

varied nonlinearly (Mukai et al., 2024). Specifically, no synchronization tendency was observed in children aged 5–6, while a stronger tendency was found in children aged 7–10 than in those aged 11–12. Moreover, a study involving participants in their 20s to 70s indicated that a synchronization tendency is stronger in individuals in their 70s than in those in their 20s (Mukai et al., 2025).

These findings demonstrate that interpersonal body synchronization may change across the lifespan, suggesting that it may serve as a sensitive marker for understanding age-related changes in social functioning. Furthermore, understanding these dynamics may have important implications for identifying social deficits in individuals such as those with autism spectrum disorder or social anxiety, or older adults at risk of social isolation. Further studies should examine whether changes in synchronization affect social functioning causally, and how these processes emerge in naturalistic interactions. Most existing studies rely on controlled laboratory settings; therefore, investigating interpersonal synchronization in ecologically valid, real-world interactions remains a significant challenge.

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Simulating PBH formation from generic curvature fluctuations and characterizing the threshold in the type-II region

Introduction

Primordial black holes (PBHs) are hypothetical cosmic relics that may have formed in the very early Universe through the gravitational collapse of large-amplitude curvature fluctuations that were generated during inflation (1). These PBHs remain a compelling dark matter candidate, particularly in the asteroid to lunar mass range, and may help resolve various astrophysical and cosmological puzzles (2).

One of the most widely studied formation channels involves the collapse of super-horizon curvature perturbations during the radiation-dominated era. These perturbations, if sufficiently large when they re-enter the cosmological horizon, can collapse into a black hole. This mechanism has received extensive attention because the abundance of PBHs is exponentially sensitive to the profile of these fluctuations, and precise knowledge about under which conditions PBHs are formed is required.

Studying PBH formation requires fully relativistic numerical simulations, as the process inherently involves highly nonlinear dynamics and strong gravitational fields. Since analytical approaches are insufficient in this regime, solving the Einstein field equations numerically is essential to determine whether a given perturbation leads to black hole formation or ultimately disperses. Simulations provide the only reliable framework to explore these conditions with the necessary precision and consistency.

A new Misner–Sharp approach

A powerful tool for these simulations under the assumption of spherical symmetry is the Misner–Sharp formalism (3), which casts Einstein's equations in comoving gauge for fluid systems. However, recent developments have identified and studied a novel class of curvature perturbations, dubbed "type-II fluctuations" (4, 5), in which the areal radius is nonmonotonic (different from the standard type-I fluctuations) and may have important implications in specific scenarios. In the standard Misner–Sharp approach, these type-II fluctuations lead to divergences (0/0 terms) in the evolution equations, which previously made their simulation infeasible.

In recent work (6), a new approach has been proposed to solve these issues, by using the trace of the extrinsic curvature as an auxiliary variable within the Misner–Sharp framework. The numerical methodology is based on previous work (7), and this new method is found to be equally optimal and efficient. This allows a proper exploration of the threshold for black hole formation and the mass spectrum as well as a deep study on the dynamics of the gravitational collapse for generic curvature fluctuations (type-I/II) by using the Misner–Sharp formalism. Compared with other recent work (5), there is excellent agreement between the numerical results.

The threshold for PBH formation in the type-II region

Using this new approach, recent work (8) has focused on the

type-II critical thresholds for PBH formation (which means that the critical initial conditions for black hole formation correspond to type-II fluctuations). By considering several curvature fluctuation profiles, the results have shown that the threshold does not necessarily saturate at the boundary between the type-I and type-II regions, which differs from previous expectations.

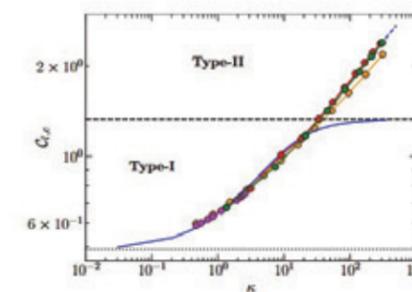


Figure 1. Threshold for PBH formation defined in terms of the linear component of the critical compaction function and parametrized in terms of κ .

Previous analytical estimates exist to predict the threshold for PBH formation in the type-I region (see blue line in Fig. 1), but not for the type-II region, for which a new analytical framework is required. In this work, new variables are introduced to extend the analytical estimation to the type-II region for specific curvature profiles, using the linear component of the compaction function (9) and the curvature shape around its maximum (denoted by κ).

The results have direct applications in predicting the PBH abundance from inflationary models, where precise knowledge of the threshold is essential for statistically estimating the production rate of PBHs from a given power spectrum. Both results (6, 8) enhance the understanding of type-II fluctuations and their implications in the Universe.

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Microfluidic-based Control Technology for Simultaneously Detecting Multiple Nucleic Acids

INTRODUCTION

Genetic diagnostic technology is applied in many fields, such as infectious diseases and food allergies. It plays an important role in ensuring people's livelihoods and well-being. However, conventional testing methods, such as polymerase chain reaction, require skilled operators and expensive equipment. Furthermore, it is necessary to prepare numerous samples or reagent mixes for individually testing each infectious virus. Therefore, the diagnosis of multiple viral diseases requires laborious operations and relatively large amounts of reagents, enhancing costs and the time taken to obtain the results.

To address this issue, we developed a microfluidic device that enables the multiplexed detection of target nucleic acids (DNA or RNA) (Fig. 1). It sequentially dispenses the mixture of samples and reagents into microchambers (3 μ L each) for detecting each target nucleic acid. This innovation reduces the number of operations and minimizes reagent consumption, thus serving as a low-cost and high-throughput diagnostic system.

MICROFLUIDICS-BASED AUTONOMOUS CONTROL

To realize sequential sample dispensing, a pair of narrow-channeled passive valves was designed into each chamber (Fig. 2). As surface tension is significant at the microscale, the narrow channels temporarily function as passive valves. The flowing fluid is temporarily stopped at the first passive valve S_1 and subsequently changes direction toward the reaction chamber. After the reaction chamber is filled, the fluid reaches the second valve S_2 . As the pressure resistance of S_1 is designed to be smaller than that of S_2 , the fluid flows over the valve S_1 and into the next reaction chamber. The process is repeated to fill all microchambers with the liquid.

MULTIPLEXED GENETIC DETECTION

The microfluidic device was used with loop-mediated isothermal amplification. Figure 3 shows the detection results for *Salmonella* and *Vibrio parahaemolyticus*, which are foodborne pathogens. After 60 min, the reaction mixes in chambers 1 and 3 changed from purple to blue, indicating a positive detection of *Salmonella* nucleic acids. The color of the reaction chambers 7 and 9 indicated the positive detection of *V. parahaemolyticus* nucleic acids. Furthermore, by analyzing the temporal color changes, it is possible to quantify the concentration of the target nucleic acids in the sample. Microfluidic-based genetic detection systems have been utilized to identify infectious viruses [1, 2], food allergens [3], foodborne pathogens [4], and illegal substances [5].

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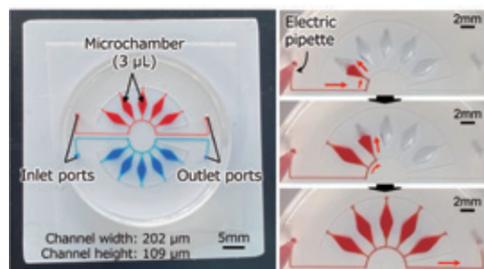


Figure 1. A schematic of a microfluidic device for multiplexed genetic detection and demonstration of autonomous dispensing into multiple reaction chambers.

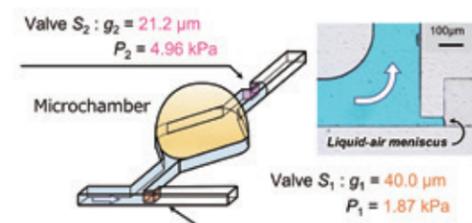


Figure 2. Detailed design of the microchamber integrated with a pair of passive valves.

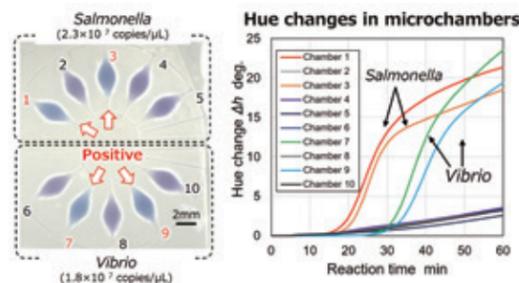


Figure 3. Loop-mediated isothermal amplification-based detection of *Salmonella* and *Vibrio*, and a quantitative analysis of color changes in reaction microchambers.

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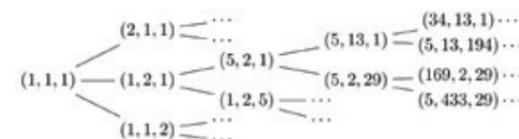
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The World of Markov Numbers

Markov Equation and Markov Numbers

The Markov equation $x^2 + y^2 + z^2 = 3xyz$ was first studied by Markov (1879) in the context of the theory of approximating irrational numbers by rational numbers. For around 150 years, it has fascinated mathematicians. One of the most important features of this equation is that all positive integer solutions can be generated by a simple algorithm, and all solutions are obtained this way. Starting from the solution (1, 1, 1), for any triple (a, b, c), we compute (3bc - a, b, c), (a, 3ac - b, c), (a, b, 3ab - c). Except for the initial case, one of these three will already have appeared; hence, each step yields two new triples. Iterating this gives a tree whose nodes are all solutions (see below).

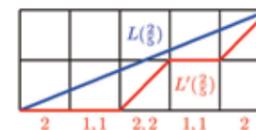


The integers appearing in this tree are called *Markov numbers*. For example, 1, 2, 5, 13, 29, 34, 169, 194, 433... are Markov numbers, and there are infinitely many of them.

Geometric Appearance of Markov Numbers

Markov numbers arise in unexpected places. One striking example was discovered in lattice geometry.

Draw a grid in the xy plane. For a reduced fraction $p/q < 1$, consider the segment $L(p/q)$ from (0, 0) to (p, q). Take all lattice points just below $L(p/q)$, connect them in order by segments, and call the resulting broken line $L'(p/q)$. The following diagram shows the case where $p/q = 2/5$:



Assign the label "2" to the first and last segments of $L'(p/q)$, "1, 1" to the interior horizontal parts, and "2, 2" to the interior diagonal parts (see the previous diagram). Reading these numbers from left to right gives a sequence of 1s and 2s. Form the continued fraction associated with this sequence. For example, if $p/q = 2/5$, the continued fraction is as follows:

$$2 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{2 + \cfrac{1}{1 + \cfrac{1}{2}}}}} = \frac{194}{75}$$

As can be seen, the numerator is always a Markov number. Indeed, 194 appears in the previous solution tree. This remarkable coincidence links positive integer solutions of the equation with a quantity computed from geometric data.

Open Problem

A famous unsolved question, posed by Frobenius (1913), asks: "For each Markov number, is there a unique solution (up to permutation) to the Markov equation where this number is the largest entry?"

For instance, 5 is the largest entry of (1, 2, 5), and no other solution has 5 as its largest component up to permutation. Whether this uniqueness holds for all Markov numbers remains unknown. Recent work explores geometric methods similar to the ones presented earlier to approach this problem.

Generalization of Markov Equation and Markov Numbers

To study the conjecture, we introduced a broader family of equations:

$$x^2 + y^2 + z^2 + k(yz + zx + xy) = (3 + 3k)xyz,$$

where k is a nonnegative integer (Gyoda-Matsushita, 2023). For $k = 0$, we recover the Markov equation; fixing k gives the k -generalized Markov equation. This equation has a similar algorithm to the Markov equation that generates all positive integer solutions: starting from (1, 1, 1), repeatedly compute $(3bc - a - kb - kc, b, c)$, $(a, 3ac - b - ka - kc, c)$, $(a, b, 3ab - c - ka - kb)$.

The integers in the solutions are the k -generalized Markov numbers, which share many properties with ordinary Markov numbers, including a geometric description via broken lines and continued fractions. Notably, when $k = 2$, the solutions precisely yield the squares of ordinary Markov numbers, showing a deep connection between the two equations (Gyoda -Matsushita, 2023; Gyoda-Maruyama-Sato, 2024).

Connection of Markov Numbers with Other Areas of Mathematics

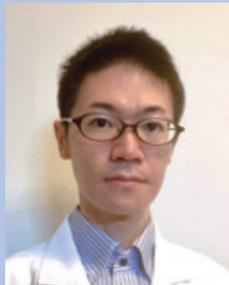
My goal is not only to solve Frobenius' conjecture. The Markov equation and Markov numbers, beyond their original motivation in approximation theory and the lattice geometry mentioned earlier, are known to appear in many branches of mathematics. Examples include hyperbolic geometry, toric geometry, cluster algebras, one-dimensional dynamical systems, and the representation theory of algebras.

My ultimate aim is to deepen our understanding of these fields through the study of Markov numbers and to contribute to building a more unified and refined mathematical framework.

From this perspective, my current main interest is to extend the connections that Markov numbers have in these areas to the generalized Markov numbers that have been introduced. I will continue this line of work to further enrich our mathematical world.

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Elucidating Molecular and Metabolic Profiles of Cancer and Environmental Stress Responses: Toward Novel Disease Classification and Personalized Medicine

Introduction

This study focuses on understanding how intrinsic cellular mechanisms and extrinsic environmental factors contribute to human disease, particularly cancer. Moreover, the study aims to define molecular and metabolic subtypes of cancer and its surrounding stroma (tumor microenvironment; TME) using multi-omics analyses; and to elucidate how environmental stressors, particularly micro-nanoplastics (MNPs), affect human health. The study seeks to uncover novel disease mechanisms and contribute to the development of innovative strategies for diagnosis, prevention, and personalized therapy by integrating transcriptomics, metabolomics, pathology, and redox biology.

Molecular and Metabolic Profiling of Cancer and Its Micro-environment

Cancers are complex ecosystems composed of cancer cells and various stromal components including fibroblasts, immune cells, endothelial cells, and extracellular matrix. These noncancerous elements, collectively called the TME, influence cancer proliferation, therapeutic resistance, and metastatic potential.

The present study focuses on pancreatic ductal adenocarcinoma (PDAC) and malignant mesothelioma, aiming to characterize the gene expression and metabolism of cancer and stromal cells. In PDAC, bulk transcriptomic analysis has determined two major molecular subtypes: classical/progenitor and basal-like/squamous, with the latter being more aggressive. In contrast, metabolism is a hallmark of cancer and is a crucial mechanism for survival. Metabolomics has revealed metabolic subtypes in PDAC. Using integrated transcriptomics and metabolomics, key regulators of PDAC molecular and metabolic subtypes were identified¹⁻⁴. *SERPIN3* was found to promote a basal-like/squamous subtype and lung metastasis accompanied with increased amino acid and carnitine metabolism¹, whereas *LMO3* and *ADRA2A* were identified as suppressors of the basal-like/squamous subtype^{2,3}.

Regarding mesothelioma, previous studies concentrated on asbestos-induced oxidative stress, iron metabolism, and TME^{5,6}. However, molecular and metabolic subtyping of the TME in mesothelioma and PDAC remains unclear. Thus, this study expands subtyping efforts to the stromal compartment, using spatial transcriptomics and metabolomics to investigate how stromal states influence tumor behavior. Furthermore, by combining spatial omics with artificial intelligence (AI)-based image analysis of routine hematoxylin and eosin-stained sections, the current study aims to develop a cost-effective system for high-resolution subtype classification applicable to routine diagnostics and personalized treatment planning.

Environmental Stress and Disease: Impact of MNPs

Environmental pollutants, particularly MNPs, are emerging as potential risk factors for cancer and other diseases. MNPs can induce

oxidative stress and DNA damage in cells. Despite increasing concern, their effects on human health remain largely uncharacterized.

In this study, the direct and indirect effects of MNPs on human diseases, including cancers, are intended to be evaluated using *in vitro* and *in vivo* models. The direct effects include oxidative stress and metabolic alterations in cancer and stromal cells, whereas the indirect effects involve changes in the microbiota and systemic immunity. Using transcriptomics, metabolomics, and pathology on tissues from rodents exposed to various MNPs (e.g., polystyrene and polyethylene terephthalate), their impact on tumorigenesis, TME remodeling, and systemic homeostasis will be evaluated. The same spatial omics and AI imaging pipeline developed for cancer subtyping may be applied to MNP-exposed tissues to localize particles and infer their molecular and metabolic effects at a cellular level.

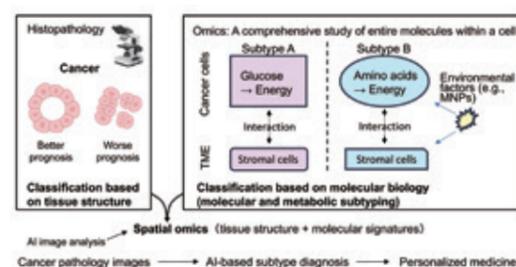


Figure 1. Pathologists classify a cancer into subtypes based on their differentiation status, providing insights into their clinical relevance. In contrast, molecular biologists classify a cancer using omics approaches such as genomics, transcriptomics, and metabolomics. Integrating histopathology, transcriptomics, and metabolomics with AI-based analysis enables rapid and cost-effective subtyping for personalized medicine.

Future Directions and Significance

The development of an integrated approach that combines spatial transcriptomics and metabolomics with machine learning on H&E-stained images will enable the detection of gene expression and metabolism at single-cell resolution. This technique allows for rapid and low-cost characterization of cancer and stromal cells without relying on expensive RNA sequencing or mass spectrometry. Such characterization may lead to the discovery of novel therapeutic strategies and accessible personalized medicine. Furthermore, the findings may be beneficial for evaluating the carcinogenic potential of MNPs and provide a scientific basis for environmental risk management.

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Regulation of Aberrant Protein Translation as a Therapeutic Strategy for Neurodegenerative Disorders

INTRODUCTION

Neurodegenerative disorders are characterized by progressive neurological symptoms, including motor and cognitive dysfunctions. Recent studies have shown that, prior to the onset of clinical symptoms, toxic abnormal proteins accumulate in the neurons and glial cells of patients with neurodegenerative disorders. Reducing the buildup of these proteins is considered a promising therapeutic strategy, particularly in the early stages of disease. Our research focuses on regulating the translation of these toxic proteins to prevent their accumulation and mitigate neurological symptoms in neurodegenerative disorders.

SELECTIVE INHIBITION OF ABNORMAL PROTEINS BY siRNA

Polyglutamine (polyQ) diseases are inherited neurodegenerative disorders caused by an abnormal increase in cytosine-adenine-guanine (CAG) repeats in the causative genes. The diseases include spinal and bulbar muscular atrophy (SBMA), Huntington's disease (HD), and seven types of spinocerebellar ataxias. Targeting expanded CAG repeats is a common therapeutic strategy for polyQ diseases. However, this approach can also suppress normal CAG repeats in other genes, with potentially toxic effects. Previous studies have demonstrated that siRNAs that target CAG repeats can selectively suppress abnormal protein expression in *in vitro* cell models of polyQ diseases. However, their therapeutic efficacy *in vivo* remains unclear. We investigated the potency and allele selectivity of artificial unlocked nucleic acid (UNA)-modified small interfering ribonucleic acid (siRNA) that targets CAG expansion in mouse models of SBMA and HD [1]. Our results demonstrated that lipid nanoparticle-mediated delivery of the UNA-modified siRNA selectively suppresses polyQ proteins in the mouse central nervous system (Figure 1). We are currently developing a new CAG repeat-targeting siRNA for clinical application. This incorporates highly stable chemical modifications that confer nuclease resistance, allowing it to function effectively without the need for a drug delivery system.

ALTERED TRANSLATION OF ABNORMAL PROTEINS

SBMA is an adult-onset hereditary neurodegenerative disease caused by the expansion of CAG repeats in the androgen receptor (AR) gene. Androgen-dependent nuclear accumulation of pathogenic AR protein leads to the degeneration of motor neurons. However, the mechanisms underlying the selective vulnerability of motor neurons remain unclear.

Mid1 encodes an RNA-binding protein that facilitates the translation of CAG repeat-containing messenger RNA (mRNA) via mechanistic target of rapamycin (mTOR) signaling. We identified upregulation of *Mid1* in the motor neurons of SBMA mice [2]. We also demonstrated that knockdown of *Mid1* ameliorates impaired axonal regeneration in spinal cord cultures from SBMA mice. These findings suggest that *Mid1*-dependent aberrant protein translation contributes to the

vulnerability of motor neurons in SBMA. Thus, the inhibition of this translation process may help prevent neurodegeneration.

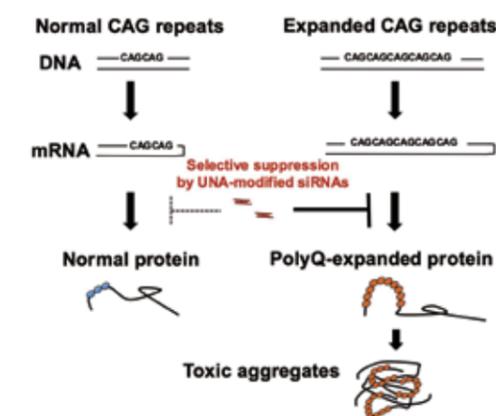


Figure 1. Selective suppression of polyglutamine (polyQ) proteins by unlocked nucleic acid (UNA)-modified siRNA that target expanded CAG repeats. PolyQ, polyglutamine; CAG, cytosine-adenine-guanine

TRANSLATIONAL REGULATION BY PHYSICAL EXERCISE

Alterations in global protein translation, including the dysregulation of mTOR signaling, have been observed in various neurodegenerative and neuromuscular disorders. We have demonstrated that physical exercise during the early stages of SBMA in mice reduces the aberrant activation of mTOR signaling and the accumulation of polyQ proteins in skeletal muscle. This results in improved motor function [3]. Our transcriptomic and biochemical analyses revealed this inhibition of mTOR signaling to be associated with the activation of adenosine monophosphate-activated protein kinase (AMPK) signaling. Furthermore, we found that the pharmacological activation of AMPK effectively suppressed mTOR signaling and reduced the buildup of polyQ proteins in a C2C12 muscle cell model of SBMA. Our findings illustrate the therapeutic potential of AMPK activation through physical exercise in neuromuscular disorders caused by abnormal protein accumulation.

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A high-resolution characterization of florigen-producing cells: coordination of reproductive transition in plants

INTRODUCTION

The timing of flowering impacts the success of sexual reproduction; thus, plants monitor seasonal information, such as day length and temperature, to precisely time their transition into the reproductive growth phase. It also affects agricultural productivity. Through the domestication of important crop species such as rice and soybean, humans have selected early-flowering varieties to improve yield.

In the model plant species *Arabidopsis thaliana*, seasonal information is mainly sensed by the leaves, but not the floral organs. Once plants perceive the optimal flowering time, they synthesize “florigen,” a mobile flowering-promoting molecule that travels from leaves to the shoot apical meristem (SAM). Scientists finally identified a small protein, FLOWERING LOCUS T (FT), as a florigen, 70 years after its presence was first suggested. In *Arabidopsis*, strong FT expression is confined to the specialized phloem companion cells at the distal part of the leaf vasculature (Figure 1), suggesting that this subset of cells exclusively controls plant responses to seasonal changes. Despite their significance in understanding plant survival strategies during phase transition, the detailed molecular characteristics of the FT-expressing cells remain elusive.¹⁾

Identification of a novel flowering and stem elongation-promoting signal protein, PPF1-LIKE PROTEIN 1 (FLP1)

To understand the unique characteristics of FT-expressing companion cells, we investigated their gene expression profiles. The biggest challenge was isolating mRNA, since these cells are deeply embedded within the leaf vasculature, rendering their physical isolation impractical. To overcome this problem, we have employed a tissue-specific transcriptome analysis method (TRAP-seq).²⁾ In this method, the ribosomal protein RPL18 fused with a FLAG-tag is expressed in the target tissues and co-immunoprecipitated with the translating mRNA. Our TRAP-seq analysis targeting the FT-expressing cells revealed that FLP1 spatiotemporally co-expressed with FT. To characterize FLP1, the effects of its overexpression or mutation were tested. We discovered that FLP1 promotes flowering independently of FT, indicating that plants send multiple flowering-promoting signals from the companion cells.

Next, a question arises regarding the necessity for multiple flowering-promoting factors. Why FLP1 is required in addition to FT? Our detailed phenotypic analyses demonstrated that FLP1 promotes not only flowering but also inflorescence stem elongation at the early stage of the phase transition. Stem elongation is crucial for plant survival, as it contributes to the attraction of pollinators, seed dispersal, etc. Despite this vital role, the identity of the molecular component coordinating flowering and stem elongation remains elusive. In this work, we obtained the gene expression profiles of season-sensing companion cells and identified FLP1, which coordinates plant flowering and stem elongation during the growth phase transition (Figure 1).

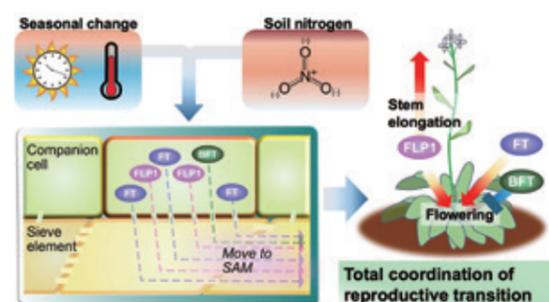


Figure 1. A small subset of leaf companion cells monitors seasonal changes and soil nitrogen status to regulate the synthesis of the small mobile proteins, FT, FLP1, and BFT. These signaling proteins are translocated to the shoot apical meristem (SAM) to regulate the timing of flowering and stem elongation. FT is a florigen that specializes in flowering promotion. FLP1 promotes both flowering and stem elongation, coordinating morphological changes during phase transition. BFT is an anti-florigen that counteracts the effects of FT.

FT-expressing companion cells produce small mobile proteins

To capture the gene expression profile of FT-expressing companion cells at an even higher resolution, we developed a single-nucleus RNA-seq (snRNA-seq) method by combining it with fluorescence-activated nucleus sorting.³⁾ It successfully subcategorized different phloem cell types. It revealed that the specialized companion cells preferentially express not only FT and FLP1, but also the genes encoding other small proteins, including the FT homolog BROTHER OF FT AND TFL1 (BFT), an anti-florigen. Our functional assay indicated that BFT driven by the companion cell-specific promoter delayed flowering, suggesting that the florigen-producing cells synthesize both florigens and anti-florigens to fine-tune flowering initiation. Moreover, we found that the consensus binding motifs of the nitrogen-responsive transcription factors enriched in the promoters of genes highly expressed in FT-expressing companion cells, suggesting that these cells monitor not only seasonal information but also the soil nitrogen status (Figure 1).

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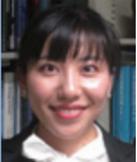
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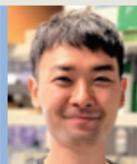
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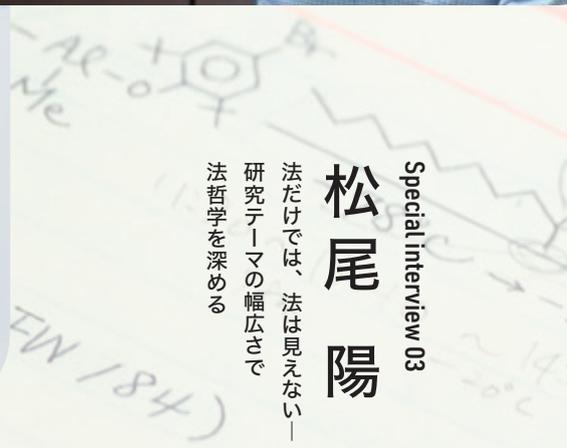
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Special Interview 01
大井 貴史
 研究者の個性を問う—
 あなたが積み重ねてきたものは何か



Special Interview 02
川口 由紀
 新たな物理現象を予言せよ！
 理論研究で挑む、
 極低温原子の未知のふるまい



Special Interview 03
松尾 陽
 法だけでは、法は見えない—
 研究テーマの幅広さで
 法哲学を深める



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