TOYOTA KONPON RESEARCH INSTITUTE INC.

ANNUAL REPORT 2024

TOYOTA KONPON RESEARCH INSTITUTE INC.
Toyota Commemorative Museum of Industry and Technology,
1-35, Noritake Shinmachi 4-chome, Nishi-ku, Nagoya City, Aichi 451-0051 Japan
Tel : 052-551-6330 Fax : 052-551-6340
URL : https://konpon.toyota

PHILOSOPHY

The role of the Toyota Konpon Research Institute

Moving forward resolutely in a diversifying and changing society
Purpose, Vision, Mission, and Value

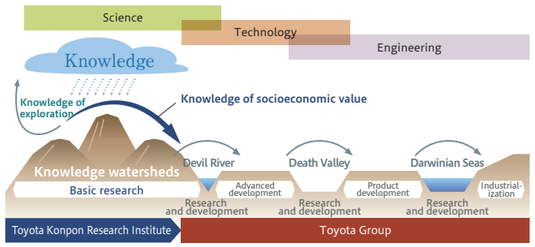
The Institute follows unchanging guidelines such as the Five Main Principles of Toyoda. We also believe that we need to systematically express our current thoughts into words. Based on the guidelines, we begin with a search for new ways to constantly improve. As we plan to continue to improve for a long time to come, this will always produce changes. It is important to use setbacks as a springboard for renewed efforts. Toyota Konpon Research Institute will continue to carry on these guidelines to put these philosophies into practice.
The objective of our activities is to become more open to academia to foster collaboration and joint exploration of new research topics. We encourage researchers from various fields to come together and engage deeply in research. In this way, we aim to create a space where colleagues can share ideas and continue to link to one another.

PURPOSE | Contribute to the happiness and progress of humanity and to the harmony with the Earth and all living things

We are embracing the challenge of an approach that is driven by dreams. This encourages each individual to make their aspirations come true. No one can foresee what will be useful in the future. Our Institute wants to increase options for the future. We look at things from the perspective of foundational elements and prepare for the unknown. A variety of research projects arise from this approach. We define our purpose as representing a future with connections to diverse and interesting research to show the direction we are heading.
"Happiness and progress of humanity" and "harmony with the Earth and all living things" are equally important. Our purpose expresses the desire to work together in order to improve both of these concepts.

VISION | Fly over "knowledge watersheds"

From the time of conducting trials for the new Konpon Research Institute in 2022, we have strived to create direction that would contribute to realizing the happiness and progress of humanity and the harmony with the Earth and all living things. Furthermore, based on our desire to discover many options beyond the Toyota Group, we took our approach to "flying over knowledge watersheds." As we think of knowledge watersheds as mountains of science, it is only by traversing those mountains that research in Devil River can begin. Our Institute eagers to create projects that will fly over the watersheds.



MISSION | Research what to research

The mission expresses our origins and our raison d'être. By continually considering the meaning of our existence, we will understand what actions must be taken next.

VALUE | Think from the perspective of foundational elements, be more open, and enjoy exploring a frontier.

We view our values with great importance. Moreover, we want researchers involved in our Institute to empathize with the values. With that in mind, we defined our values to make Toyota Konpon Research Institute more appealing, beloved worldwide, and to inspire researchers to collaborate here. Our origin is truly to "think from the perspective of foundational elements." "Being more open" reflects the expansion of our actions. Connecting with more associates is the key to enhancing our activities. Finally, we want to base our actions on "enjoying frontier exploration." Although a majority of the research does not proceed as plan, it is essential to enjoy the process and take the next step toward the future. Our Institute is committed to going forward with colleagues who empathize with the values.

Three pillars which are our core activities

In July 2023, we changed our corporate name to Toyota Konpon Research Institute. The idea behind this change was to return to our roots. We started afresh as an institute that conducts research to identify significant research direction by pondering on the thoughts we had when we founded it. At the trial period for the new Konpon Research Institute in 2022, we established three pillars to serve as the role of the Institute. Since then, these pillars have become the main axis of our activities.

【The first pillar】
Explore and investigate future research projects

【The second pillar】
Increase interest in science and enhance scientific literacy

【The third pillar】
Develop human resources who can connect with diverse researchers

To strengthen and add greater meaning to these pillars, we are continually embracing the challenges that come with improvement and creating changes aimed at enhancing our efforts for the next year and beyond.

Ask President Kikuchi

A deep dive on the Toyota Konpon Research Institute's philosophy of activity

Noboru Kikuchi
President
Toyota Konpon Research Institute Inc.

Interviewer:
Yuko Ikkatai, Associate Professor
Institute of Human and Social Sciences, Kanazawa University

— Today, we will talk to Mr. Kikuchi, President of Toyota Konpon Research Institute, about the Institute's philosophy of activity. Toyota Konpon Research Institute was established in 1996 and, as a "research institute that researches what to research," aims to conduct research that starts from the initial stage of basic research and leads to social implementation, is that correct?

Overcoming "knowledge watersheds," as set forth in our vision, means finding the potential for future contributions to society and aiming to bring benefits to future industries, even when the research does not seem to be of direct use.

— What approach should the institute take to fly over these "knowledge watersheds?"

I think it is important for researchers from many different fields to work together to pool various forms of brainpower, such as knowledge, intelligence, intellect, and wisdom. Rather than thinking alone about areas of high uncertainty, we want to break new ground by expanding our expertise through collaboration with people from diverse areas.

— Speaking of diverse fields, please tell us about the importance of interdisciplinary research.

Today's complex issues are difficult to solve in a single field, so integrating knowledge of different fields increases the chances of a breakthrough. For example, complying with the Muskie Act requires knowledge of not only engineering and science, but also of social sciences and humanities. Through our Research Exploration Program and similar efforts, we are providing opportunities for exchange between diverse researchers to surpass stereotypes and build new interdisciplinary fields.

— How does Toyota's founding spirit influence activities at the institute?

All the founders had the spirit of taking the plunge into difficult situations or highly competitive fields (red oceans) to create new values. Sakichi's move to enter weaving machine manufacturing and Kiichiro's entering the automobile industry are typical examples of this. Honorary Chairman Shoichiro had an insatiable thirst for knowledge in science and a strong passion for human resource development. Additionally, the spirit of "building connections," which emphasizes collaboration with external researchers, is what the founders have in common.

— In terms of entering the "red ocean," how do you view the activities of the modern-day Toyota Konpon Research Institute?

Our institute focuses on identifying areas with the potential to become a red ocean in the near future and working with external colleagues to create new values. Through these activities, I hope we can embody the spirit inherited from our founders.

— Thank you very much. Today's interview gave us a deeper understanding of the philosophy and activities of the Toyota Konpon Research Institute.

For even more people to learn about our institute, I will continue to conduct research that keeps up with the times together with colleagues who share the same aspirations.

For details regarding this interview, please visit our official note section.
(https://note.com/toyotakonpon/n/n8e376ad24a48)

We began working with leading global universities, aiming to become a research institute that brings together researchers from around the world.

This year, in addition to our activities in Japan, we launched new initiatives in collaboration with distinguished international universities. Our goal is to further elevate our efforts and become a research institute that attracts world-leading researchers.

Overview of activities

By partnering with strategic offices at top global universities, we have co-developed collaborative plans that build on each institution's unique strengths. This year, we launched concrete joint activities with Imperial College London in the UK and Princeton University in the USA.

Imperial College London

IMPERIAL — To explore potential research directions, workshops were held with researchers from Imperial College London.

Princeton University

PRINCETON UNIVERSITY — Five top-class researchers familiar with trends in cutting-edge science research were invited from Princeton University to visit the Toyota Group companies and hold seminars.

—These activities were carried out with the support of Imperial College London and Imperial Consultants.—

IMPERIAL Activities with Imperial College London

Aim

To explore "what to research" together with researchers from Imperial College London (hereinafter, "Imperial"), two workshops were held in London and Japan jointly with the Imperial team led by Professor Mary Ryan, Vice Provost (Research and Enterprise) at Imperial.

Activity results

Through the workshops, we were able to participate in Imperial's project creation process and gained valuable insight. In particular, the mechanism generates challenging ideas that are realistic and actionable, through fastpaced one-day sessions involving researchers with diverse backgrounds in terms of discipline, nationality, career stage, age, and gender. The process by which the panels select projects anticipates the development of discussion from the perspective of their foresight and expertise, facilitating and deepening the conversation. We will use this experience to raise the level of our ongoing activities and expand the scope of our activities with Imperial to grow together.

Vice Provost (Research and Enterprise) **Prof.Mary Ryan**

Partnering with TOYOTA KONPON has been an enriching experience.
The exchange of ideas between our institutions has led to fortuitous insights and a deeper understanding of our shared goals.

Associate Dean (Industry Partnerships, Engineering) **Prof.Ricardo Martinez-Botas**

To be engaged in this workshop, that asked big questions, has been illuminating, exciting, and fun. It is great to see a major industrial partner to be interested in this type of big exploration where the gains are very much focused on benefit to humanity; this is aligned with our strategy at Imperial.

Innovation Ecosystem Manager **Dr. Jing Pang**

It has also been a great pleasure to work with the TKRI team. The cultural and geography differences have not only made the conversation better, but it has also synergised the quality of discussions by utilising the best of both worlds. We are looking forward to deepening our friendship and making a positive future a reality together.

Activity details

Idea generation workshops were held twice: once in London and once in Japan. In London, 35 Imperial researchers participated and contributed their ideas. The ideas selected in London were then elaborated on and presented in Japan.

Day1 • Dinner Broadening our thinking

On the eve of the workshop, participants were grouped into teams and invited to reflect on the proposed project. Individual reflections were shared, synthesised into a collective team perspective, and presented over dinner. This activity helped broaden thinking ahead of the workshop and served as a valuable icebreaker, fostering early connections among participants.

Presenting science fiction that each team developed

Day2 • Morning Exploring Perspectivess

The participants were divided into teams and discussed a "what if" question: what kind of world would be desirable in the future?

Broadening ideas by writing them down

Day2 • Lunch Idea Evaluation

Before the selection, each team presented their ideas, and participants voted on the concepts they found most compelling.

Participants voting for ideas

Day2 • Afternoon Identifying bottlenecks

Participants were divided into groups with members different from their original groups, and discussed potential bottlenecks that may emerge in accomplishing the selected ideas.

After the workshop Developing Selected Concepts

Four concepts were selected from the ideas generated during the London workshop. These were further developed and presented at the follow-up session in Japan.

Presentation

❶ Empathy detection ❷ Autonomously Intelligent Materials
❸ Edible Bio-nano coating ❹ Superplants

Presentation at the workshop in Japan

More than 10 researchers from Imperial attended the workshop in Japan, alongside approximately 30 participants from Japan—including research advisors from the Search Program and representatives from various Toyota Group companies. The Imperial-led sessions offered participants the opportunity to experience Imperial's approach to idea creation first-hand.

Group photo

Prospects for 2025

Imperial College London

■ Taking the idea creation workshop to the next level

This year, the workshop brought together researchers specialising in materialsand engineering to discuss visions for the future. Next year, we plan to expand participation across a wider range of disciplines to spark more diverse ideas— both in topic and in the approach to idea creation.

■ Feasibility study of selected projects

Two projects will be selected from those presented and a feasibility study will be conducted to assess their viability.

Activities with Princeton University

Aim

In 2023, we invited Professor Craig B. Arnold, Vice Dean for Innovation, and Dr. Sacha Patera, strategic liaison office, to Japan to introduce Princeton University's approach to establishing research projects. In 2024, taking one step further, our goal is for each participant to develop a "future vision" on what to choose as a subject in the advanced research field and how to move it forward. To that end, we invited professors from Princeton University to Japan, world-class leaders in advanced research.

Activity results

"Princeton Days" was held in Tokyo and Aichi for three days from February 18 to 20, 2025. After repeated discussions with Prof. Arnold and Dr. Patera, we invited five professors involved in AI and quantum research (see below). The professors shared their latest research results along with explanations of the larger picture and future outlook of each discipline at the Toyota Group's major research institutes (Woven by Toyota, Toyota Central R&D Labs., and the DENSO Advanced Research and Innovation Center). Additionally, each research institute set up a forum for their researchers to introduce their research accompanying a series of discussions. Attended not only by the Toyota Group but also by research advisors in the Research Exploration Program (Professor Imai, Osaka University and Professor Ozawa, Tohoku University), Princeton Days provided a new opportunity for academia internally and externally.

Prof. Craig B. Arnold
Vice Dean for Innovation

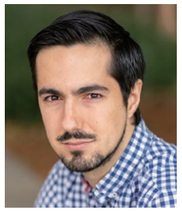
Dr. Sacha Patera
Corporate Engagement & Foundation Relations

Our relationship with the Toyota Konpon Research Institute since 2023 is valuable to Princeton in many ways. In particular, it was very beneficial to have met the talented and creative leaders and related parties from the Institute and Toyota's research and development organizations. The culture of pushing back the limits of engineering and science with an intensely curious and inquisitive mindset inspired us a lot and that motivates our involvement.
We also would like to express our deep respect for Dr. Kikuchi's vision for the Toyota Konpon Research Institute and his proposal for mutually beneficial value that the partnership with Princeton will bring.

— Professor Craig Arnold, Innovation Officer, Princeton University.

LECTURE 1

February 18, 2025
At Woven by Toyota



Speech Title **Can AI Unlock Robot Safety?**

Lecturer **Jaime Fernández Fisac**

Assistant Professor, Department of Electrical and Computer Engineering

https://saferobotics.princeton.edu/

LECTURE 2

February 19, 2025
At Toyota Central R&D Labs

Speech Title **Understanding Natural and Artificial Minds**

Lecturer **Thomas Griffiths**

Henry R. Luce Professor of Information Technology, Consciousness, and Culture; Professor of Psychology and Computer Science; Director of the Computational Cognitive Science Lab; Director of the Princeton Laboratory for Artificial Intelligence

https://cocosci.princeton.edu/index.php

LECTURE 3

February 19, 2025
At Toyota Central R&D Labs

Speech Title **Limits and Opportunities for Photonic Control**

Lecturer **Alejandro Rodriguez**

Professor, Electrical and Computer Engineering

https://arodriguez.princeton.edu/

LECTURE 4

February 20, 2025
At the DENSO Advanced Research and Innovation Center

Speech Title **A Window into Novel Quantum Materials and Future Qubits**

Lecturer **Ali Yazdani**

James S. McDonnell Distinguished University Professor of Physics; Co-director of the Princeton Quantum Initiative; Director of the Princeton Center for Complex Materials

https://yazdanilab.princeton.edu/

LECTURE 5

February 20, 2025
At the DENSO Advanced Research and Innovation Center

Speech Title **Superconducting Quantum Computing: From Materials to Mathematics**

Lecturer **Andrew Houck**

Anthony H.P. Lee '79 P11 P14 Professor of Electrical and Computer Engineering; Associated Faculty in Physics; Co-director of the Princeton Quantum Initiative

https://houcklab.princeton.edu/

Prospects for 2025
Princeton University

Princeton Days brought us closer to Princeton University and we were able to easily exchange opinions. We were able to achieve some understanding of the future in the extensive, cutting-edge fields of AI and quantum. In 2025, we will further narrow down the research areas and members in terms of research project creation, providing opportunities for intensive discussions.

Prospects for 2025

Future activities

In 2024, we launched specific efforts to "research what to research" together with Imperial College London and Princeton University. In 2025, we place the focus of our activities on ① taking our relationship with the two universities to the next stage and further defining "what to research," as well as ② working to develop new partners who agree with our PVMV. Our activities aim to lay a foundation that connects academia both at home and abroad as well as global business entities.

SEARCH

Expanding and advancing systems to cultivate curiosity-driven exploratory research topics through collaboration with academia

This program launched in 2022 by inviting active academic researchers from various fields to serve as research advisors. Interdisciplinary projects were researched based on cutting-edge research results. In 2024, the program's third year, we implemented the search Exploration Program in broader research domains with a greater number of invited researchers, creating a "framework" made up of activities themselves.

Framework of research project creation

Which mountain should I choose from the mountain range?

Activities that look across the vast mountain range [research field] and discover an unexplored, cutting-edge, and interdisciplinary mountain [research project]

Search > Exploration

Are there any precious gemstones in that mountain?

Activities to verify, evaluate, review, and determine research projects identified through exploratory efforts

The search and exploration of research themes require broad insight, deep expertise, and diverse perspectives. There are limits to activities that rely on the abilities of individual researchers. In our Search program, we invite researchers engaged in cutting-edge research from a variety of fields. Through discussions with these researchers, we work to discover unexplored research projects from many standpoints.

Evolution in 2024

■ Broadening ideas by expanding into the humanities:

In 2023, joint exploration efforts with 21 researchers from three fields of natural science (science of matter/materials and science of intelligence/intellect and life Sciences) and humanities found four exploratory research projects. In 2024, we invited two researchers from the design and art fields in an attempt to fuse the three fields of natural science with the humanities, aiming not only to "comprehensively and fundamentally ascertain matters" as set forth in 2023, but also to identify new research theme that induce a feeling of being related to mankind in the future while creating knowledge from a different angle, instead of the perspective of natural science.

■ Creating opportunities for face-to-face meetings

In 2023, more than twice as many research advisors participated compared to the previous year. We were able to increase the number of workshops and opportunities for face-to-face discussions, but it was still not enough for every research advisor to meet in person. Based on our policy that face-to-face communication is essential for creating research projects, we set up a "kickoff meetup" in the style of a training camp to get together initially.

Approach to projects creation

To help researchers from different fields create interdisciplinary projects, we held the kickoff meetup one month earlier than last year. It was held in 2023 for early initiation of dialogue towards the projects, based on the approach and steps introduced in 2023. Additionally, to facilitate research advisors' proactive participation in discussions, the annual schedule and aims of each meeting were shared at this early stage.

STEP 1	Getting to know each other	Discover new topics based on other cutting-edge research fields
STEP 2	Broadening ideas	Share sensory ideas to eliminate difference in senses
STEP 3	Converging ideas	Converge different ideas and refine topics
STEP 4	Deciding research topics	Decide projects by discovering the appeal of each topic

Steps required to decide on projects and the results of activities

Shown below are the steps required for research advisors to co-create (co-run) new research topics based on their empathy across disciplines. The search Program 2024 was held with the participation of 25 research advisors. Researchers from different fields proposed nine research topics through the four steps and selected two new interdisciplinary research project.

STEP 1 Getting to know each other

Training camp: April — 25 researchers

Step 1 provides researchers who do not usually meet each other the opportunity to discuss their current research interest and aspirations, such as research topics they want to take on in the future.
The aim is to identify new interdisciplinary research topics based on cutting-edge research results. We scheduled meetups to allow researchers to know each other better, which were planned in 2023, as well as one-on-one meetings for mutual communication, in a training camp style. As a way to remove physical/psychological barriers between participants, the camp offered opportunities to share extraordinary experiences through cruising and other excursions in addition to formal introductions.

Get-together at Meetup training camp

STEP 2 Broadening ideas

Workshop 1: May; Workshop 2: June — 28 ideas

To encourage broader thinking in research advisors, it is important to share sensory ideas that are difficult to verbalize. At the Workshop in May, we partially incorporated graphic recording into group dialogues, and we reconciled interdisciplinary differences in senses hard to express in words by sharing pictures and diagrams.
This activity helped researchers generate 28 seeds of ideas for interdisciplinary projects.

Dialogue at workshop

STEP 3 Converging ideas

Workshop: July; Ideathon: September — 9 topics

To accelerate team dialogue by focusing on a specific topic that motivates researchers chosen from those proposed, one "convener" was appointed for each topic to facilitate each discussion. Also, with the number of team members per topic limited to four, research topics were announced at the July workshop.
The Ideathon was also held as a forum for brainstorming ways to improve ideas in ways that researchers in other teams would find them more intriguing, interesting, or relatable. The "seeds of ideas" developed through STEP 2 were required to meet a certain standard. For that reason, with some changes from the year before last, the seeds were converged on nine topics by putting the narratives of the topics into words and arranged according to the criteria 1 to 5 (with a special emphasis on 4: Who cares?) of the Heilmeier Catechism.

Announcement of research topics

STEP 4 Deciding research topics

Contest: November — 2 projects

Based on feedback obtained from the Ideathon, a Contest was held in November where researchers relied on their curiosity to decide which research themes would move on to the exploration phase. The Contest was held face-to-face to encourage enthusiasm and a deeper exploration into the content and topics. Research advisors formed teams comprising members who wanted to work together, and each team presented their research Project, followed by peer voting by research advisors and voting by research coordinators to finally decide on research Project.

Presentation at the Contest

2024 selected projects

In addition to the projects selected through peer voting by research advisors, projects were also selected by research coordinators. Ultimately, the following two projects were selected for exploration. After formulating research plans, researchers will begin exploratory research for the selected projects.

- Between Life and Death
- Prediction and Control of Large-Scale and Complex Systems

Feedback from research advisors

A bridge between researchers and the Toyota Group in collaboration

Yuko Ikkatai
Associate Professor, Institute of Human and Social Sciences, Kanazawa University

At first, I was a little confused because the approach was different from my approach with the research I do every day. As I participated as a research advisor, however, I realized that there are some types of research that can only be achieved through nascent initiatives like these, and that the Toyota Group places great importance on collaboration with external researchers.

Chances for unprecedented encounters and new challenges

Rina Takagi
Associate Professor, The Institute for Solid State Physics, The University of Tokyo

When I was approached, I was not sure if I could contribute as a research advisor while taking care of a five-month-old baby, but the kind words, “There are many research advisors who are raising children, and you can use childcare services,” pushed me to try. As it turned out, I was able to participate in all the on-site programs with peace of mind. It was a wonderful opportunity for both me and my child to meet new people and take on new challenges.

Prospects for 2025

■ Early creation and selection of higher-level research topics (with the Contest moved forward by another two months)

In 2024, we were able to remove psychological barriers by gathering everyone together in person early on, which fostered dialogue on project creation at an early stage. While the project creation period was set early on, the period from STEP 3 “Converging ideas” to the Contest in November was prolonged. With this in mind, in 2025 the Contest will be scheduled in September to balance the period between project creation and convergence.

■ Approaching the search Program scientifically from the perspective of a research advisor

To this point, we have designed the Search Program from the perspective of research coordinators and established a tentative “framework” for generating ideas leading to interdisciplinary research projects. Aiming at a higher level of meticulousness in exploration, we will not only focus on creating fertile ground for the program from the perspective of research advisors but also challenge ourselves to analyze data obtained from research advisors participating in new interdisciplinary projects and the ground for innovation. Based on the data accumulated here, we will pursue fundamental (Konpon) factors necessary for the creation of high-level research topics.

EXPLORATION

Building on research plans developed through academic exploration, our projects are evolving and attracting researchers from many diverse fields of endeavor.

Framework of research project creation

Which mountain should I choose from the mountain range?

Activities that look across the vast mountain range [research field] and discover an unexplored, cutting-edge, and interdisciplinary mountain [research project]

Search > Exploration

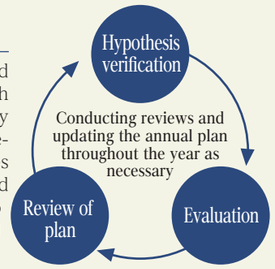
Are there any precious gemstones in that mountain?

Activities to verify, evaluate, review, and determine research projects identified through exploratory efforts

Exploring themes require broad insight, deep expertise, and diverse perspectives. There are limits to activities that rely on the abilities of individual researchers. In our exploration efforts, we invite researchers engaged in cutting-edge research from a variety of fields. Through discussions with these researchers, we work to discover unexplored research projects from many standpoints.

How to Proceed with Research Exploration

Many exploratory research projects are challenges in unknown and unexplored research fields. Consequently, we can expect situations which do not proceed or differ from initial assumptions. Therefore, it is necessary to agilely review the original plan. Through a continuous cycle of hypothesis verification, evaluation, and refinement, we strive to develop theories and technologies that are not only original but also expandable and universally applicable. By iteratively evolving these concepts, we aim to establish them as the next generation of cutting-edge exploration-based research projects that will attract a diverse range of researchers.



Exploratory Research Projects Launched in 2024

Convenor
Miho Yanagisawa
Associate Professor
Graduate School of Arts and Sciences
The University of Tokyo

Exploration of Universal Structures in Multi-component, Polydisperse Systems

We study multi-component, polydisperse systems with an extremely large number of components and degrees of dispersion, treating them as model systems representative of our complex world. This method facilitates our mathematical approach and supports our goal to identify points of universality. Specifically, we are committed to building a mathematical framework, presenting experimental examples, and conducting data analysis in a manner incorporating machine learning. Our primary goal is to establish, within three years, a broad correspondence between basic theory and experimentation.

Convenor
Asa Ito
Professor
Institute of Innovative Research
Tokyo Institute of Technology

Artificial Embodied Intelligence

By endowing AI with the leakage characteristics of internal organs (thereby opening up the AI's calculation processes to the outside world), we aim to imbue AI with the same "here-and-now" sensibility we possess as humans when making our own judgments.

Convenor
Hitoshi Matsui
Associate Professor
Graduate School of Environmental Studies
Nagoya University

Convenor
Kosuke Fujishima
Associate Professor
Earth-Life Science Institute
Institute of Science Tokyo

Designing the Future of the Earth's Environment

Geo-bioengineering represents an innovative attempt to minimize the impact of global warming by actively controlling this phenomenon through the twin-pronged approach of climate and biology. We intend to guide the global environment in a positive direction in the future by implementing environmental design through a wide-ranging collaboration encompassing climate science, the life sciences, forecasting science, and the social sciences.

Exploratory Research Projects Launched in 2023

Convenor
Tetsuya Kobayashi
Professor
Institute of Industrial Science
The University of Tokyo

Principles and Limitation of Frontier Exploration

We aim to define the concept of "frontier exploration" as the quest for groundbreaking discoveries of knowledge that lies outside the realm of current human understanding, at the same time clarifying both the relevant principles and scope of application. Specifically, we are focused on studying theories, algorithms, and methodologies that are likely to improve the efficiency of frontier exploration while using a mathematical approach to elucidate the effectiveness and limitations of this approach.

Convenor
Tomoko Isomura
Associate Professor
Department of Cognitive and Psychological Sciences
Graduate School of Informatics
Nagoya University

Multi-Dimensionality of Nonverbal Communication

It is well known that when humans communicate, patterns and rhythms such as bodily movements, heart rate, and brain waves tend to become synchronized in a phenomenon that contributes to closer communication and more efficient learning. The mechanisms by which this synchronization and desynchronization occur remain unclear, however. In this study, we aim to clarify the mechanisms driving this tendency toward synchronization and desynchronization, focusing on bodily coordination and mass transfer. We also propose a novel approach that reconsiders human communication as an exchange via neurotransmission, with the expectation that this research can be applied to the symbiosis that occurs between organisms.

Convenor
Kei Hirose
Professor
Department of Earth and Planetary Science
Graduate School of Science
The University of Tokyo

Syntheses of Iron Polyhydrides under Extreme Conditions

We aim to synthesize iron polyhydrides, which do not readily form under normal pressure, under conditions of ultra-high temperature and pressure while clarifying their structure and properties. Specifically, we intend to synthesize iron polyhydrides — whose existence has been predicted in theory but not yet been realized in practice — in order to identify their crystalline structures and evaluate their properties. This research will also enable us to elucidate the mechanism by which iron polyhydrides may be formed in the Earth's core and deep mantle. This research holds the promise of revealing the essence of the Earth's origin and evolution.

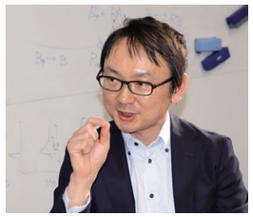
Convenor
Ayuko Hoshino
Professor
Research Center for Advanced Science and Technology
The University of Tokyo

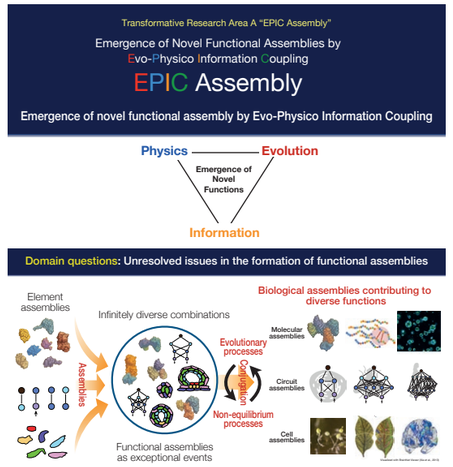
Elucidating Exosomal Trajectory in Aging and Age-related Disease

Exosomes are microvesicles that transport and transmit cellular information in packages, serving as a means of communication between cells and organs. This study seeks to quantify the health status of people of various age groups by using the cellular information contained in the exosomes released by all cells and organs to predict and detect Alzheimer disease and other diseases of aging at an early stage. Through this research, we will clarify the information transmission mechanism of exosomes and their universality.

From Exploratory Research to the Development of Transformative Research A under the JSPS

A novel area of focused research known as "EPIC Assembly" has been adopted as Transformative Research A (specifically, Publicly Offered Research) under the Japan Society for the Promotion of Science (JSPS). This topic springs from the researcher network and research insights expanded by the workshop activities of the exploratory research project under Professor Tetsuya Kobayashi of the Institute of Industrial Science, The University of Tokyo, who is a phase one research assistant of the Toyota Konpon Research Institute. In April 2025, a national project was launched in parallel with this exploratory research project.





LECTURE SERIES

It provides a novel forum for individuals looking to utilize cutting-edge research as a means of envisioning their own future prospects.

“Where Do We Come From and Where Are We Going?”

Adopting the above question as a common theme, the Toyota Konpon Research Institute has been hosting its own eponymous lecture series since fiscal 2022. The aim of this initiative is twofold: to raise interest in the flow of knowledge that links science, technology, and engineering; and to develop a foundation that interconnects the intelligence acquired through this initiative to the full-scale research undertaken by Toyota Group companies. This lecture series introduces the latest scientific findings to a wider audience, aiming to improve scientific literacy by providing novel perspectives, broader horizons, and elevated viewpoints.
In addition to presenting our conventional lecture series, we launched our new Outlook Program in fiscal 2024 that employs the concept of posing the same questions. This program is designed for those who aspire to make use of cutting-edge research and aims to support them in shaping their future outlook through dialogue with the lecturers. It provides an opportunity to consider the journey of fundamental science up to the present day, to ponder how it will develop in the future, and to envision how it will interact with our technology.
The scope of these lectures includes the three pillars of the Toyota Konpon Research Institute: The Science of Matter/Materials; The Science of Intelligence/Intellect(mathematical science + information science); and The Life Sciences. In 2024, “The Life Sciences” and The Science of Intelligence/intellect were presented as Toyota Konpon Research Institute lectures, while The Science of Matter/Materials was the featured lecture of the Outlook Program.

TOYOTA KONPON RESEARCH INSTITUTE Lecture Series

— Target Audience —
A wide audience across the Toyota Group

— Purpose —
To improve scientific literacy

Outlook Program

— Target Audience —
Those seeking to leverage cutting-edge research

— Purpose —
To enable participants to envision their own future prospects through dialogue with lecturers

Common Concept: Where Do We Come From and Where Are We Going?

Life Sciences

Science of Intelligence/Intellect Science of Matter/Materials

Science of Intelligence/Intellect Science of Matter/Materials

TOYOTA KONPON RESEARCH INSTITUTE Lecture Series

Overview of activities

Regarding the series on the Life Sciences, we aimed to provide a broad understanding of this branch of science by having one lecturer present a total of three lectures. On the other hand, regarding the Science of Intelligence & Intellect series, we adopted a lecture theme that responds to current trends by focusing on generative AI. We invited three lecturers active in this field to each present a lecture that conveyed the forefront of research in this field.
As in the previous year, we maintained a hybrid format and provided a platform for group discussions following the lectures. This not only deepened understanding through discussions with the lecturers but also created a good opportunity for participants to share their awareness of issues.

What is Life?

Series I [Life Sciences]

Unraveling the Large-scale Systems of Life from a Scientific Perspective

The human body comprises 11 major organ systems, which in turn are composed of an astonishing 37 trillion cells. In these life systems, which are grounded in concepts much different from those common to present-day engineering, substances are metabolized randomly while functionality and appearance are maintained, which results in systems that are both efficient and highly rational.
In the first session, “Life from a Cellular Perspective,” we took an overarching view of all life systems starting with the basic unit of life, the cell. In the second session, “Autophagy as the Guardian of Life,” we examined the formation of unique response environments and the mechanisms of material transport in living systems. In the third session, “The Future of Autophagy Manipulation,” we studied the cutting edge of the life sciences as we enter an era characterized by a shift from elucidation to intervention.

Session 1: May 28, 2024 Participants: 871
Session 2: July 24, 2024 Participants: 935
Session 3: August 23, 2024 Participants: 825

Session 1 “Life from a Cellular Perspective”
Session 2 “Autophagy as the Guardian of Life” (Co-hosted by the Toyota Physical and Chemical Research Institute Forum)
Session 3 “The Future of Autophagy Manipulation”

Tamotsu Yoshimori
Specially Appointed Professor
Comprehensive Health Promotion Science Program
Division of Health Sciences
Graduate School of Medicine
The University of Osaka

Rethinking Intelligence in the Era of Generative AI

Series II [Science of Intelligence]

How can we adapt and grow in an era of coexistence and collaboration with Generative AI?

Session 1 “The Evolution of Generative AI and the Democratization of Intelligence”
Daisuke Okanohara
Representative Director & Chief Executive Researcher
Preferred Networks Inc.

Session 2 “How Can Humans Thrive in the Era of Generative AI?”
Shota Imai
CEO
GenesisAI Co., Ltd.

Session 3 “Human-AI-Integration”
Junichi Rekimoto
Professor
Graduate School of Interdisciplinary Information Studies
The University of Tokyo
Chief Science Officer / Fellow
Sony Computer Science Laboratories, Inc.

In our 2023 lecture series, we presented a conference broadly focused on AI, but over the following year, Generative AI emerged at an even more rapid pace, taking the world by storm. Acknowledging this trend in fiscal 2024, we focused the conference theme specifically on Generative AI.
To discuss this rapidly changing field, we invited three speakers celebrated as researchers as well as business leaders. In the first session, Daisuke Okanohara provided an overview of the rapid evolution of Generative AI and its current application. In the second session, Shota Imai re-evaluated the changes in work and human creativity following the proliferation of Generative AI. In the third session, Junichi Rekimoto delved into the values that will be needed moving forward.

Session 1: December 11, 2024 Participants: 1,275
Session 2: January 17, 2025 Participants: 1,259
Session 3: February 13, 2025 Participants: 1,290

Outlook Program

Overview of activities

In 2024, we adopted the theme of “Earth and Planetary Science.” As humans, we tend to perceive things at the scale we inhabit — the time scale of a human life and the scales of temperature and pressure that humans can endure. However, the materials that surround us have been created on the broad scales of time, temperature, and pressure that have been present on Earth at various times. The Outlook Program, meanwhile, focused on materials and resources viewed from the perspectives of Earth and planetary science.

[Science of Matter and Materials]

Session 1 September 20, 2024 **“The Earth’s Iron, Hydrogen and Helium: Using the Formation of the Earth to Understand the Universality of Planets Capable of Hosting Life in the Universe”**

Kei Hirose

Professor, Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Iron is the heaviest element among those abundant in the solar system, and it forms the core of planets—not just Earth. Hydrogen and helium are the most abundant elements in the solar system, and they are recognized as the main components of the gas giants Jupiter and Saturn, which each have a strong gravitational pull. It is still not well understood how much hydrogen (water) and helium exist on the smaller planets such as Earth and Mars. Under atmospheric pressure, the solubility of hydrogen in iron is very low; furthermore, helium is representative of the inert gases. However, recently we have found that under high pressure, both hydrogen and helium have a strong affinity for iron, significantly changing our understanding of the origins of Earth’s water (specifically, its oceans) and the amounts of hydrogen and helium within its core.

We have also succeeded in synthesizing previously unknown iron hydrides under ultra-high pressure. We are currently exploring their crystalline structure, as it is possible that their hydrogen atoms are quite close together. It is therefore anticipated that physical properties similar to those of metallic hydrogen will be observed.

Session 2 November 20, 2024 **“The Evolving Earth and Its Resources: The Building Blocks of Our World”**

Masayuki Ikeda

Associate Professor, Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Resources are important elements that provide the very foundation of industry and society. Over the 4.6 billion years of evolutionary processes that have taken place on Earth, a diverse array of resources — including mineral resources, hydrocarbons, and water — have taken form. Since its birth, the Earth has been constantly changing through volcanic activity associated with plate tectonics, climate change, and the evolution of life. These processes play a significant role in the generation of metal deposits and energy resources, which is why these resources are unevenly distributed across the planet. It has also become clear that the impact of the emergence and evolution of life on the Earth’s environment — particularly changes in the redox state of the atmosphere and oceans such as the increased atmospheric oxygen due to photosynthesis and changes in dissolved oxygen concentrations in the oceans due to warming — have led to the emergence of new resources. We asked Professor Ikeda to share the latest findings on how the resources we use on a daily basis circulate within the Earth’s material cycle.

Post-lecture Discussion

Lecturer Session 1: Kei Hirose
Session 2: Masayuki Ikeda

Facilitator Kazuhiro Egashira Corporate Planning and Promotion Department Toyota Central R&D Labs., Inc.

Following the lecture, a discussion was hosted by a facilitator who led the discussion by asking intriguing questions of the participants and speakers. This created an atmosphere of lively dialogue throughout the venue, with many opinions and questions being exchanged among the participants. As the discussion expanded, a variety of perspectives were presented, providing an opportunity for discussion of deeper insights and new discoveries that would be difficult to develop at a typical lecture.

Comments from lecture participants

Life Sciences

I was particularly interested in the lecture on the theme of thinking about life. There are many things I thought I understood but actually didn’t, such as COVID, genes, DNA, and genomes. It reminded me once again of the importance of deconstructing and thinking about things like this.

Science of Intelligence

Until now, I only had the image of AI as a means of improving efficiency, but I was very impressed by the idea that it can also give a sense of efficacy. It was a good opportunity for me to think about how we can take advantage of AI not only in work but also in daily life.

Science of Intelligence

I learned a lot from the lucid and persuasive discussions on the latest research results.

Outlook Program

During the panel discussion, I was able to hear questions and opinions from listeners who had different perspectives from my own about the lecturer’s explanatory materials. I think it would make panel discussions even better if the panelists looked back on their material that seemed particularly important and presented different perspectives on the topics.

Outlook Program

I’m grateful that people with specialized knowledge talked with us to initiate discussion. The pressure I initially felt from the word “discussion” was off, and it turned into a time for learning.

Prospects for 2025

In 2025, we will continue to provide Toyota Konpon Research Institute lectures on a regular basis to broadly enhance science literacy as well as outlooks for individuals seeking to access cutting-edge research as a means to envision the future.

2025 Lecture Series Preview

A series of lectures covering a variety of research topics have been scheduled for this year. For Series I, we are preparing to give three lectures on quantum science. The basic concept of quantum technology, which is receiving a great deal of attention from society and industry, will be discussed, as well as the concept of teleportation. From the fourth lecture onwards, lectures will be held on different topics. In each lecture, experts will comment on the latest research results and technological trends. Please look forward to these presentations.

In-depth exploration of lecture topics in books

[Life Sciences]

LIFE SCIENCE: Lectures for the Era of Mandatory Longevity
Nikkei Business Publications, Inc.
Tamotsu Yoshimori (Author)

[Science of Intelligence]

SCIENCE: How Generative AI Works: “Flow” Creates Images, Audio, and Video”
Iwanami Shoten, Publishers
Daisuke Okanohara (Author)

How Generative AI Will Change the World
SB Shinsho
Shota Imai (Author)

10 Predictions for the Future Discussed by University of Tokyo Professors
Daiwashobo
Junichi Rekimoto et al. (Authors)

Connecting academia from different fields and promoting “researching what to research”

Research coordinators connect with a variety of researchers, including promising academic researchers and well-known researchers. While learning varied and unique ideas and perspectives through dialogue with researchers, coordinators work together to create new knowledge and fly over knowledge watersheds. By collaborating with researchers to “research what to research” in science, coordinators are gaining valuable experience to think, execute, and make improvements on their own initiative. This experience will equip them to lead effective science initiatives within their organizations. In 2024, two new research coordinators joined us to promote the mission of Toyota Konpon Research Institute.

Main activities

• Planning and management of Research Exploration Program • Planning and promotion of exploratory projects • Collaboration with overseas universities • Planning and management of lectures

Introducing research coordinators

■ Members seconded from Toyota group companies

Tomoya Takatani
Toyota Motor Corporation

Mitsuru Nakano
Toyota Central R&D Labs., Inc.

Yusuke Hongo
Denso Corporation

Masaki Otomori
Aisin Corporation

Akihiro Suzuki
Toyota Industries Corporation

Kanae Hamaguchi
Toyota Central R&D Labs., Inc.

■ Members invited from academia

Momo Nakanishi
Associate Professor, Graduate School of Agricultural and Life Sciences, The University of Tokyo

A research coordinator invited from academia for the Research Exploration Program in 2024, continuing from 2023, planning and managing discussion that ensures psychological safety as well as connecting ideas between Toyota Konpon Research Institute and academia.

Column 01
(Akihiro Suzuki)

I used to work as an assistant professor at a university. Now that I’ve got another chance to be involved in academia, I’m excited to create new knowledge from a fresh perspective compared to back then.

Column 02
(Kanae Hamaguchi)

I have had the valuable opportunity to meet with professors at the forefront of wide-ranging academic fields to think collaboratively about interdisciplinary research from its earliest phases. I will continue to work on new value creation, utilizing this new network of contacts.

Passing the baton from our predecessors to the next generation (Tomoya Takatani)

In April 2022, I was seconded from Toyota Motor Corporation, inspired by this institute’s founding philosophy of “researching what to research.” The Research Exploration Program and exploratory research put this philosophy into practical use, tailored to modern academic research settings. A total of 37 researchers participated in the three years of exploratory research, resulting in eight exploratory research projects.
In the fall of 2024, our exploration activities developed into joint work with overseas universities, sprouting new seeds of collaboration. Furthermore, in February 2025, one of our exploratory research projects was adopted as a research project for the Japan Society for the Promotion of Science’s Transformative Research A. We owe these achievements to the support of many people who discussed the program’s direction, researchers who resonated with our philosophy and participated in the program even when it was still in its inchoate stages, and research coordinators who have worked hard together. I would like to express my sincere gratitude to you all.

Prospects for 2025

A new research coordinator will be joining our team. Making the most of the knowledge gained from collaboration with academia in Japan and overseas, we will further enhance our explorative research and investigative research activities to create new projects. Additionally, two research coordinators have returned to their own companies. We are convinced that their experience and connections acquired at Toyota Konpon Research Institute will be useful in their continuous contribution to science-based activities at each company.

Company name	Toyota Konpon Research Institute Inc.
Established	June 11, 1996
Capital JPY	100 million
Location	Nishi-ku, Nagoya City Inside the Toyota Commemorative Museum of Industry and Technology
Representative Director	Takeshi Uchiyamada
President	Noboru Kikuchi
Directors	Tetsuro Toyoda Hiroyuki Wakabayashi Morito Oshita Hirofumi Inoue Hiroyasu Watanabe
Auditors	Hisaaki Takao Hirotaka Takeda
Business details	1. Research, investigation, and provision of technical information regarding future social predictions 2. Research, testing, and investigation of humanities and social sciences, natural sciences, and comprehensive technologies based on those sciences 3. Research, testing, and investigation regarding the development and use of science and technology, and the resulting effects and impacts 4. Research, testing, surveys, and the training and development of researchers and engineers conducted through mutual contracting or jointly with countries, administrative agencies, organizations, and research institutions
Shareholders	Toyota Motor Corporation Toyota Industries Corporation Aisin Corporation Denso Corporation Toyota Central R&D Labs., Inc. Aichi Steel Corporation JTEKT Corporation Toyota Auto Body Co., Ltd. Toyota Tsusho Corporation Toyota Boshoku Corporation Toyota Motor East Japan, Inc. Toyoda Gosei Co., Ltd.
History	June 1996 Established the Genesis Research Institute in the Toyota Commemorative Museum of Industry and Technology in Nishi-ku, Nagoya May 1997 Opened the East Tokyo Laboratory in the Cluster Research Laboratory of the Toyota Technological Institute, Ichikawa City, Chiba Prefecture March 2023 Closed the East Tokyo Laboratory July 2023 Changed the company name to Toyota Konpon Research Institute in an aim to become a research institute where the world’s top diverse researchers gather

Message from the Editor

Thank you for reading our Annual Report 2024. In our diversifying and changing society, Toyota Konpon Research Institute strives for “happiness and progress of humanity” as well as “harmony with the Earth and all living things” based on the Five Main Principles of Toyoda and our purpose of establishment, expanding our possibilities for the future. We have opened ourselves up to collaboration with academia and are co-creating research projects, aiming to become a research institute that continuously seeks and embraces new challenges.