Keio University Medical-Engineering Collaboration Project for Advanced Research and Education

○ Achievements

● AY 2024

Educational Activities: As of March 2024, the project comprised 72 faculty members, graduate students, medical students, and auditors. We held weekly meetings that included study groups, journal clubs, research progress sessions, active learning activities, and seminars with invited guest speakers and welcomed participation from medical students, graduate students, and physicians in fields such as ophthalmology, pediatrics, and obstetrics and gynecology. Auditing students from the Faculty of Science and Technology and the Graduate School of Business Administration also participated. In 2024, the program held five public seminars and symposia, attracting many students, researchers, and clinicians from both within and outside Keio University, leading to lively exchanges. For second-year medical students, we offered the course Medical Professionalism II "AI-Driven Healthcare: From AI and Medical Data Science to Extended Intelligence in Medicine," presenting the latest applications of AI in healthcare and medicine. In the Laboratory and Field Studies for third-year medical students, we accepted six students who conducted research on data science and biomechanics. At the graduate level, we welcomed two new first-year doctoral students who began their research. We offered an Introduction to Medicine course for master's students. As part of the Keio Global Science Campus project, we supervised one high school student who presented at a scientific conference. We have also been involved as planners, coordinators, mentors, organizers, and evaluators of the Health Medical AI Design Program (MAP). In 2024, we launched the Shinanomachi Data Science Forum, a university-wide research initiative aimed at promoting cross-disciplinary data science development, in collaboration with departments such as Biostatistics, Healthcare Policy and Management, and Preventive Medicine and Public Health within the School of Medicine. The forum was held twelve times over the year. In collaboration with the Department of Radiology, which has led the AI Hospital Project, we held monthly data science study sessions on AI in healthcare and medicine. As a central partner in the Next-Generation Cancer Medical Professional Training Program (Cancer Pro), we prepared and offered the intensive course "Prognostic Prediction and Prevention of Cancer Based on Medical Big Data," which attracted more participants than anticipated. The Cancer Pro program was

launched as a joint initiative among seven graduate schools: Institute of Science Tokyo, Graduate School of Medical and Dental Sciences; Keio University Graduate Schools of Medicine, Health Management, and Pharmaceutical Sciences; International University of Health and Welfare Graduate Schools of Medicine, Pharmacy, Pharmaceutical Sciences, and Public Health; Juntendo University Graduate School of Medicine; Tokai University Graduate School of Medicine; Tokyo Dental College Graduate School of Dental Science; and Tokyo University of Pharmacy and Life Sciences Graduate School of Pharmacy. In November 2024, we held a discussion session with Dr. Demis Hassabis, who delivered a lecture at the 29th Keio Medical Science Prize Commemorative Lecture, and graduate and medical students from our department, to explore the future of medicine and healthcare in the AI era.

Research Activities: As part of our join research within Keio University, we conducted research developing machine learning models based on clinical issues in partnership with multiple departments: Neurology; Rehabilitation; Rheumatology; Dermatology; Preventive Medicine; Nephrology, Endocrinology and Metabolism; Neuropsychiatry; Pulmonary Medicine; and Obstetrics and Gynecology. We also supervised undergraduate medical students, graduate students, and physicians engaged in data analysis. Under AMED's medical device project, we began developing a predictive model for pediatric food allergies in collaboration with Mie National Hospital. Under the Program on Open Innovation Platforms for Industry-Academia Co-Creation (COI-NEXT), we strengthened collaboration between RIKEN and Keio University teams, and advanced the implementation of the Science Knowledge Data Platform (SKDP) for research purposes. In collaboration with the Department of Nephrology, Endocrinology and Metabolism, we launched a project on renal aging. In 2024, research findings on biomechanical theory were published in a scientific journal and featured in the June 24 evening edition of the Asahi Shimbun's "Buratto Lab" column under the title "AI x Physics: Predicting the Future of Disease."

Medical-Engineering Collaborations: As part of our medical-engineering collaborations, we hosted the Ishii-Ishibashi Memorial Lecture, where Associate Professor Shu Tanaka from the Faculty of Science and Technology (Title at the time. Currently Professor, Faculty of Science and Engineering) gave a lecture titled "The Current Status of Quantum Computing Technology and Future Prospects." This event also initiated discussions on potential collaborative projects. Under the Program on Open Innovation Platforms for Industry-Academia Co-Creation (COI-NEXT), we continued

implementing the Science Knowledge Data Platform (SKDP) in collaboration with the Faculty of Science and Technology. We also initiated discussions with Carnegie Mellon University on applying the embodiment models developed in our program to robotics.

In March 2025, we hosted the Ishii-Ishibashi Memorial Lecture (Extended Intelligence for Medicine) International Symposium. Featured speakers included Dr. Miles C. Andrews (Australia), Dr. A. Gordon Robertson (Canada), and Dr. Scott E. Woodman (United States). A lively panel discussion followed, addressing the challenges of achieving personalized medicine using health and medical data and AI.
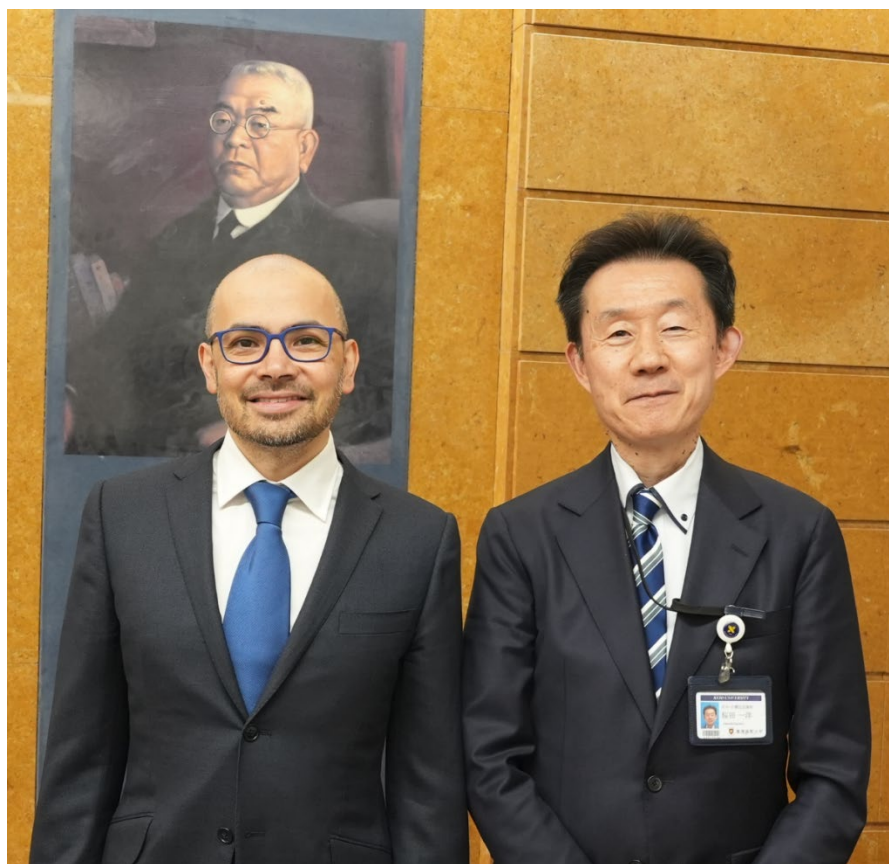
Sir Demis Hassabis with Professor Kazuhiro Sakurada, during Sir Demis' visit to Keio University in November 2024, where he gave a lecture at the 29th Keio Medical Science Prize Ceremony and Commemorative Lecture. That same year, he was also awarded the Nobel Prize in Chemistry.

Members of our department engaged in lively discussions.

In October 2024, at the 3rd Ishii-Ishibashi Memorial Lecture (Extended Intelligence for Medicine) Public Seminar, Associate Professor Shu Tanaka from the Faculty of Science and Technology gave a lecture titled "The Current Status of Quantum Computing Technology and Future Prospects." Many students from the Faculty of Science and Technology also took part, sparking active dialogue and meaningful exchanges between students and researchers from the School of Medicine and the Faculty of Science and Technology after the lecture.
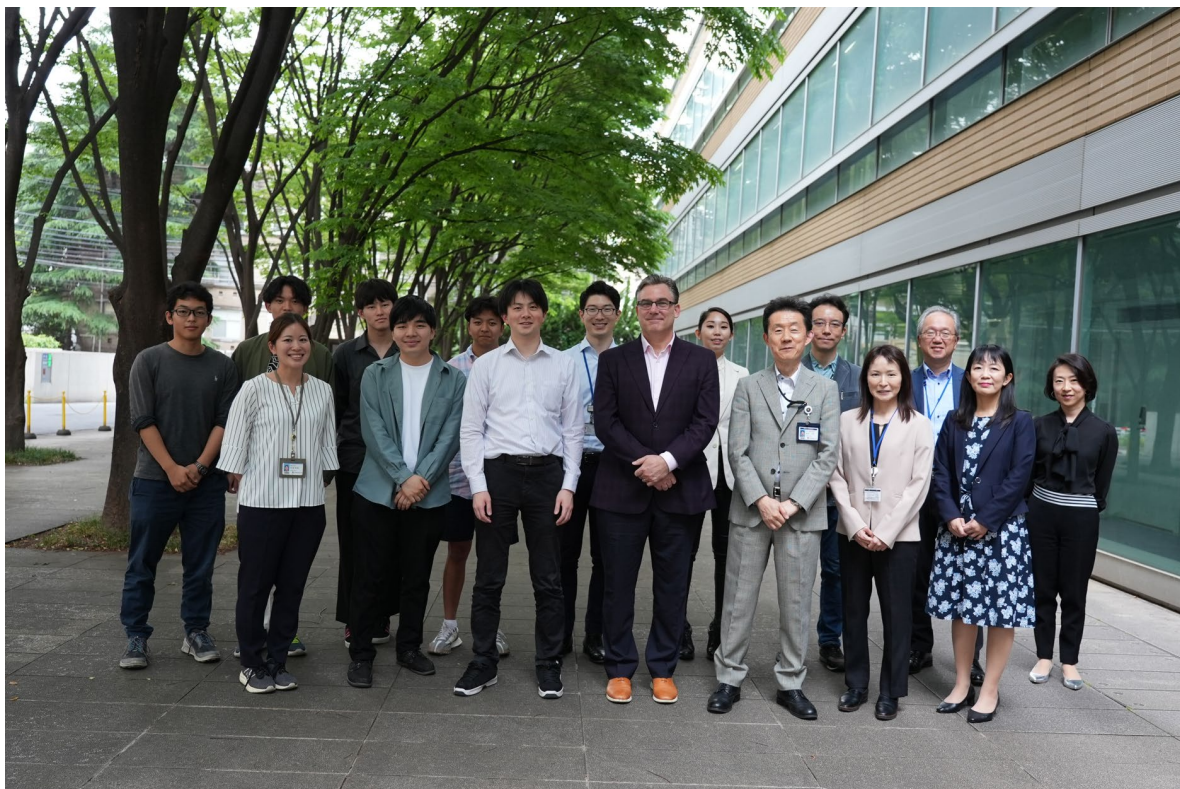
In May 2024, we held the 1st Ishii-Ishibashi Memorial Lecture (Extended Intelligence in Medicine) Public Seminar, where Dr. Scott E. Woodman from the University of Texas MD Anderson Cancer Center gave a lecture titled "Aggregation, Integration and Analysis of Multi-Dimensional, Multimodal Omics and Clinical Data Across Cancers."

In May 2024, Professor Sakurada participated in a panel discussion on AI and healthcare in Finland.

●AY 2023

Educational Activities: At the medical school, we hosted five first-year students for the Introduction to Medicine seminar and eight students for the lab tour, and three first-year students joined our department and began their research activities. We hosted six third-year students for independent study and provided them with programming instruction. Subsequently, nine third-year students joined our department and started their research activities. One of them is analyzing clinical data. Two fifth-year students in the MD-PhD program continued their research in our course. A total of 10 lectures on Introduction to Extended Intelligence Medicine were given to applicants at all levels of the medical school. At the Graduate School, we hosted a first-year doctoral program student to begin research. A lecture on Introduction to Medicine was given to the master's students. We are also mentoring a high school student as part of the Keio Global Science Campus project. We have also been involved as planners, coordinators, mentors, organizers, and evaluators of the Medical-Health AI-Design Program (MAP). Internationally, we have lectured as part of the AI4ONEHEALTH master's program at the Université Grenoble Alpes in France.

Research Activities: Collaborative research was initiated with the Department of Rehabilitation Medicine, the Department of Neurology, the Department of Rheumatology, the Department of Obstetrics and Gynecology, the Department of Dermatology, the Department of Neurosurgery, the Division of Tumor Immunology at the Institute for Advanced Medical Research, and the Center for Preventive Medicine. With the support of the JST Co-Creation Opportunity Formation Support Program (COI-NEXT), we participated in Research Project 2 and implemented the Science Knowledge Data Platform. We developed and published a paper on a universal analysis technique using non-negative tensor decomposition to analyze time-series biomedical data. In collaboration with the

Division of Tumor Immunology at the Institute for Advanced Medical Research, we developed a support tool for efficient genetic modification of T cells and published a paper and a press release. Developed a physical theory underlying predictive medicine, also resulting in a published paper and press release.

https://www.keio.ac.jp/ja/press-releases/2023/11/22/28-154650/ (Japanese)

https://www.keio.ac.jp/ja/press-releases/2024/1/16/28-156153/ (Japanese)

Medical-Engineering Collaborative Activities: We gave a special lecture on "AI Healthcare and Medical Treatment" at the AI and Advanced Programming Consortium (AIC), and began discussions on collaborations with Nanyang Technological University in Singapore and Findata in Finland. This year, we developed a basic theory of predictive medicine that combines principles from physics (non-equilibrium thermodynamics and quantum mechanics) with AI analysis, laying the foundation for a hybrid AI system. To promote interdisciplinary collaboration between medicine and engineering using this core technology, we participated in "Quantum-like Modeling" in Biology, Cognitive & Social Sciences, an event hosted by RIKEN, where we discussed the potential for integrating quantum mechanics with medical science.

https://ithems.riken.jp/en/events/quantum-like-modeling-in-biology-cognitive-social-sciences
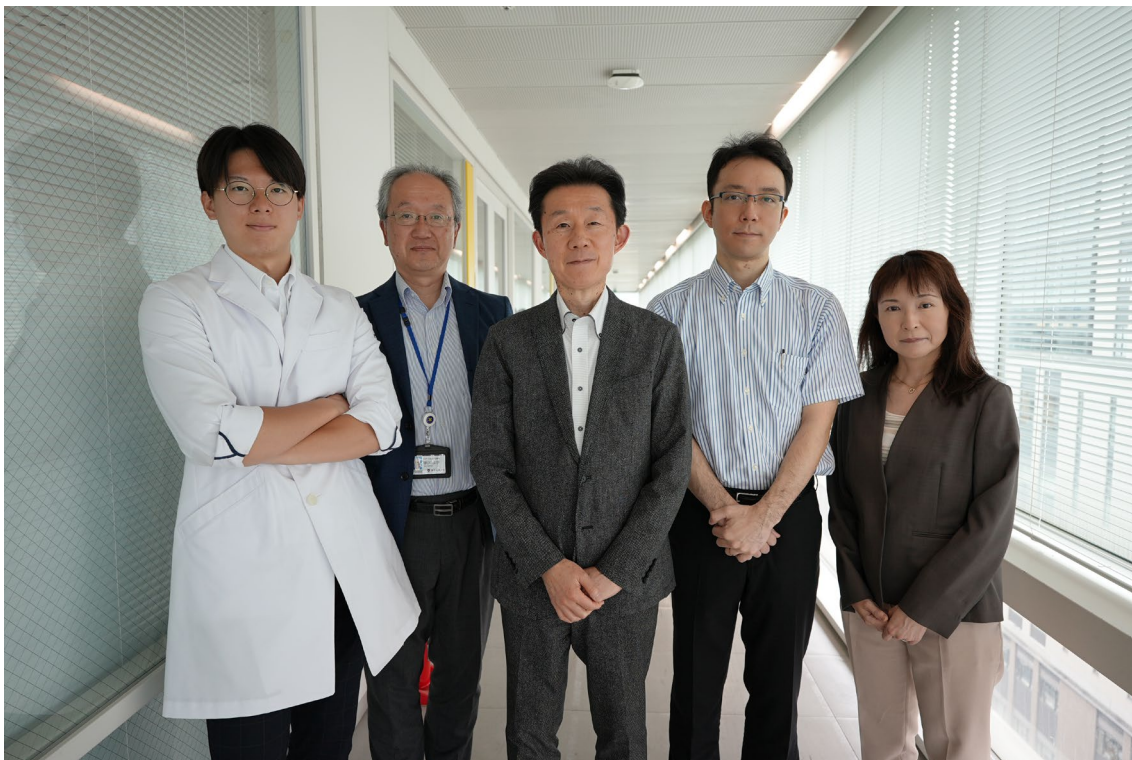
●AY 2022

April 2022: Dr. Tetsuo Ishikawa assumed the position of Associate Professor while Dr. Junna Oba and Dr. Ryoichi Yokoyama took up the post of Assistant Professor at the Ishii-Ishibashi Memorial Laboratory. In addition, in October 2022, Dr. Yoshihiro Fujie joined as Project Assistant Professor.

Educational Activities: The School of Medicine held an Introduction to Medicine Seminar for first-year students (4 sessions in total) and special lectures for second-year to sixth-year students (10 sessions in total). For graduate students in the Graduate School of Medicine doctoral and master's programs, lectures on AI and medical data science were held (3 sessions in total). At the Joint Medicine/Pharmacy Summer School, Professor Kazuhiro Sakurada delivered a lecture titled "From Artificial Intelligence to Extended Intelligence: Contemplating the Future of Bioscience and Medical Treatment." Two fourth-year

students in the physician-scientist training program (MD-PhD Program) began their research.

Research Activities: Joint research was initiated with the Department of Rehabilitation Medicine, the Department of Neurology, and the Department of Rheumatology. Under JST, Co-Creation Opportunity Formation Support Program (COI-NEXT), a platform called "Science Knowledge Data Platform" was designed and implemented. This research and development project was designed with the aim of creating an environment in which diverse academia can pool their wisdom and collaborate on data analysis. The implementation of a cloud-based system is currently underway. Associate Professor Tetsuo Ishikawa was invited by the Karolinska Institutet in Sweden and the University of Tübingen in Germany to introduce the latest analysis methods that utilize AI and present the results at a symposium. He also visited the University of Luxembourg, and the University of California, Los Angeles in the U.S., where he had exchanges with local researchers and professors on technology.

Medical-Engineering Collaborative Activities: Associate Professor Tetsuo Ishikawa and Professor Kazuhiro Sakurada delivered a special lecture entitled "AI Healthcare and Medical Treatment" at the AI and Advanced Programming Consortium (AIC). Also, at the Faculty of Science and Technology, Professor Kazuhiro Sakurada gave a lecture on "New Bioscience and Medical Treatment in the Age of AI and Data Science" under the theme of "Examining the Forefront of the Combined Technologies of Science and Medicine." In addition, Assistant Professor Ryoichi Yokoyama provided instruction to master's students in the Faculty of Science and Technology on the topic of diagnosing autism through deep learning of brain images sourced from open data.

●AY 2021

October 2021: Dr. Kazuhiro Sakurada assumed the position of the Ishii-Ishibashi Laboratory Chair as a professor. The laboratory was given the name "Department of Extended Intelligence for Medicine". In conjunction with the appointment, the Keio University Steering Committee for Advanced Biomedical Engineering Research and Education Project and the Joint Steering Committee for the Ishii-Ishibashi Laboratory were organized and held, and plans for future education, research, and organizational structure were reported.

November 2021: [Start of educational activities] Prof. Sakurada gave a lecture on "Creation of New Medical Care Based on Medical Data Science: From Artificial Intelligence to Extended Intelligence" to second-year medical students.

[Start of research activities] Professor Sakurada was appointed as the leader of Research Project 2 of "Urban Health Commons Co-Creation Center for Well-Being by Connecting and Involving Everyone" under JST, Co-Creation Opportunity Formation Support Program (COI-NEXT). This project is responsible for building a platform called "Science Knowledge Data Platform (SKDP)" to integrate medical data (disease names, medical records,

specimen tests, image reports and laboratory images, prescriptions, injections, etc.) and post-treatment data (nursing home records, sensor data from homes, etc.) scattered among hospitals, nursing care facilities, IT companies, etc. for advanced analysis by specialists. This data platform is designed to allow specialists to perform advanced analysis. This data platform is composed mainly of information that has been processed using pseudonyms to appropriately protect personal information. In addition, in order to improve the accuracy of analysis using machine learning and deep learning, the data platform provide users with data science techniques such as feature engineering and algorithm selection for solving health care problems. By March, the construction of the core data platform was completed.

https://www.health-commons.com/randd (Japanese)

Feb. 2022: Tetsuo Ishikawa was appointed as Associate Professor, and Junna Oba and Ryoichi Yokoyama were appointed as Assistant Professor.

March 2022: Construction of a laboratory for medical data science was completed on the 9th floor of the Center for Integrated Medical Research (Research Park) at the Shinanomachi campus.