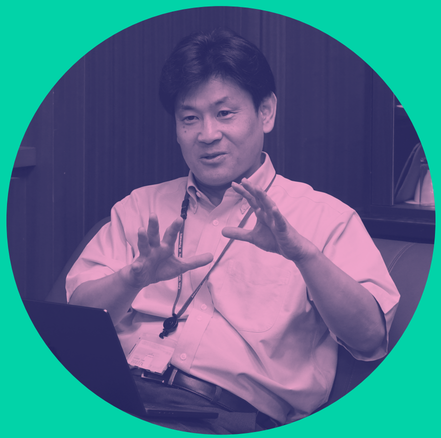

Do you have a message for the young people reading this?

In terms of contributing to society, I believe the most important phase is discovery—creating something new from zero to one. Students should think about which phase they want to focus on, but it's crucial not to choose the application phase without understanding the underlying theory and science. Gaining a solid foundation during your student years is vital. While aiming for original discoveries can be challenging, it's incredibly rewarding to pursue something no one has done before.

Moreover, understanding the basics is essential. For example, if you don't grasp chemistry, you won't fully understand the structure of a lipid, and if you lack knowledge in mathematics or physical chemistry, you won't be able to verify or interpret your findings. It would be a shame if your research became interesting but you couldn't keep up because you lacked fundamental academic skills. I believe a broad education helps you realize what excites you when you encounter new ideas or engage in conversations. You should prepare yourself to enjoy research fully and be ready to dive in when you find something interesting. This is why taking advantage of opportunities to study a wide range of academic disciplines is so important.

> I would like you to study a wide range of basic academic disciplines so that you are prepared to dive into something when you find it interesting.

What is Bio2Q?

Bio2Q is a world-class research center at Keio University. It aims to use quantum computing and AI to analyze the interaction between Human Biology and Microbiome, revealing uncharted territories of the human body and developing new treatments for intractable diseases.

It is the first private university to be selected for the World Premier International Research Center Initiative (WPI) program promoted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Bio2Q

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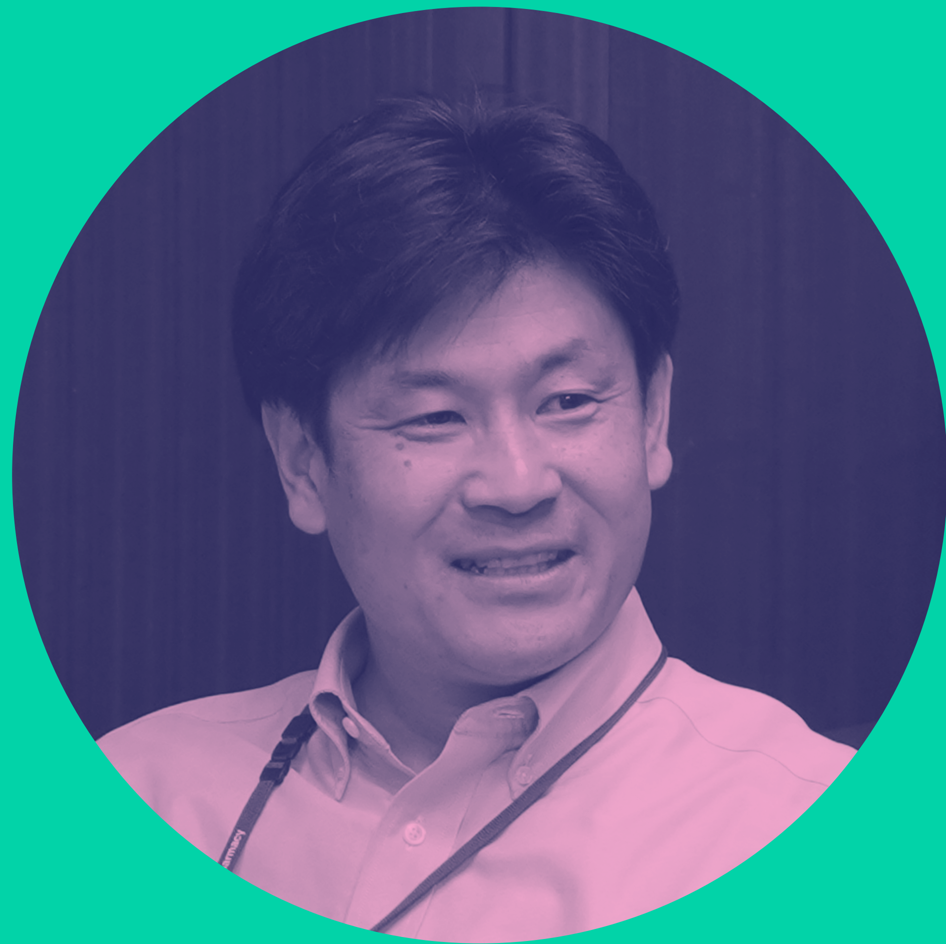
WPI Research Center
Keio University
Bio2Q Human Biology Microbiome Quantum Research Center

Keio University Human Biology-Microbiome-Quantum Research Center (Bio2Q)



Bio2Q Researchers

Professor Makoto Arita

Bio2Q Bio-1 Core Director, Metabolomics Team / Professor, Keio University Faculty of Pharmacy

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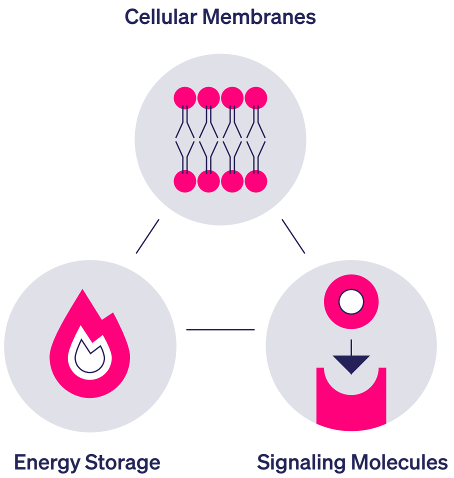
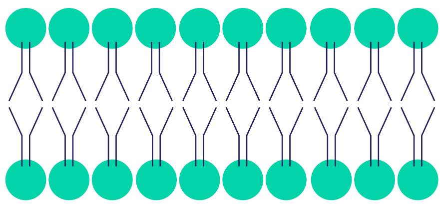
Roles Played by Lipids



Diversity in Lipid Structures

100,000

Over 100,000 Lipid Molecules in Nature



8	Categories
84	Major Classes
372	Subclasses
10,000	Annotated Compounds
100,000	Totals Including Estimates

Greater number of compounds may exist.

Please tell us about your research.

I seek to understand how living organisms adapt to their environment, as adaptation is the essence of life. Living beings constantly sense, process, and respond to environmental changes like diet, air quality, and UV exposure. My research aims to visualize complex metabolic* networks, focusing particularly on lipid metabolism. Lipids are vital in biology; they form cellular membranes, store energy, and act as signaling molecules (lipid mediators). For instance, dietary omega-3 fatty acids (EPA and DHA) are widely considered beneficial to health. The lipid composition of organs and cells is directly influenced by the balance of fatty acids in the diet. A well-known example is the Inuit of Greenland, who have a lower risk of myocardial infarction and autoimmune diseases than Caucasians living in the same region. This difference may be attributed to the Inuit's high consumption of omega-3 fatty acids from seal meat.

However, the body also has a homeostatic mechanism that synthesizes and degrades lipids to maintain metabolic balance. If lipid intake is unbalanced, metabolic pathways work to restore equilibrium. It's a dynamic interaction between external environmental factors and the body's adaptive mechanisms. Living organisms are remarkably well designed for this. My research aims to uncover the causal relationships and mechanisms governing these metabolic adaptations by analyzing the intricate networks involved.

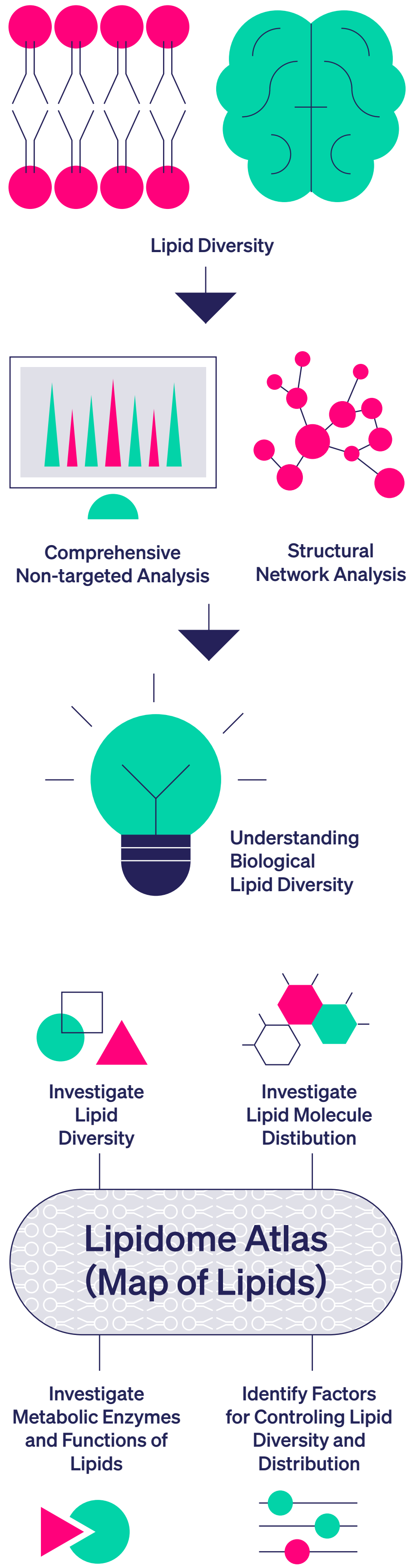
How are you involved in Bio2Q?

At Bio2Q, we study multiorgan interactions and the relationship between gut microbiota and the host through the lens of metabolic networks. With over 100,000 lipid molecules in nature, we utilize advanced mass spectrometry to differentiate between their complex structures. Our research reveals that gut microbiota possesses a unique metabolic system distinct from the host, leading us to realize that the body's metabolic network is more intricate than previously thought, involving extensive host-microbiota interactions.

Our state-of-the-art, non-targeted lipidomics technology, which we originally developed, enables unbiased analysis of thousands of lipids simultaneously. This system not only measures known lipids but also uncovers new lipid structures. For instance, it visualizes unique lipids in organs like the brain and kidneys and tracks changes associated with aging. This gives us an unparalleled perspective on lipid metabolism.

By applying this cutting-edge technology at Bio2Q, we believe we can identify even more unique and significant metabolites. Furthermore, by investigating the receptors these metabolites affect, new hypotheses and research themes may emerge. Our expertise in lipid analysis positions us as leaders in this field. Through effective collaboration within Bio2Q, we are confident in our ability to conduct groundbreaking, original research that advances our understanding of lipid metabolites at the highest level.

* General term for chemical reactions taking place in living organisms.



What is the Lipidome Atlas project that you are leading?

If an interesting lipid is found in the brain, the next step is identifying which brain cells contain it. Similarly, if a lipid affects the immune system, you need to locate it within immune tissues and understand the mechanisms governing its distribution. To answer these questions, visualizing lipid localization is crucial. However, conventional analysis methods lose spatial information when tissues are processed. The Lipidome Atlas project aims to map lipid locations and create a new "atlas." So far, hundreds of lipid molecules have been visualized from single tissue sections.

This project seeks to uncover the biological significance of lipid diversity and their localization, as well as how their disruption might lead to disease. We believe that by deciphering lipidome signatures, we can gain a deeper understanding of tissue and cell individuality, ultimately providing valuable insights into the state of living systems.

It is amazing to be able to visualize the spatial distribution and localization of hundreds of lipids from tissue sections.

Metabolic and biochemical studies of individual lipids have been conducted for a long time, but until now, there has never been the technology to examine thousands of them from a bird's eye view. Science and technology are like the two wheels of a cart, moving together. In the past, people looked at the stars with the naked eye, and while their observations weren't wrong, they lacked depth. Today's instruments, much like astronomical telescopes, allow us to see what we couldn't see before.

> Science and technology are like the two wheels of a cart. Advances in both expand our horizons and enable us to see the new world that no one has seen before.

This changes our interpretations and understandings, as we uncover new insights into the nature of the universe. As our observations become more precise, new rules and concepts emerge, expanding our horizons. This is known as data-driven science. Visualizing data prompts simple questions like "What is this?", leading to intuitive comprehension, new hypotheses, and further exploration. We are currently applying these technologies to study the lipid diversity generated by gut microbiota, visualizing their characteristic distribution and chemical structures. Our goal is to determine their functions by identifying the intestinal bacteria and metabolic enzymes responsible for producing each metabolite and understanding their effects on the host. We expect that the Bio2Q framework, which brings together researchers from diverse backgrounds, will create the synergies needed to tackle these challenges and uncover new scientific insights.