Biophysics at Kyushu University

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Kyushu University was established in 1911. It is the largest university in Kyushu and currently has over ten faculties and many institutes. This university has several campuses in Fukuoka city. As shown in Table 1, the annual meeting of the Biophysical Society of Japan has been held five times in Fukuoka city. Kyushu is the westernmost of the four main islands in Japan, and the railway for the bullet train was not extended to Hakata station until 1975. Table 1 includes details of the 10th annual meeting in 1971 although access was not so good at that time. This history shows that researchers at Kyushu University have been conducting biophysics investigations since the early years of biophysics research in Japan.

Kyushu University has many biophysics research groups although it does not have a department of biophysics. Given the interdisciplinary nature of biophysics, these groups belong to their respective faculties and institutes. The Faculty of Science at Ito Campus and the Medical Institute of Bioregulation at Maidashi Campus both have many groups. Eight of these biophysical research groups are introduced in this report.

The Medical Institute of Bioregulation was established in 1973. Its aim is to help understand the host-defense mechanisms that operate against infection in humans and other organisms at the molecular, cellular, and individual levels. Daisuke Kohda, the chair of the 46th Annual Meeting, belongs to this institute (see Table 1). This institute has several biophysical research groups. Here, we introduce the groups of Kohda and Kubota.

Daisuke Kohda, Medical Institute of Bioregulation, is interested in the structural basis of promiscuous recognition of diverse ligands by proteins. Long-term research on the mitochondrial presequence receptor, Tom20, led to the proposal of a new mechanism, multiple partial recognitions in dynamic equilibrium (MPRIDE) (Kohda 2018). Kohda also developed a method for creating crystal contact-free space in protein crystals and succeeded in observing the spatial movements of a presequence peptide in the binding site of Tom20 (Matsuoka et al. 2016).

Hiroyuki Kubota, Medical Institute of Bioregulation, is interested in the dynamics of molecules across multiple omic layers. He has developed a new method to reconstruct a “transomic network” by combining experimental data and databases together (Yugi et al. 2014). He has also examined the temporal patterns of insulin and found that insulin selectively regulates downstream molecules depending on the temporal patterns (Kubota et al. 2018). This work provided a conceptual paradigm shift in understanding the signal transduction mechanism *in vivo*.

The Faculty of Science was established in 1920. As noted above, biophysical studies have been carried out since the early years of biophysics research in Japan. We can find the names, K. Tawada, H. Matsuda, H. Morita, and M. Kuwabara listed in Table 1. Furthermore, Michiko Go (Former President, Honorary Member), Nobuhiro Go (Former President, Honorary Member), and other researchers also studied in this faculty before moving on to other universities. Yoh Iwasa had a mathematical biology group in this faculty and was also the Dean of the Institute for Advanced Study at Kyushu University until 2018. He has moved to Kwansei Gakuin University. The mathematical biology group is still active in the Department of Biology at Kyushu University.

The Department of Physics has two biophysical research groups. In the department, basic principles are emphasized. Here, we introduce the groups of Mizuno and Maeda. Mechanics and metabolic activities are intricately and often peculiarly related in living systems since they are driven far

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Table 1 Annual meetings of the Biophysical Society of Japan in Fukuoka

	Venue	Chair
The 46th Annual Meeting (Dec. 3–5, 2008)	Fukuoka Convention Center	Daisuke Kohda (Kyushu University)
The 36th Annual Meeting (Oct. 2–4, 1998)	Kyushu University (Ropponmatsu)	Katsuhisa Tawada (Kyushu University)
The 28th Annual Meeting (Oct. 11–13, 1990)	Kyushu University (Hakozaki)	Hirotsugu Matsuda (Kyushu University)
The 19th Annual Meeting (Oct. 10–12, 1981)	Kyushu University (Ropponmatsu)	Hiromichi Morita (Kyushu University)
The 10th Annual Meeting (Oct. 23–25, 1971)	Fukuoka University	Masutaro Kuwabara (Kyushu University)

from equilibrium by non-thermal fluctuations generated by mechanoenzymes such as molecular motors. Daisuke Mizuno's group explores the statistical mechanics of "life" in such a typical non-equilibrium open system, mainly based on experimental perspectives. The group has introduced experimental (Nishizawa et al. 2017a; Nishizawa et al. 2017b) and theoretical (Zaid and Mizuno 2016) approaches that allow us to quantify the spatial and temporal correlations of non-thermal fluctuations utilizing the violation of fundamental theorems (fluctuation–dissipation theorem [Nishizawa et al. 2017a; Nishizawa et al. 2017b] and central limiting theorem [Zaid and Mizuno 2016]). Believing that the link between the novel observables and metabolic activities is the key to understanding the non-equilibrium mechanics of living systems, Daisuke Mizuno's group is currently investigating this aspect in vivo in cells, tissues, and in vitro in model systems made of soft biological materials.

"There's plenty of room at the bottom" has inspired one of the great challenges of the century: engineering complex systems at the microscopic level. When it comes to downsizing, mimicking nature has always proven to be a good bet. By taking such a bottom-up approach, Yusuke Maeda's group studies self-organization, self-propulsive motion, and self-replication inspired by biological systems. The interests in his group range from transport phenomena related to the origin of life (Maeda et al. 2012) to the ordered structure of active matter (Beppu et al. 2017) and artificial cells (Izri et al. 2019). The universality behind rich dynamics and ordered structure will advance our understanding of soft and active matter as miniaturized biological systems.

Modern chemistry is expanding its targets. Because it also encompasses the subjects and methods of biology and physics, the Department of Chemistry has many biophysical research groups. Some of the groups collaborate with biologists and/or physicists. Here, we introduce the groups of Annaka, Matsumori, Yoshida, and Akiyama.

To adapt the physical properties of living materials to their biological functions, nature has developed polymers with

outstanding physical behavior. The structure and dynamics of macromolecules and networks can be manipulated in many ways by making use of the tricks of nature. One of the primary aims of Annaka's group is to investigate the fundamental properties of macromolecules and networks, given that many of these polymers are also of great potential interest in polymer science (Annaka and Matsuura 2016). Another intention of the group is to bridge the gap between biological material research and the physics and chemistry of polymers and other complex fluids (Fujiki et al. 2016; Mortensen and Annaka 2016; Mortensen and Annaka 2018).

Nobuaki Matsumori is studying the biophysics and chemical biology of lipids and membrane proteins (MPs) and currently focusing on three main themes. First, he developed a concise method to quantitatively measure the interaction between lipids and MPs (Inada et al. 2019b) and revealed that MP-specific lipids have strong effects on the structure and function of MPs (Inada et al. 2019a). Second, he is investigating the molecular basis of lipid raft formation by developing new fluorescent derivatives of raft-related lipids (Kinoshita et al. 2017; Matsufuji et al. 2019). He also explores the actions of drugs and toxins on membranes and/or MPs. In particular, he is interested in the mechanism of anesthesia and analyzes the actions of anesthetics at the molecular level (Kinoshita et al. 2019).

Norio Yoshida and co-workers are developing theories applicable to the chemical and physical processes in biological systems, such as molecular recognition, ion transportation, enzymatic reaction, aggregation/dispersion, and phase separation, based on the statistical mechanics theory of molecular liquids, which is called the three-dimensional reference interaction site model (3D-RISM) theory, in collaboration with Nakano's group (Yoshida 2017). The group has also developed a theory called extended molecular Ornstein–Zernike (XMOZ) theory, which can explicitly consider the orientation of solvent molecules (Ishizuka and Yoshida 2013). A multiscale hybrid method based on the 3D-RISM and XMOZ theories with quantum chemical electronic structure

theory and molecular dynamics has been developed and applied to various biological processes focusing on solvation.

Ryo Akiyama is studying biophysics and chemical physics in the Department of Chemistry. His group mainly investigates effective intermolecular interactions in the liquid phase, phase behavior, and diffusion phenomena in a solution using statistical mechanics theory. For example, the group's theoretical studies for effective attraction between like-charged particles in an electrolyte solution explained the reentrant condensation behaviors of acidic protein (Akiyama and Sakata 2011; Suematsu et al. 2018). The group is also studying various excluded volume effects in a liquid phase using Asakura–Oosawa theory and integral equation theory for liquids. Recently, related experiments have also been started by some of the group members (Chiba et al. 2019).

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