Session 1SHA—control of biological functions with hydrostatic pressure stimulation

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Living organisms change their shape and activity in response to external forces. The origin of these responses found at the level of changes in the biomolecules that constitute the organisms. Hydrostatic pressure has been used as a tool for applying isotropic forces to investigate the response of molecular structures and functions to force. However, pressures used in previous studies were often so high that the biomolecules were denatured (Akasaka and Matsuki 2015; Hata et al., 2020b). Recent studies have shown that much lower pressures that retain the structures of biomolecules can affect cellular functions (Wakai et al. 2014). We organized this symposium to discuss the control of cellular functions by pressure and the mechanism underlying the pressure effect. The speakers were the following (Fig. 1).

Masayoshi Nishiyama (Kindai University) introduced a novel apparatus that enables the acquisition of microscope images at high pressure (Nishiyama 2017; Yagi and Nishiyama 2020). He successfully visualized high hydrostatic pressure-induced vigorous flagellar beating in *Chlamydomonas* paralyzed-flagella mutants. Masatoshi Morimatsu (Okayama University) investigated individual tissues using a high-pressure microscope. He observed that high pressure decreased the size of cells and the expression levels of genes encoding extracellular matrix proteins were increased

after the pressurizing process (Watanabe et al. 2020). Ryo Kitahara (Ritsumeikan University) reported pressure effects on prokaryotic circadian rhythms. He found that the cycle of the KaiC phosphorylation in the cyanobacterial circadian clock was accelerated at 20 MPa (Kitahara et al. 2019). Ikuro Kawagishi (Hosei University) showed that pressure affects bacterial chemotaxis. He demonstrated that high hydrostatic pressure can induce counter-clockwise rotation of the flagellar motor of *Escherichia coli* (Hata et al. 2020a). Katsumi Imada (Osaka University) reported the molecular mechanisms of pressure-dependent fluorescence change of a yellow fluorescent protein mutated by the insertion of three glycine residues at $\beta 7$ (YFP-3G) (Watanabe et al. 2013). Hiroaki Hata (Tokyo Institute of Technology) indicated that pressure enhanced hydration around proteins can inhibit the protein-protein interactions that play a key role in bacterial chemotaxis (Hata et al. 2020a). In addition, Oleg Dobrokhotov (Nagoya University) showed that artificial induction of actomyosin-generated tension inhibits proliferation and promotes differentiation of keratinocyte carcinoma cells.

In this symposium, it was clearly shown that hydrostatic pressure can be used as a mechanical stimulus for cells and tissues. We envision that pressure will be increasingly recognized as a tool for analysis and control of functions of living organisms.

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Fig. 1 Speakers and their research

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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