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Commentary and Perspective

Biophysical elucidation of neural network and chemical regeneration of neural tissue

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Brain science has made remarkable progress over the past decade. Unveiling the development of neural tissue, understanding neural circuits, and elucidation of signal transduction processes at the molecular level have been carried out. Not only neuroscience but also mechanistic biochemical and biophysical studies on neural diseases are progressing. Neurodegenerative diseases are one representative example, and the structure and dynamics of the causative proteins are being investigated at the molecular level. Integrating discussions between biophysical neuroscience and biochemical research of the brain should address important unexplored issues such as the molecular- and cellular-scale elucidation of brain functions and the development of functional molecules and biomaterials for neuronal tissue regeneration. To highlight recent progress in this research field, we organize a symposium during the 60th Annual Meeting of the Biophysical Society of Japan held in September 2022. Five researchers including biophysicists, neurobiologists and biochemists in Japan and Korea are invited to talk about their recent achievements in the fields of brain science. The topics of the talks are highlighted as below.

Autophagy is an intracellular degradation system delivering cytoplasmic constituents to the lysosome. Recent studies report its wide variety of physiological roles including intracellular clearance in the brain and pathological consequences such as neurodegeneration caused by its dysfunction [1]. Dr. Yuko Fujioka (Hokkaido University) has investigated the structural and biochemical analyses of autophagy-related proteins for elucidation of the autophagy mechanisms [2,3]. Based on her studies on the Atg1 complex, a scaffold protein complex responsible for autophagy initiation, she discovered phase separation and liquid-like droplet formation of Atg1 complex as a reaction chamber for enzymatic reaction relating to autophagy progression. In the symposium, she will talk about her recent achievement in phase separation providing a reaction chamber for autophagy progression.

Accumulation of protein misfolding, aggregation and fibrillation leads the cause of several protein misfolding diseases, namely amyloidogenesis, such as Alzheimer's disease and Parkinson's disease [4]. Dr. Young-Ho Lee (Korea Basic Science Institute, University of Science and Technology, Chungnam National University) will talk about the molecular mechanism of protein aggregation, particularly amyloid fibrillation, in neurodegenerative disease. His talk will cover important properties of amyloid fibrillation such as polymorphic amyloidogenesis and physicochemical mechanisms of amyloid formation based on molecular-level structures and solubility/supersaturation phase diagrams of the misfolded proteins [5–7].

Single-molecule imaging is a powerful technique to visualize the actions of neurons at the molecular level. In recent years, single-molecule imaging plays an important role that contributes to the detection of abnormalities in disease model

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cells with high sensitivity, leading to an understanding of the mechanisms of pathology. Dr. Hiroko Bannai (Waseda University) will talk about the current status, problems, and potential of single-molecule imaging studies in neurological disease research [8,9].

It has been believed that the brain is a non-regenerative tissue. However, it is being elucidated that the injured brain has regenerative potential. Dr. Itsuki Ajioka (Tokyo Medical Dental University, KISTEC) will present injured brain regeneration using supramolecular peptide hydrogels [10–12]. Self-assembling peptides form a hydrogel by supramolecular interactions. Because of the potential biocompatibility and chemical customizability, the self-assembling peptides fit for medical applications. He will show applications of the peptidic materials with self-assembling properties to injured brain regeneration.

As odors induce innate behaviors such as attraction and aversion, they are associated with values ranging from positive to negative. However, how the opposing and innate values of odors are represented and computed in the brain remain unclear. Dr. Hokto Kazama (RIKEN) is addressing this issue in fruit fly *Drosophila* by combining behavioral analysis in virtual reality and physiological analysis using calcium imaging [13,14]. He will talk about representations and circuits for opposing odor values in the higher-order brain regions.

Collectively, we will share the recent findings and progresses regarding neural network and regeneration of neural tissue in this symposium. Not only neuroscientists but also scientists in structural biology, biochemistry, and biophysics can discuss the current topics and future perspectives of this research field. This symposium provides a chance for interdisciplinary discussion that cultivates and evolves future collaborations and transformative research.

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