Abstract

The nervous system of organisms is a complex system composed of various types of cells forming a neural network that uses electrical signals to control, process, and record the body's activity. Therefore, experiments and analyses on the dynamic flow of these electrical signals are necessary to understand the phenomena occurring in the human body. The study of bioelectricity and electrical properties of living organisms is known as electrophysiology, and the techniques used for such research are called electrophysiological techniques.

Electrophysiology technology using microelectrodes has a limitation in that it cannot selectively target specific types of cells within a variety of cells. These limitations make it difficult to study the functions and roles of specific cells. An optical electrophysiology technique using a fluorescence probe has recently emerged to solve this problem. However, this also has technical limitations. In particular, conventional electrophysiology techniques that can be used together with optical electrophysiology techniques are limited to intracellular recording using patch clamps or Insertion electrodes that damage cells. In addition, it is difficult to accurately measure action potentials solely with optical signals due to the low temporal resolution.

This study was conducted to overcome the limitations of conventional electrophysiology techniques using microelectrodes by using IL1RAPL1 (Interleukin-1 receptor accessory protein-like-1), a type of synapse organizer. Synapse organizers refer to adhesion molecules responsible for synapse formation and induction on the surface of the branch terminals of neurons.

This experiment consists of three chapters. The first chapter demonstrates the process of making the electrode smaller than the area of the axon terminal, as well as the presentation of the process of stably functionalizing the surface of the electrode. In the second chapter, neurons were cultured on the surface of electrodes that had been functionalized with IL1RAPL1, and then the inductive synaptic differentiation between the functionalized electrodes and neurons was confirmed. In the third chapter, based on the information obtained from the fabricated MEAs, simulation was used to test whether action potentials could be measured from neurons. Since the electrodes were smaller than the axon terminal, it was expected that they would induce wrapping from the axon terminal, resulting in the formation of a high Rseal and the ability to measure the action potential of the axon terminal.

Unfortunately, recording action potentials from actual neurons was impossible in this study. However, the experiment demonstrated that the common limitations of conventional electrophysiology techniques using microelectrodes can be overcome. A new technique of introducing synapse organizers into electrodes was proposed and a stable method was established. These findings suggest that in future electrophysiological experiments using microelectrodes, long-term observation and analysis can be achieved through an extracellular recording by selectively targeting specific types of cells. The same lab is also experimenting with making synapse organizers respond to specific targets, which indicates that large-scale parallel measurement through more accurate targeting will be possible in the future.

Finally, this study showcases a novel approach to electrophysiology techniques employing microelectrodes. However, there are still many unfinished aspects left. Although these techniques have problems, ongoing improvement efforts can address these imperfections. i believe that this novel form of

electrophysiology technology has the potential to make substantial contributions to future research in the field.

Keyword: Electrophysiology, Molecular biology, Biosensor, Neuron, Fluorescent protein