THE CHINESE UNIVERSITY OF HONG KONG

SCHOOL OF LIFE SCIENCES

Beyond action potentials: roles of voltage-gated sodium channels in neuronal input-output transformation across multiple timescales for hippocampal memory system

By

Dr Hsu Ching-Lung

Research Scientist

Janelia Research Campus

Howard Hughes Medical Institute

Ashburn, Virginia, United States

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Neurons are the building blocks of the brain. To understand how the brain works, we need to have thorough understanding of how neurons collect and store information, form internal representations of the external world, compare the current state of the system with past experiences, and generate output. The hippocampus is a mammalian brain structure critically implicated in the formation of memories, and hippocampal pyramidal neurons can perform computations crucial for each of these operations. Work from the past two decades revealed that pyramidal neurons, the principal cell type of cortical areas in the brain, can utilize different cellular compartments to process electrical signals and encode information in highly nonlinear manners. However, the underlying ionic mechanisms—especially the roles of voltage-gated sodium (Na_v) channels—have not been well understood, due to technical constraints.

In this talk, I will discuss how a biophysically similar class of Na_v channels acts as a key link between local signal integration in dendritic/peri-somatic compartments and long-lasting synaptic plasticity, which support neuronal input-output transformation across multiple timescales, from milliseconds, seconds, to (at least) tens of minutes, based on our work using approaches that combine electrophysiology, imaging, refined pharmacology, and computational modeling. Furthermore, applying patch-clamp recording in awake, behaving rodents in a behavioral system based on virtual reality, I further provide direct evidence that Na_v channels shape the neural coding of spatial information—a crucial component of event memories—in hippocampal pyramidal neurons, in a way that is independent of their canonical role in the generation of action potentials.

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