Complexity Science and Engineering

Hayashi Laboratory

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Precise physical measurements are important for cells to understand molecular mechanisms occurred in cells as well as for solid state materials. However, *in vivo* measurements are difficult because intracellular environments are complex non-equilibrium states, in which theories of statistical physics are often violated.

In our lab, we develop techniques to precisely measure physical quantities such as force, velocity and energy for proteins and organelle inside cells, based on fluorescence microscopy. We think development of analytical methods (software) using statistical physics, information science and mathematics as well as development of microscopes (hardware). We aim to understand cellular phenomena quantitatively by constructing theoretical models using the measured physical quantities.

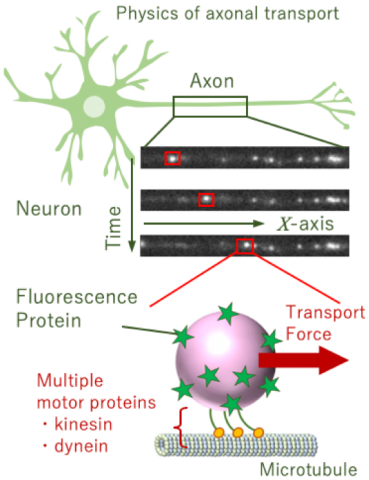
We hope such theories can contribute to the understanding of neurological disorders particularly.

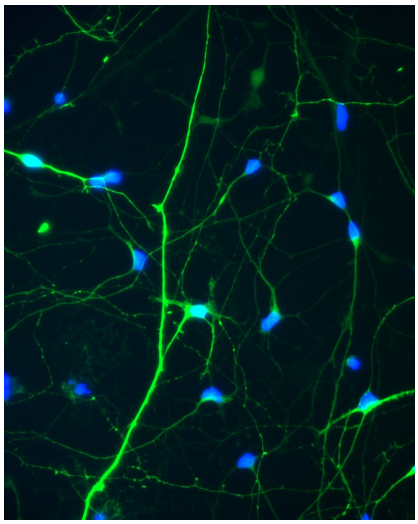
In 2024, our current research topics include fluorescence imaging of axonal transport in human iPSC-derived neurons, force measurements of motor proteins using DNA origami-made nanosprings, and data analysis using Bayesian estimation.

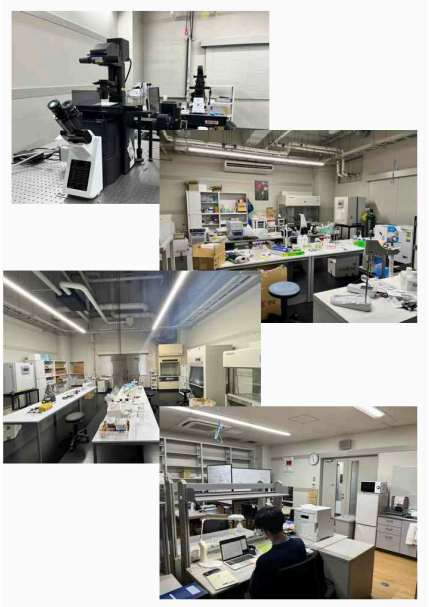
Axonal transport in human iPSC-derived neurons: Materials such as those for synapses are synthesized in the cell body of neurons and transported by motor proteins, kinesin and dynein. We also develop our own software for tracking transport particles.

Force measurement of motor proteins using nanosprings: We measure the force of motor proteins using springs made from DNA origami.

Data analysis using Bayesian estimation: We use Bayesian estimation for parameter estimation of experimental data.







Left figure: Schematic diagram of axonal transport in neurons. Motor proteins transport materials such as those for synapses. By analyzing physical quantities, we aim to elucidate the molecular mechanisms of intrabody transport phenomena and contribute to the understanding of neurological diseases related to transport disorders. Right figure: Fluorescence imaging of human iPSC-derived neurons (nucleus: blue, axons: green).

— Lab visits are always welcome —
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For more details, please visit our lab's website.