Name	Yoshihiko Hasegawa Associate Professor	**Place**	Hongo	**Research Topic**	Information Biology

Information Biology, Complex Systems

Biology becomes a frontier field among sciences and unveiling the systems' behavior requires exploitation of recent progress in diverse research fields. Although experimental studies have hitherto been played central roles in biology, advancements in observation technology enable quantitative understanding of biological systems. Accordingly, theoretical frameworks such as "Systems Biology" and "Bioinformatics" are becoming more important, as they can provide a unified perspective on how biological mechanisms function reliably and efficiently. My laboratory focuses on theoretical understanding of biology through information science and nonlinear physics.

Research Topics

Biological systems and optimization Biology does not seem to have as unified theories as physics or chemistry. Nevertheless, because all organisms participated natural selection, they optimally adapt to the environment through the evolution. Therefore, their existence and necessity can be accounted for by the notion of optimality. We are trying to answer many biological riddles by mathematical optimization. Specifically, we studied an optimal design of circadian clocks (24 h biological clock). Many terrestrial species from bacteria to humans acquired circadian oscillatory systems to increase chances of survival. In order to maintain the endogenous clocks, two properties are necessary: *regularity*, to keep time precisely and *entrainability* to synchronize the internal time to the environmental cycle. However, these two requirements are trade-off factors and it is difficult to satisfy them simultaneously. By using mathematical optimization, we found for the first time that all existing circadian clocks are near optimal and that many inherent properties of circadian clocks can be explained by the optimality.

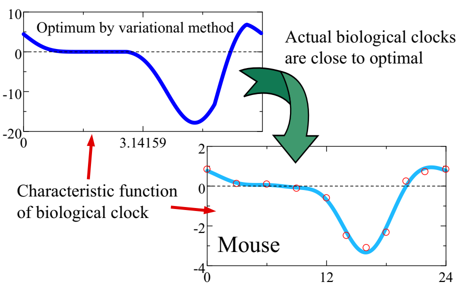

Fig 1: Optimal biological clock by theory and actual mouse clock.

Analysis of biological oscillation All biological clocks belong to a "limit-cycle oscillator" which exhibits qualitatively different behavior from that of a harmonic oscillator (oscillation induced by a spring and a weight). Because mechanisms behind limit-cycle are the same as those behind oscillatory electronic circuits, dynamical aspects of limit-cycle can be analyzed with the electronic engineering (nonlinear physics). We are applying these theoretical tools to study biological oscillations.

Biological noise As denoted above, biological and electronic systems have a lot in common. Still, there is one remarkable difference between the two systems; biological systems are always subject to noise which interferes with their reliability. Biological noise is inevitable as it is derived from smallness of cells. Through the evolution, biological systems acquired ability to resist noise and even to take advantage of noise to enhance their functionalities. We study noisy aspects of biological systems by stochastic process theories.

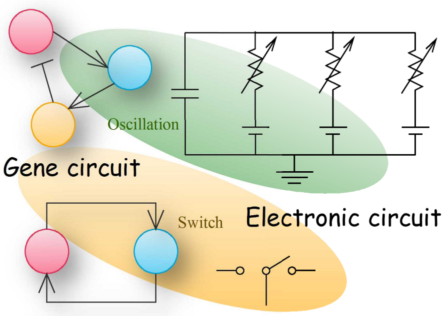

Fig 2: Similarity between electronic and gene regulatory circuits

About laboratory Research topics of Hasegawa laboratory are basically theoretical understanding of biology (still, I will not exclude other possible research topics). Because the researches exploit theoretical tools such as dynamical systems and stochastic processes, applicants do not necessarily know about biology. We do welcome those who are interested in all aspects of biology!

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