Dr. Alexander Ratushny, Seattle Biomed and Institute for Systems Biology

Presents

Mathematical Modeling of Dynamical Biological Systems

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1:30 P.M. - 2:30 P.M.

Mathematical models have become indispensable tools for integrating and interpreting heterogeneous biological data, understanding fundamental principles of biological systems, generating testable hypotheses, and identifying potential diagnostic markers and therapeutic targets. To construct models with predictive utility, it is critical to describe biological mechanisms with the appropriate level of detail. Despite the tremendous data-generating capabilities of new high-throughput technologies, the compendium of available measurements of many cellular component levels and process rates remains sparse. Often, the available data are not sufficient to infer the detailed molecular mechanisms underlying a given biological process. Furthermore, current knowledge of molecular mechanisms is highly non-uniform, varying from the well supported and very detailed to the hypothetical and poorly described. Thus, it is impossible to describe all processes in the model equally comprehensively. The ideal modeling method should allow rational selection of the most appropriate level of detail in the model based on prior knowledge of relevant pathways and the resolution of relevant measurements. To address this problem we are developing computational approaches for mathematical modeling and systematic exploration of topological features and parametric space of dynamical biological systems with partially known or poorly understood molecular mechanisms. In this talk, I will present a recently developed modeling method based on the generalized Hill functions and the generalized time-frequency analysis of dynamical molecular systems. I will also present several ongoing projects where we discovered and mathematically modeled novel biological regulatory systems in various prokaryotic, archaeal, lower and higher eukaryotic organisms. These studies reveal evolutionary advantages for the discovered regulatory systems, principles of operation, and mechanisms for control, that are relevant to pharmacological and biotechnological intervention and synthetic biology applications.