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Frontiers in Systems and Integrative Biology

Large-Deviations Theory for Living Systems

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ABSTRACT

The separation of timescales, in systems whose state spaces are highly structured, is a major source of hierarchy, complexity, and robustness in living systems. Fluctuations or excursions that are rare on the timescale of microscopic processes may be the key functional events at the next higher scale of aggregation, whose characteristic timescale may be exponentially (in the relative scales of aggregation) longer than the microscopic timescale. Examples include rate-limiting steps in catalysis, checkpoints in signaling or cell division, and perhaps improbable (but not infinitely improbable!) steps in the emergence of life. Quantitative estimation of the rate and structure of rare events in biology requires new methods beyond those familiar from classical statistical mechanics, because living systems are out of equilibrium, because numbers of degrees of freedom are often mesoscopic, and because their heterogeneity precludes many simplifications from high degrees of symmetry. In this talk I will first introduce principles and methods from dynamical large-deviations theory, which apply to such problems and are also at the interface with recent active work in non-equilibrium statistical mechanics. I will then review a few biological applications, some of which have been solved, and others (particularly in the origin of life) which are suggestive but are still looking for an adequate empirical and mathematical framing of the right questions.

Host: Van Savage, Ph.D.

To receive e-mail seminar notices, contact David Tomita (dtomita@biomath.ucla.edu)