Insights into the relation between noise and biological complexity

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Understanding how the intrinsic noise in biological systems is related to their complexity and dynamics is a fascinating goal of fundamental importance for both synthetic and systems biology. To explore these issues, we thoroughly analyzed a series of chemical reaction networks [1] with different topologies and complexity, described by mass-action kinetics. More specifically, we used the Itō stochastic differential equation formalism to investigate the dynamical behavior of these systems, focusing on the global level of fluctuations at the steady state, measured by the sum over all species of the Fano factors of the number of molecules. We found an intriguing relation between this sum and some characteristics of the chemical reaction network, namely its rank, its deficiency and the fluxes between the molecular complexes. For zero-deficiency systems, the Fano factor sum is independent of the system's parameters and equal to the rank. For CRNs with higher deficiencies, additional terms appear in this sum, which are proportional to the reaction fluxes between the molecular complexes. We showed [2, 3, 4] that the system's global intrinsic noise is reduced if all fluxes flow from the molecular species of lower to higher complexity, whereas it is amplified when the fluxes are directed towards lower complexity species. Finally, some examples of applications of these results to biological systems are briefly discussed.

References

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