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Gene Expression Noise, Fitness Landscapes, and Evolution[1]

DANIEL CHARLEBOIS, Laufer Center for Physical and Quantitative Biology, Stony Brook University — The stochastic (or noisy) process of gene expression can have fitness consequences for living organisms. For example, gene expression noise facilitates the development of drug resistance by increasing the time scale at which beneficial phenotypic states can be maintained [1]. The present work investigates the relationship between gene expression noise and the fitness landscape [2]. By incorporating the costs and benefits of gene expression, we track how the fluctuation magnitude and timescale of expression noise evolve in simulations of cell populations under stress. We find that properties of expression noise evolve to maximize fitness on the fitness landscape, and that low levels of expression noise emerge when the fitness benefits of gene expression exceed the fitness costs (and that high levels of noise emerge when the costs of expression exceed the benefits). The findings from our theoretical/computational work offer new hypotheses on the development of drug resistance, some of which are now being investigated in evolution experiments in our laboratory using well-characterized synthetic gene regulatory networks in budding yeast. [1] D.A. Charlebois, N. Abdennur, M. Kaern, Gene expression noise facilitates adaptation and drug resistance independently of mutation, Physical Review Letters, 107, 218101 (2011). [2] D.A. Charlebois, Effect and Evolution of Gene Expression Noise on the Fitness Landscape, Physical Review E, 022713 (2015).

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