345c Design Principles in Biological Oscillation

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Biological oscillations have received much attention because of its intriguing dynamics and sophisticated control mechanism. Typical biological oscillators in nature operate though interaction between multiple biological processes, which makes their design principle obscure. The emergence of synthetic biology and gene-circuit engineering provides a means to elucidating the underlying design principle of biological oscillators by *de novo* construction. Early generations of synthetic gene circuit oscillators [1,2] typically utilize single level of transcriptional control and the recently published gene-metabolic oscillator [3] controls oscillation by coupling transcription with metabolism. The goal of this talk is to compare these two types of synthetic oscillators to elucidate the design principles in bio-oscillation.

Our investigations were conducted along two directions. We investigated the dependence of oscillation period on key parameters such as protein degradation rate and mRNA synthesis rate. We found that the exponent of the scaling law correlates period with parameters depends on the number of biological processes involved in the system. In addition, we explore the robustness of the oscillation by examining the stability regions and phase diagrams whose corresponding steady state solution lost its stability through a Hopf bifurcation. Specifically, a new robustness measure is devised to characterize the difference among synthetic bio-oscillator designs. These investigations highlight the key design features to achieve the oscillatory dynamics in synthetic biological systems and suggest the similarities between natural and synthetic biological oscillators.

[1] Elowitz, MB & Leibler, S. Nature 403, 335–338 (2000)

[2] Atkinson, MR, MA Savageau, JT Myers, & AJ Ninfa, Cell 113, 597–607 (2003)

[3] Fung E, WW Wilson, JK Suen, T Buelter, S Lee, & JC Liao Nature 435: 118-122 (2005)