Multi-Scale Models for Synthetic Circuit Design

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Abstract

Synthetic biology, the technology counterpart of systems biology, aims at establishing novel, useful biological functions by suitably combining well-characterized parts. Synthetic circuits, however, have to operate in natural systems such as cells or organisms, with corresponding load on and crosstalk with them. Here, we discuss how synthetic circuit design based on mathematical models can account for relevant interactions between synthetic and natural systems. Explicit representations of the combined, multi-scale system cannot only help anticipating and reducing the impact of the host on the synthetic circuit's operations. They also allow for a more integrated design, in which parts of the natural system are augmented by (minimal) prosthetic networks to achieve new functionalities. We will use examples ranging from elementary circuits such as switches to mammalian gene circuits for in vivo feedback control in biomedical applications to argue that novel systems analysis methods are needed to enable efficient computational design of synthetic circuits, and how the design of synthetic systems also allows us to refine our understanding of natural biological systems.

Keywords: mathematical models, design, multi, scale

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