Exploring Evolution Through Synthetic Approaches

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The origin of organelles is one of the key outstanding questions in the evolution of eukaryotic organisms. Based on the endosymbiotic theory, eukaryotic organelles like mitochondria and chloroplasts are proposed to have originated and evolved from bacterial endosymbionts during an early stage of evolution; sequencing studies spanning several decades have supported this hypothesis. However, there is minimal understanding (if any) of how bacterial endosymbionts evolved and transformed into organelles. In this talk, I will briefly describe our synthetic approaches to experimentally model mitochondria and chloroplast evolution in laboratory setting. As a first step, we modeled the early stages of mitochondrial evolution by engineering endosymbiosis between two genetically tractable model organisms, E. coli (model bacteria) and S. cerevisiae (budding yeast) where the engineered E. coli cells provided ATP to a respiration-deficient yeast mutant and in a reciprocal fashion, the yeast cells provided thiamin (vitamin B1) to an endosymbiotic E. coli thiamin auxotroph. Similarly, I will describe our initial efforts involving engineering cyanobacterial endosymbionts in yeast cells as a step towards recapitulating chloroplast evolution. These readily manipulated model systems should allow us to investigate various aspects of eukaryogenesis, particularly organelle evolution. Our studies are inspired from previous laboratory evolution efforts (e.g., directed evolution of proteins) and similar to these investigations, we seek to recapitulate evolution in laboratory setting and also develop synthetic biology platforms that have the potential to directly impact human life; for example, using bacterial endosymbionts to model and correct mitochondriopathies.