SCIENTIFIC SEMINAR

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Intrinsically Disordered Proteins for New-To-Nature Carbon Fixation

Membraneless organelles are crucial for the spatial and temporal organization of cellular processes across all domains of life, including carbon fixation. However, the molecular basis and the minimal components required for carbon fixation in membraneless organelles, such as the pyrenoid, remain poorly understood. The pyrenoid is a liquid phase separated structure that localizes and improves the carbon fixation process via an intrinsically disordered protein (IDP) called essential pyrenoid component 1 (EPYC1). We utilize a synthetic biology and evolutionary biochemical approach to investigate the mechanisms by which EPYC1 and its homologs influence pyrenoid formation and function. We demonstrate that these minimal pyrenoids exhibit a carbon concentrating function and reconstitute their evolutionary trajectory through ancestral sequence reconstruction. As such, our findings reveal that EPYC1-based condensates evolved from increasing the initial carboxylation rate to enhanced specificity in selected cases. Our findings from combining structural elucidation, kinetic characterization, modelling and material property analysis show that the carbon concentrating mechanism (CCM) is based on mass action kinetic effects. Moreover, transplanting this organelle into cyanobacteria can help us to compare the efficacies of the two biophysical CCMs occurring in nature, carboxysomes and pyrenoids. Our research advances our understanding of the minimal molecular determinants of this type of CCM and opens new avenues for enhancing photosynthetic efficiency in CO2-fixing organisms through synthetic biology approaches. In the future, IDP based engineering may open up new avenues for de novo enzyme evolution as well as in vivo synthetic biology leading to fundamental understanding of structure and organelle emergence.

Monday, 07.10.2024, 2:00 pm

Host: Holger Stark, Managing Director

Large Seminar Room, Fassberg Campus

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