

Investigating the organization, assembly and physical properties of the unique lipids of thylakoid membranes

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Biological cells and some internal structures are surrounded by membranes comprised of lipid bilayers and membrane proteins. Certain specialized biomembranes are stacked into multi-layers, allowing a high content of protein-lipid bilayers in a small volume. Chloroplasts (the photosynthetic organelle found within plant cells) contain a network of stacked membranes, termed "thylakoids", specialised for photosynthesis. The increased surface area allowed by this membrane organization is important for enhancing the chloroplast's capacity for energy trapping. The unusual lipids found within thylakoid membranes appear to play an essential structural role in maintaining this organization, however, they are relatively unstudied.

This PhD project would characterize the physical properties, dynamic organization and assembly of stacked architectures of thylakoid lipids, in order to better understand the biophysical basis of the natural membrane system (experimental/ biophysics).

The thylakoid lipid MGDG (monogalactosyl diglyceride) has a high degree of negative curvature, whereas DGDG (digalactosyl diglyceride) is relatively planar; other thylakoid lipids (SQDG and PG) provide charged groups.

We will systematically vary the relative ratios of each lipid and characterize how this affects the system, as follows. The lipid bilayer surface structure will be visualized with atomic force microscopy at high spatial resolution (sub-nanometer), revealing phase segregation in single layers and the height of stacked membrane layers. Neutron reflectivity will be used to characterize bilayer thickness and number of multilayers. Differential scanning calorimetry and Langmuir trough measurements will reveal how melting transition temperature and lipid density varies. Fluorescence microscopy will allow observation of mobile lipid multilayer membranes and tracking of membrane fluidity.

Finally, experiments incorporating photosynthetic proteins at increasing concentrations into our test membranes will reveal their effect on membrane assembly. Analysis of these experiments is expected to reveal the mechanisms driving the fundamentally-important curvature and multilayer stacking of these photosynthetic membranes.