Bilayers at the ILL

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Contribution of galactoglycerolipids to the three-dimensional architecture of thylakoids

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Photosynthetic membranes, also called thylakoids, have a unique and unusual lipid composition. They contain an extremely high amount of unique classes of glycolipids, constituted of galactolipids, i.e. mono- and di-galactosyldiacylglycerol (MGDG and DGDG) and of a sulfolipid, i.e. sulfoquinovosediacylglycerol (SQDG). A remarkable feature of the evolution from cyanobacteria to higher plants is the conservation of MGDG, DGDG, SQDG and phosphatidylglycerol (PG), the only phospholipid present in thylakoids. Using neutron diffraction, on reconstituted thylakoid lipid extracts, we observed that the thylakoid lipid mixture self-organizes as a regular stack of bilayers. The natural mixture of thylakoid lipids was shown to switch from hexagonal II toward lamellar phase upon hydration. This transition and the observed phase coexistence are modulated by the fine-tuning of the lipid profile, in particular the MGDG/DGDG ratio, and by the hydration. Our analysis followed by Molecular Dynamics simulation highlights the critical role of DGDG as a contributing component to the membrane stacking via hydrogen bonds between galactose polar heads of adjacent bilayers. DGDG cohesive interactions balance the repulsive electrostatic contribution of charged lipids like PG and SQDG and allow the persistence of regularly stacked membranes at high hydration. The membrane binding of MGD1, the committing enzyme of galactolipid biosynthesis in Arabidopsis, is also dependent of the membrane lipid composition and sensitive to the presence of DGDG. Altogether, these results show that galactolipids are determinant factors for the nonvesicular/nonlamellar biogenesis and for the three-dimensional architecture of nascent thylakoids. A model of biogenesis of photosynthetic membrane is proposed.

References

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