Beyond the Ordinary: Diamond- and Gyroid-Shaped Membranes in Plant Plastids

Łucja Kowalewska[1*]
[1]*Department of Plant Anatomy and Cytology, Institute of Experimental Plant Biology and Biotechnology, Faculty of Biology, University of Warsaw, Miecznikowa 1, PL-02-096 Warsaw, Poland* [2]*Times New Roman Italic 10 pt*
*email: lucja.kowalewska@uw.edu.pl

Cellular membranes exhibit the remarkable ability to self-organize into diverse morphologies. Among these, bicontinuous membrane (so called cubic membranes) stand out as the most complex periodic arrangements, characterized by a fascinating interplay of biological form and geometry. These cubic membranes share structural similarities with triply-periodic minimal surfaces, especially those of primitive, diamond and gyroid-type. While such intricate membrane structures have been observed in various organisms, from protozoa to mammals, our understanding of the structural and molecular mechanisms governing their formation and subsequent transformation into other membrane shapes remains limited. Due to the lengthscale of cubic membranes (around 50–500 nm) and their fluid nature, 2D and 3D transmission electron microscopy (TEM) is the analysis method of choice to decipher their nanostructural features.

In our research, we employ plant plastids' internal membranes as a model system to explore cubic morphologies. Plastids, a diverse group of organelles found in different plant organs, serve various functions closely tied to their inner membrane networks, with photosynthesis being a prominent role. By investigating the interplay between structure and composition in self-organizing cubic and lamellar arrangements during plastid ontogenesis, we aim to decipher how changes in membrane composition impact the formation and stability of these unique membrane assemblies.

During my presentation, I will delve into our approach for recognizing and annotating cubic assemblies using the SPIRE software tool [1]. SPIRE facilitates the identification of bicontinuous membrane structures from TEM sections by interactive matching against mathematical "nodal surface" models. I will also describe the specific features, assembly mechanisms, and biological function of two physiologically important examples of cubic membranes in plant plastids - the Diamond-shaped prolamellar body of the etioplast occurring naturally during plant development and Gyroid thylakoid assembly transiently present in fully developed and photosynthetically active chloroplast (Figure 1).

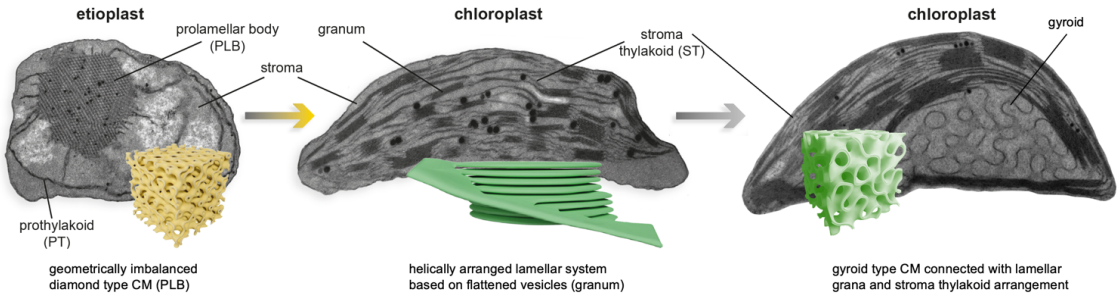

Figure 1 Figure legend. (Times New Roman, 9 pt)

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[1] T. Hain, M. Bykowski, M. Saba, M. Evans, G. Schröder-Turk, Ł. Kowalewska, *Plant Physiology*, **188**, 1 (2022).