

Douce R & Joyard J. Structure and function of the plastid envelope.

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The plastid envelope has received little attention despite its importance in the functional and structural integrity of the chloroplast. In this review we discuss the structure, isolation, chemical composition, and origin of the higher plant chloroplast envelope. [The *SCI*® indicates that this paper has been cited in over 130 publications.]

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H.W. Woolhouse, the editor of *Advances in Botanical Research*, considering the fact that more work had been published on the erythrocyte membrane than all the types of plant cell membranes put together, asked for a review to provide an introduction to the study of the chloroplast envelope membranes.

The review was mostly based on the work done first by Roland Douce during postdoctoral work at the Scripps Institution of Oceanography (La Jolla, California) under the supervision of Andrew A. Benson and then in collaboration with Jacques Joyard at Grenoble Nuclear Center and University (France). During the initial work with Benson,¹ a method was developed for the preparation of envelope membranes devoid of contaminants from other plastidial and extraplastidial compartments. The polar lipid composition, the presence of carotenoids, and the characterization of specific markers for envelope membranes (a Mg²⁺-dependent ATPase¹ and an enzyme² responsible for the biosynthesis of the major plant polar lipid: monoga-

lactosyldiacylglycerol, or MGDG) were described in these first articles.

When Douce came to Grenoble, the work was continued together with Joyard, who started his thesis on envelope membranes. A complete study of envelope properties, a comparison with envelope membranes from other plastids, was undertaken. This work is still in progress almost 15 years later! Our idea was that since envelope membranes are a permanent structure in all plastids analyzed so far and contain specific plastid components (lipids, pigments, quinones, and so on), they should play a major role in plastid biogenesis. Indeed, we have demonstrated that this hypothesis was true,³ and we have described, in envelope membranes, more than 20 enzymes involved in the biosynthesis of plastid lipids and prenylquinones.⁴

We are convinced that the paper has been cited mostly because we tried to present an exhaustive view of the problems related to envelope membranes: structure, interaction with the other cell membranes, chemical composition, role in metabolite transport and regulation of photosynthesis, role in the biosynthesis of plastid lipids, role in the transport of plastid proteins that are synthesized on cytoribosomes, origin of envelope membranes, and so on. Thus, in this review, we have presented together numerous ideas that indeed stimulated research in the field.

Almost 10 years after this review, we are still working on envelope membranes. Significant progress has been made,^{4,7} and a more recent review⁴ details all the properties and enzymes that have been demonstrated on the outer or the inner envelope membranes that can now be separated. We are still fascinated by this unique membrane system. But what we feel most important to mention is that the two authors of the original review on chloroplast envelope membranes are still working together, are good friends, and are still trying to understand this membrane system together with a limited number of people: M.A. Block, A.J. Dorne, and, more recently, C. Alban. We are convinced that this was the key for improving our knowledge of plastid envelope membranes, which was still very much in its infancy when we wrote this review.

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