NMR Studies on the Structural and Functional Roles of Lipids in Model and Biological Membranes

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All biological membranes contain in addition to bilayer forming lipids appreciable amounts of lipids, which when isolated and dispersed in excess buffer prefer non-bilayer phases such as the hexagonal H_{II} phase. The presence of these lipids in membranes can be expected to destabilize the bilayer structure of the membrane and suggest that these lipids are actively involved in membrane processes in which the bilayer configuration must be temporarily disrupted. These include membrane fusion,protein insertion and lipid "flip-flop" (1).

^{31}P NMR, ^{13}C NMR and freeze-fracture studies demonstrate that bilayer → non-bilayer transitions in aqueous dispersions of both synthetic and natural lipids can be induced by temperature variation, changes in divalent cation concentration and protein-lipid interactions. In mixtures of bilayer forming lipids (such as phosphatidylcholine) and non-bilayer lipids (such as phosphatidylethanolamine) as well as the total lipid extracts of E. coli and rod outer segment membranes novel "lipidic particle" structures have been observed which most likely represent inverted micelles sandwiched in between the two monolayers of the lipid bilayer. Our model system studies indicate that these structures occur as intermediates in membrane fusion and greatly facilitate lipid "flip-flop". Although conclusive evidence for the occurrence of non-bilayer phases in biological membranes is at present lacking ^{31}P NMR and ^{13}C NMR studies on isolated microsomes,mitochondria and perfused rat liver demonstrate that under physiological conditions phospholipids in inner mitochondrial and microsomal membranes undergo much faster isotropic motion than expected from extended lipid bilayers which could originate from "transitory" non-bilayer phases in these membranes.

1. Cullis, P.R. and de Kruijff, B. (1979) Biochim. Biophys. Acta 399 - 420.