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Review article

»Membrane Fluidity«, more than one single parameter

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This paper is a review of parameters for membrane order and dynamics related to »Membrane Fluidity«. These parameters include lateral and rotational diffusion constants, the half-time for lipid flip-flop, order parameters, domain formation and asymmetry. Data have been gathered from the literature on nuclear magnetic resonance, electron spin resonance, fluorescence and related spectroscopic techniques.

The generally accepted model of membrane structure is the Fluid Mosaic Model, proposed by Singer and Nicholson (1). In this model the membrane is envisioned as a sea of lipids, in which proteins are floating like icebergs (2). The lipids form a bilayer. Non-bilayer lipid structures may transiently exist as well, however (3). Proteins are either bound to the membrane surface (peripheral proteins) or bound both to the hydrophobic core of the bilayer and to the polar surface (integral proteins). The model emphasizes the fluidity of the structure (2); the molecules have freedom to move laterally and to rotate or wobble (4). Beautiful cartoons are available illustrating the fluid mosaic structure (2). Proteins form the major component of all biomembranes, from 50 to 70% by mass, with the exception of myelin, in which the lipids account for nearly 90% of the mass (2). Proteins perform most of the biological functions of the membrane, like transport, enzymatic activity, and immunorecognition, while lipids are believed to be mainly responsible for its fluidity, whereas they have other functions as well (5). Although the Fluid Mosaic Model has been criticized for being derived from thermodynamic considerations that are too naive (6) and for neglecting the role of the cytoskeleton (7), it is still considered as »the last of the celebrated membrane models« (6).

Ever since the introduction of the Fluid Mosaic Model, membrane scientists have tried to quantify the degree of fluidity of the membrane. At first, the goal was to describe the physical state of the membrane in terms of one parameter called »Membrane Fluidity« or »Microviscosity«, the inverse of »Membrane Fluidity«. One of the most productive techniques was the fluorescence depolarization method (8 - 11) which measures the degree of hindrance of rotational motion of fluorescence membrane probes. Another powerful technique was FRAP, which stands for fluorescence recovery after photobleaching (12 - - 15). If indeed the physical state of the membrane could be characterized by one parameter, there should be a relationship between fluorescence depolarization data and FRAP results. The fact that such a relationship did not exist for all membranes clearly indicated that having one single parameter for the physical state of the membrane was an