Electron paramagnetic resonance (EPR) spin-labeling methods provide a number of unique approaches to determining several important membrane properties as a function of bilayer depth. These include structural and dynamic parameters of alkyl chains, such as order parameter and fluidity, as well as local hydrophobicity, diffusion-concentration products for oxygen and nitric-oxide molecules, and penetration depth of metal ions and metal-ion complexes. Additionally, using spin labeling, membrane domains or coexisting membrane phases can be discriminated, and, in some cases, transmembrane profiles of the above-mentioned properties can be obtained for these domains and phases without the need for their physical separation. Thus, EPR spin-labeling methods provide rather complete information about the three-dimensional dynamic structure of lipid-bilayer membranes, including lateral organization and transmembrane structure. The physical membrane properties mentioned above can vary drastically with membrane composition, depth, and domain formation. Thus, the microenvironmental factors presented by the membrane should be taken into account in the analysis of chemical reactions and physical processes that occur in the lipid-bilayer environment. Detailed profiles of physical properties can be obtained not only across simple model membranes, but also across bilayers composed of lipids extracted from biological samples, as well as across intact biological membranes. These profiles provide useful guidelines that aid in the understanding of chemical processes in biological membranes—for example, those processes involving reactive oxygen, reactive nitrogen, and other radical species.

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