Preface

Cell membranes are important biological structures. Not only do they serve a structural and containment role for the cell but they also regulate transport, intracellular signaling, adhesion, and enzymatic reactions. To fulfill these roles, the cell membrane is composed of a highly complex composite of lipids and proteins which not only serve a direct function but also modify and regulate membrane biophysical parameters; a complexity which is only now being understood. This edition provides protocols for investigating membranes and their component lipids in both artificial membranes, cells and in silico.

The contribution begins with three introductory chapters. Chapter 1 examines the properties of the component lipids themselves, exploring the specific motifs of some of the most common archetypes. Chapter 2 introduces membranes and their biophysical properties and how these relate to their biological role. Finally, Chapter 3 discusses the latest advances in fluorescent probes for studying membranes: Fluorescence has been one of the major tools for examining lipid bilayers in recent years, especially in live cells due to its specific and noninvasive nature, and is a subject of several of the subsequent chapters.

Chapters 4–8 concern sample preparation. The relative simplicity of artificial membranes compared to cellular membranes has been an impasse in comparing in vitro and in vivo results. Recently, however, more realistic systems have been developed. For example, Chapter 4 describes the use of tethered lipid bilayers, Chapter 5 focuses on the use of detergent-resistant membrane methods to extract membrane subsets, Chapter 6 on the formation of artificial vesicles composed of cell membrane lipids, and Chapter 7 on the creation of realistic, asymmetric planar lipid bilayers. It is also useful to be able to modify membrane composition and properties in order to examine the effect on biological function; the subject of Chapter 8.

Once samples have been obtained, a range of physical techniques are available to study membrane composition, properties, and function. Eleven of these are the subjects of Chapters 9–19; for example, bilayer composition can be studied using mass spectrometry (Chapter 9). The packing density of lipids within a bilayer can be studied using environmentally sensitive fluorescent membrane probes (Chapter 10), and the lateral distributions of lipids and proteins within the bilayer can be characterized using newly developed super-resolution fluorescence imaging microscopy methods based on single-molecule detection (Chapter 11), a technique which is complemented by the gold standard in high-resolution imaging—electron microscopy (Chapter 12). Chapter 13 gives a detailed protocol for the use of atomic force microscopy (AFM) to study bilayers whereas Chapter 14 introduces another fluorescence-based method to examine the molecular orientations of lipids. Chapter 15 shows how fluorescence correlation spectroscopy (FCS) can be used to study the diffusion of lipids and proteins within the plane of the bilayer whereas Chapters 16 and 17 give detailed methods on studying lipid phase behavior in artificial systems using X-ray scattering and nuclear magnetic resonance (NMR) respectively. The section concludes with two further fluorescence techniques; measuring lateral mobility in membranes using photobleaching (Chapter 18) and a new method to analyze signals from environmentally sensitive dyes such as those used in Chapter 10 (Chapter 19).

It is important that physical observations be backed up with a strong theoretical framework and comprehensive computer modeling. The volume therefore ends with two examples of in silico analysis: One to model the behavior of cholesterol within a bilayer (Chapter 20) and one to examine cholesterol-dependent phase separation (Chapter 21).

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