Subcellular Biochemistry

Volume 23

**Physicochemical Methods in
the Study of Biomembranes**

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Volume 23

**Physicochemical Methods in
the Study of Biomembranes**

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Preface

In mammalian cells many physiological processes rely on the dynamics of the organization of lipids and proteins in biological membranes. The topics in this volume deal with physicochemical methods in the study of biomembranes. Some of them have a long and respectable history in the study of soluble proteins and have only recently been applied to the study of membranes. Some have traditionally been applied to studies of model systems of lipids of well-defined composition, as well as to intact membranes. Other methods, by their very nature, apply to organized bilayers comprised of both protein and lipid.

Van Meer and van Genderen provide us with an introduction to the field (Chapter 1). From their personal perspective regarding the distribution, transport, and sorting of membrane lipids, they formulate a number of biologically relevant questions and show that the physicochemical methods described in this book may contribute in great measure to solving these issues.

The methods of analytical ultracentrifugation have served faithfully for 60 years in the study of water-soluble proteins. The use of detergent extraction of membrane proteins, and the manipulation of density with $\text{H}_2\text{O}/\text{D}_2\text{O}$ mixtures, has extended this technique to the study of proteins, and in particular their interactions, from biological membranes. As described by Morris and Ralston in Chapter 2, this technique can be used to determine a number of important properties of proteins.

Techniques such as monomolecular layers have had particular relevance to the structure of lipid bilayer membranes since the pioneering work of Gorter and Grendel in 1925, which led to the concept of lipid bilayers. The use of careful studies of the pressure–area characteristics of lipid monolayers, discussed in Chapter 3 by Demel, allows exploration of the interactions, both thermodynamic and kinetic, with the lipid layer of solutes dissolved in the aqueous subphase.

The physical properties and biological functions of biological membranes

reflect both local and global organization of the lipids and proteins within the membrane. In Chapter 4, Ye and Biltonen describe the use of both differential scanning calorimetry and dynamic calorimetry for probing the organization and dynamics of lipids both in model membrane systems and in biological membranes.

Whole cells are more complicated than simple bilayers and often display interaction between the lipid bilayer and the underlying cytoskeleton. These interactions, only relevant in the intact membrane, are important for control of cell shape and deformability and may be probed through the technique of ektactometry, as described by Johnson in Chapter 5.

The time scale of spin-label ESR spectroscopy is particularly suitable to resolving the motion of lipids and the restriction of such motion in the vicinity of membrane proteins, as discussed by Horváth in Chapter 6. The use of covalent ESR probes also provides a spatial dimension in probing the interaction between the protein and lipid moieties.

The use of NMR in the study of transport through membranes and into cells is based implicitly on the membrane limiting and defining the compartments inside and outside cells. The application of NMR to transport processes in biological membranes is addressed by Kuchel, Kirk, and King in Chapter 7. The authors demonstrate how this technique offers a number of advantages over more conventional techniques.

In Chapters 8, 9, and 10, Goormaghtigh, Cabiaux, and Ruyschaert, providing a very detailed account of the use of Fourier transform infrared spectroscopy, demonstrate that this method can lead to an understanding of the secondary structure of soluble proteins, and that it can be applied to the structure of proteins within a membrane as well. According to the authors, the method enables the simultaneous study of the structure of lipids and proteins in intact biological membranes without introduction of foreign perturbing probes. Chapter 8 is a summary of the basic knowledge accumulated on the different vibrations of interest for the study of proteins. In Chapter 9, the experimental problems related to recording spectra for proteins and the potentialities of the method for the study of the structure of amino acid side chains are examined. Chapter 10 deals more specifically with the recovery of protein secondary structures from the complex IR spectra.

X-ray diffraction is sensitive to regular spacing and orientation of the molecules within the lipid bilayer. In Chapter 11, Laggner describes recent developments in X-ray diffraction as applied to the lipid component of biological membranes, in particular the use of synchrotron radiation and fast detectors to overcome some of the earlier limitations of the method.

We are aware that this survey is far from complete. Many other techniques could have been included (e.g., electron microscopy) or are treated elsewhere (e.g., fluorospectroscopy in Volume 16 of this series). However, the range of

approaches covered in the present volume is representative of the need for increasing sensitivity and resolution in attempting to understand the organization, interaction, and dynamics of both lipid and protein components within the biological membrane.

We thank Professor de Kruijff for his advice in compiling this book.

Antwerp, Belgium
Sydney, Australia

Herwig J. Hilderson
Gregory B. Ralston

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