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Supported Membranes in Structural Biology

Lukas K. Tamm and

Dept. of Molecular Physiology & Biological Physics, University of Virginia, Charlottesville, VA
22908-0736, USA, Fax: (434) 982-1616

Jay T. Groves

Chemistry Department, HHMI, UC Berkeley, Berkeley, CA 94720, USA

Lukas K. Tamm: lkt2e@virginia.edu; Jay T. Groves: JTGroves@lbl.gov

This year marks the 25th anniversary of supported membrane research, which began in 1984 (Brian and McConnell, 1984; Tamm 1984). Supported membranes are lipid bilayer model membranes with or without reconstituted or native membrane proteins that have been developed to study numerous structural and functional properties of cell membranes. A key feature of supported membranes is that despite their stable attachment to solid substrates, they retain the fluidity of biological membranes. To commemorate this event, we have assembled in this Special Issue a collection of 23 primary research and review articles that illuminate how diversified this field has become. A PubMed search on “supported membrane” or “supported bilayer” returned 10,118 entries on July 1, 2009. Therefore, it is not feasible to provide a comprehensive overview on how far this field has proliferated over the past quarter century in this dedicated issue. Rather, the highlighted topics are somewhat selective, but we still hope that they convey the excitement that continues to exist in this field since its inception. For those who would like to read still more about the subject, we recommend a number of recent comprehensive reviews that each emphasize different aspects of supported membrane research ranging from studies of the lateral dynamic structure of membranes to the remodeling of cell membranes in signal transduction and cell adhesion (Castellana and Cremer 2006; Chan and Boxer 2007; Groves et al, 2008; Kiessling et al, 2009).

The articles in this Special Issue are organized around four specific themes. The first seven papers deal with the remodeling of membranes by proteins. The series starts out with an engineered model system to introduce nano-structured barriers in membranes. Membrane-attached actin filaments can provide such barriers as discussed in the following paper. Membranes may be perturbed by peptides, which may be monitored by combined optical and atomic force microscopy or sum-frequency vibrational spectroscopy. Two more papers in this group describe how protein dimerization may be studied in supported membranes and how lipid enzymes reorganize the lateral structure of membranes.

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The next group of papers illustrates how far one of the first applications of supported membranes has been developed, namely the use of supported membranes to measure the binding of proteins to membrane lipids or receptors. The series starts out with thorough treatments of equilibrium binding of multivalent ligands to defined binding sites in membranes and the kinetics of ligand binding to membrane receptors. The binding of the two repeat domain annexin VI is discussed from a kinetic and structural point of view in the next paper. The last two papers in this series deal with the binding, conformation, and topology of amyloid peptides and HIV-derived lipopeptides in membranes.

Several articles discuss methods for preparing cellular membranes on solid supports and how and why such membrane models are useful to study various functions of cell membranes. Cell membrane functions that are discussed in these papers include the redistribution of proteins leading to bacterial cell division, cell adhesion and the activation of immune cells, Lyn kinase redistribution after receptor activation in mast cells, electrophysiological measurements on hemi-gap junctions, and the development of an immunosensor for antibody detection in serum.

The last group of papers introduces several new concepts to engineer complex systems on solid supports that go beyond single supported membranes. The construction of double membranes is discussed using polymers, proteins, and nucleic acids. Two papers discuss different strategies to assemble bilayers on top of specifically tailored “posts” of DNA. Archaea have extremely stable surface layer protein lattices that together with lipids and glycans have been used as building blocks for forming complex supramolecular membrane structures on solid supports as reviewed in the penultimate paper and probed by AFM force measurements in the final article of this Special Issue.

As this collection of articles shows, supported membrane technology has expanded to cover many areas that are of interest to structural and cell biologists who wish to better understand biological processes occurring at cell membranes. Just as researchers begin to tackle increasingly complex functions of cell membranes, supported membranes of increasing complexity are being developed to elucidate complex membrane processes such as membrane fusion, membrane fission, morphogenetic signaling, and many more.

In conclusion, we hope that this series of papers will stimulate another quarter century of exciting research using supported membranes as a tool to further explore new structural, dynamical and functional properties of cell membranes and to develop them into numerous practical devices.

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