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Membrane Hydration

The Role of Water in the Structure and Function of Biological Membranes

Springer

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Water, water, everywhere,
And all the boards did shrink;
Water, water, everywhere,
Nor any drop to drink.

The Rime of the Ancient Mariner
Samuel Taylor Coleridge (1797)

Preface

Biological membranes are unique material in terms of surface and mechanical properties due to its contact with water, and nowadays important attempts to mimic their properties in the search of biotechnological inputs in human health, food industry, crop, and energy have been developed. Thus, hydration in membranes gets new insights from the prospect of nanosystems.

Hydration is an emerging subject in the field of material sciences. In particular, in biological systems water is organized in proteins and membranes. In this last case, the amount of water average is no more than 20–25 molecules per lipid. If it is considered that it may be distributed in discrete sites of different chemical features, water environments are restricted to less than ten water molecules. With this criterion, studies of water in biological systems in general, and in membranes in particular, are within the scope of nanosciences.

This book is an effort to enlighten the importance of this subject in relation to biology and biophysics. This project has been possible due to the enthusiasm of all the authors of the chapters to which I want to particularly thank for their work.

I also like to recognize those who for different reasons could not contribute to this edition and hope that they may enrich future ones.

Among the authors I am particularly grateful to Zoran Arsov, Stephanie Tristram-Nagle, Helge Pfeiffer, and Gustavo Appignanessi for their help, advice, and comments along the preparation of the manuscripts.

The ideas about membranes and water have been built along years, and therefore, it is the product of what I have been able to collect from excellent teachers, colleagues, and friends.

For this reason I want to specially express my gratitude and recognition to Dr. Jorge Arvia and Dr. Hector Videla from INIFTA (Universidad Nacional de La Plata) with whom I began my feeling for research in biophysical chemistry and bioelectrochemistry during my PhD thesis, to Prof Raul Grigera who showed me the importance of water, and to Prof Hans de Gier from Utrecht University who introduced me in the world of lipids as a postdoc.

Also, I learned thermodynamics with Ernesto Timmermann and lipid monolayers with Bruno Maggio. With all of them I had exciting and vigorous discussions.

A special place is reserved for Sid Simon and Tom McIntosh with whom I spend my sabbatical enjoying science, tennis, and drinks.

Finally I want also to thank all the students who went through my laboratory in the Universidad Nacional de La Plata, University of Buenos Aires, University of Tucuman, and, in these last years, the University of Santiago del Estero, because along their works, their doubts, their achievements, their challenges, and their irreverences I, found new routes to pursue in this research.

I hope that this book will encourage them and the next ones in the fascinating field of biophysics of biological membranes.

Santiago del Estero, Argentina E. Anibal Disalvo

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Abbreviations

$\|F(q_z)\|$	Form factor
18:0:22:5PC	Stearoyldocosapentaenoyl-phosphatidylcholine
18:0-22:6PC	Stearoyldocosahexaenoylphosphatidylcholine
$2D_C$	Hydrocarbon thickness
AFM	Atomic force microscopy
A_L	Area/lipid
B	Bulk modulus
D, D-space	X-ray lamellar D-spacing
d, d-space	X-ray wide-angle chain spacing
D_B	Bilayer thickness
D_H'	Headgroup thickness
DHPC	Dihexadecanoyl-phosphatidylcholine
diC22:1PC	Dierucoylphosphatidylcholine
diphytanoylPC	Diphytanoyl-phosphatidylcholine
DLPC	Dilauroylphosphatidylcholine
DLPE	Dilauroylphosphatidylethanolamine
DLPG	Dilauroylphosphatidylglycerol
DMPC	Dimyristoylphosphatidylcholine
DMPE	Dimyristoylphosphatidylethanolamine
DMPG	Dimyristoylphosphatidylglycerol
DMPS	Dimyristoylphosphatidylserine
DOPC	Dioleoylphosphatidylcholine
DOPG	Dioleoylphosphatidylglycerol
DOPS	Dioleoylphosphatidylserine
DPhPC	Diphytanoylphosphatidylcholine
DPPC	Dipalmitoylphosphatidylcholine
DSC	Differential scanning calorimetry
DSPC	Distearoylphosphatidylcholine
EggPC	Egg phosphatidylcholine
EPR	Electron spin resonance
FTIR	Fourier transform infrared resonance

$I(q_z)$	X-ray intensity
interdig.	Interdigitated
K_C	Bending modulus
MD simulation	Molecular dynamics simulation
MLVs	Multilamellar vesicles
NIR	Near-infrared
NMR	Nuclear magnetic resonance
n_W	Number of waters/lipid
n_W'	Steric number of waters/lipid
OSM	Osmotic stress method
PCA	Principal component analysis
PLS	Partial least squares
POPC	Palmitoyloleoylphosphatidylcholine
POPG	Palmitoyloleoylphosphatidylglycerol
PPM	Piezotropic phase transitions method
PrP	Prion protein
SFA	Surface force apparatus
SIMCA	Soft independent modeling of class analogy
SOPC	Stearoyloleoyl-phosphatidylcholine
SOPG	Stearoyloleoylphosphatidylglycerol
Tm	Main transition melting temperature
TMCL	Tetramyristoylcardiolipin
TPM	Thermotropic phase transition method
ULVs	Unilamellar vesicles
u_n	Vertical displacement
V_L	Molecular volume/lipid
V_W	Molecular volume/water
WAMACS	Water matrix coordinates
WASP	Water spectral pattern
η	Fluctuation parameter