Biomolecular Structure and Function

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ACADEMIC PRESS New York San Francisco London 1978

A Subsidiary of Harcourt Brace Jovanovich, Publishers

ACADEMIC PRESS, INC.
111 Fifth Avenue, New York, New York 10003

United Kingdom Edition published by
ACADEMIC PRESS, INC. (LONDON) LTD.
24/28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data

Main entry under title:

Biomolecular structure and function.

Proceedings of a symposium held at the University of Missouri, Columbia, May 18–20, 1977.
Includes index.
1. Molecular biology—Congresses.
I. Agris, Paul F. II. Loeppky, Richard N.
III. Sykes, Brian D.
QH506.B555 574.8'8 77-25389
ISBN 0-12-043950-6

PRINTED IN THE UNITED STATES OF AMERICA

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Preface

Man's insatiable curiosity and his desire to improve the human condition have long led him to probe and ponder the most minute details of the life process. The past several decades have witnessed a revolution in biological science as our understanding has been brought to the molecular level of organization. The advances that attended these developments came largely from the clever and ingenious biological application of instrumentation and methodology that originated in the laboratory of the physical scientist. Even so, the biological and physical scientists are not yet comfortable bedfellows. Thus, with the goal of providing a demonstration of the application of modern physical methods to molecular research in biology and a forum for discourse between scientists, we organized a symposium, "Cellular Function and Molecular Structure: Biophysical Approaches to Biological Problems," in commemoration of 75 years of cellular research at the University of Missouri—Columbia. This book presents the proceedings of that symposium (May 18–20, 1977) and provides not only a compendium of the most recent research but a preview of the literature in this area for the next several years.

We chose eight prominent scientists, who had focused several biophysical techniques on the solution of particular biological problems, as the principal authors and speakers for the symposium. All of these authors have a background in magnetic resonance spectroscopy, particularly NMR, but the scope of this book is by no means limited to the exposition of this technique alone. In addition 54 groups of scientists present shorter papers that proclaim the diversity of approaches that may be utilized in seeking answers to complex biological puzzles. We have organized the book so that each of the different scientific inquiries is presented in a chapter with other works directed at that same subject in order to illuminate the problem with light brought by several techniques and methodologies. The lead papers in each chapter are those of the principal authors and are followed by the shorter papers.

A facet of the revolution in biology is the recognition of the important role played by membranes and an enormous amount of work is currently directed at the understanding of structural dynamics of membrane constitution in relation to function. In separate papers, I. C. P. Smith and P. Jost show how the dynamic behavior of membranes can be probed on different time scales by NMR (^2H and ^{13}C) and EPR (spin labels). Other authors amplify the utilization of these methods and demonstrate what can be learned from fluorescent probes, electrokinetics, neutron diffraction, and ion theory studies of phospholipid–protein association, hormone disease, and senescence effects on procaryotic and eucaryotic cells.

Imagine being able to simultaneously monitor the intracellular pH and phosphate metabolism in a beating heart, functioning kidney, or an intact living microorganism. Experiments and methodology (employing ^{31}P NMR) in this exciting new area are described in separate papers by G. Radda and R. Shulman as well as by other authors. No less exciting are descriptions by other investigators of the biophysical probing of intracellular fluidity and structural changes attending tissue or cell cycles.

The amazing efficacy of functional and structural proteins has long been the object of scientific wonderment. NMR spectroscopists will be astounded to find, as B. Sykes relates, that relatively narrow lines in the ^{1}H NMR spectrum of the extremely viscous complex of the muscle protein troponin and highly polymerized tropomyosin are observed and can be used to monitor the molecular conformation (and that of the protein) with pH change. R. A. Dwek describes how an array of biophysical methods including NMR, ESR, X-ray, and model building have been employed to elucidate the architecture of antigen–antibody combining sites. P. C. Lauterbur demonstrates how two NMR methods can be employed to probe the nature of the protein solvent interface even though the proteins are very large. Structure–function studies of fibrous proteins, such as collagen, the contractile proteins actin and myosin, and active site analysis of enzymes such as glutamine synthetase, carbonic anhydrase, adenylate, adenylate kinase, and ATPase, by other symposium participants add another dimension of understanding. A wide variety of methodologies and new technologies is exemplified: proton, carbon, fluorine, phosphorus, and lithium NMR spectroscopy; spin labeling and EPR spectroscopy; chemical studies; light scattering and fluorescence; and electron microscopy.

Studies of the structure and function of nucleic acids have been gaining momentum due to innovative approaches. D. Kearns shows how proton NMR in particular has given us knowledge of tRNA structure and other scientists describe how fluorescence, carbon NMR and other methodologies are helping them to further unravel the structural dynamics of tRNA interaction with nucleic acids and proteins. Other authors discuss certain structural interactions of DNA and RNA with specific proteins: phage fd DNA with its gene 5 protein; DNA with the proteins of the nucleosome; and tRNA with aminoacyl–tRNA synthetase complex.

It is our hope that the reader will find the accounts of this work as exciting and inspiring as the conference participants did and that it will lead others to explore the utilization of vast array of approaches given herein to the solutions of their scientific problems.

The editors wish to thank all of the contributors to this volume, especially the Symposium speakers. We would like to extend our thanks and gratitude to the Division of Biological Sciences and the Chemistry Department at the University of Missouri—Columbia for the aid their staff provided toward the success of the Symposium and the publication of this book. We sincerely appreciate the financial support of the Symposium by those colleges and departments of the University of Missouri—Columbia.

Acknowledgments

We would like to acknowledge the following for their contributions to the symposium.

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Experiment Station Chemical Laboratory
Department of Veterinary Anatomy–Physiology
College of Arts and Science
School of Medicine
Graduate School
Research Council
Development Fund

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