CELL SURFACE REVIEWS - Volume 6

The cell surface and neuronal function

Edited by
CARL W. COTMAN
GEORGE POSTE
and
GARTH L. NICOLSON

North-Holland

THE CELL SURFACE AND NEURONAL FUNCTION

Edited by

CARL W. COTMAN

Department of Psychobiology
University of California, Irvine, California

GEORGE POSTE

Department of Experimental Pathology
Roswell Park Memorial Institute, Buffalo, New York

and

GARTH L. NICOLSON

Department of Tumor Biology, University of Texas System Cancer Center,
M.D. Anderson Hospital and Tumor Institute, Houston, Texas

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General preface

Research on membranes and cell surfaces today occupies center stage in many areas of biology and medicine. This dominant position reflects the growing awareness that many important biological processes in animal and plant cells and in microorganisms are mediated by these structures. The extraordinary and unprecedented expansion of knowledge in molecular biology, genetics, biochemistry, cell biology, microbiology and immunology over the last fifteen years has resulted in dramatic advances in our understanding of the properties of the cell surface and heightened our appreciation of the subtle, yet complex, nature of cell surface organization.

The rapid growth of interest in all facets of research on cell membranes and surfaces owes much to the convergence of ideas and results from seemingly disparate disciplines. This, together with the recognition of common patterns of biological organization in membranes from highly different forms of life, has led to a situation in which the sharp boundaries between the classical biological disciplines are rapidly disappearing. The investigator interested in cell surfaces must be at home in many fields, ranging from the detailed biochemical and biophysical properties of the molecules and macromolecules found in membranes, to morphological and phenomenological descriptions of cellular structure and cell-to-cell interactions. Given the broad front on which research on cell surfaces is being pursued, it is not surprising that the relevant literature is scattered in a diverse range of journals and books, making it increasingly difficult for the active investigator to collate material from several areas of research. Thus, while scientists are becoming increasingly specialized in their techniques, and in the nature of the problems they study, they must interpret their results against an intellectual and conceptual background of rapidly expanding dimensions. It is with these conflicting demands and needs in mind that this series, to be known under the collective title of CELL SURFACE REVIEWS, was conceived.

CELL SURFACE REVIEWS will present up-to-date surveys of recent advances in our understanding of membranes and cell surfaces. Each volume will contain authoritative and topical reviews by investigators who have contributed to progress in their respective research fields. While individual reviews will provide comprehensive coverage of specialized topics, all of the reviews published within each volume will be related to an overall common theme. This format represents a departure from that adopted by most of the existing series of "review" publications which usually

provide heterogeneous collections of reviews on unrelated topics. While this latter format is considerably more convenient from an editorial standpoint, we feel that publication together of a number of related reviews will better serve the stated aims of this series—to bridge the information and specialization "gap" among investigators in related areas. Each volume will therefore present a fairly complete and critical survey of the more important and recent advances in well defined topics in biology and medicine. The level will be advanced, directed primarily to the needs of the research worker and graduate students.

Editorial policy will be to impose as few restrictions as possible on contributors. This is appropriate since the volumes published in this series will represent collections of review articles and will not be definitive monographs dealing with all aspects of the selected subject. Contributors will be encouraged, however, to provide comprehensive, critical reviews that attempt to integrate the available data into a broad conceptual framework. Emphasis will also be given to identification of major problems demanding further study and the possible avenues by which these might be investigated. Scope will also be offered for the presentation of new and challenging ideas and hypotheses for which complete evidence is still lacking.

The first four volumes of this series will be published within one year, after which volumes will appear at approximately one-year intervals.

GEORGE POSTE
GARTH L. NICOLSON
Editors

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Preface

Neurons are a highly specialized and functionally diverse class of cells that derive many of their special qualities from their plasma membranes. Recent research has provided significant new insights into the surface properties of these cells and this volume, the sixth in the *Cell Surface Reviews* series, provides a concise survey of recent advances in this important area of membrane research.

Neurons are designed for communication. A typical neuron receives signals from other cells at its surface, integrates them and passes a consensus along to other cells. Neuronal membranes, like those of other excitable cells, are semipermeable, have membrane potentials at rest, and generate action potentials when stimulated beyond threshold. Excitable cells have the unique property that their permeability to certain ions is voltage dependent, thus enabling them to generate powerful self-regenerating membrane currents. The three major voltage dependent ion channels identified in excitable cells are those for sodium, potassium and calcium ions and there is now a formidable body of experimental data on the molecular properties of these channels. In this volume Cahalan examines the properties of sodium channels involved in generating action potentials. New voltage dependent channels have also been discovered recently, notably for potassium ions. Thompson and Aldrich describe the properties of these channels and examine their possible role in cell function. Certain calcium channels are also voltage dependent and Llinás and Walton describe their location, properties and function in neuronal membranes. Together, these three chapters provide a detailed comparison of the major types of ion channels in excitable membranes. Hitherto this information has been widely scattered in the literature and this is the first time that these related topics have been reviewed within a single volume.

Major advances have also been made recently in identifying the cell surface receptors for neurotransmitters and psychoactive drugs. Of these, the nicotinic cholinergic receptor has been studied in most detail. Only ten years ago some still questioned its existence. Now it has been isolated and purified and its mode of action examined in great detail. Three chapters are devoted to the properties of this fascinating receptor. Steinbach discusses the functional properties of individual acetylcholine channels, primarily from a physiological point of view. Karlin critically examines the biochemical characteristics of the isolated cholinergic receptor and its structural organization within the membrane, while Patrick and Berman review the biosynthesis of the

receptor and describe how the number and distribution of receptors are influenced by deinnervation and certain neuromuscular diseases. Other transmitter receptors and their functions are also discussed. Kebabian and Zatz analyze the different classes of monoamine receptors and their coupling to cyclases. Creese describes the evidence for and against receptor abnormalities in mental disorders and Miller and Dawson document the rapid growth in information about receptors for opiates and opiate-like peptides. Finally, Peck and Lester critically discuss the difficult area of receptors for amino acid transmitters.

Communication between neurons also involves mechanisms other than ion channels and receptors. Membrane transport systems, for example, play a major role in maintaining appropriate concentrations of transmitter molecules in the vicinity of neurons. Such transport systems have distinctive characteristics and these are reviewed here by Fonnum and coworkers. In common with the specialized patterns of plasma membrane organization seen in other highly differentiated cells, many of the special features of neuronal membranes are nonuniformly dispersed over the neuron surface. The neuronal membrane is a vast mosaic of specialized macromolecules organized in precise topographic displays in different regions of the neuronal surface. Little is presently known about this aspect of neuronal architecture. Most of the available information about the general structure and molecular composition of these membranes comes from studies of synaptic membranes. Cotman and Kelly review this subject and discuss the molecular properties and major functional subsystems of these structures.

The twelve chapters in this volume illustrate the substantial progress which has been made in understanding the molecular biology and function of neuronal membranes. Although limitations of space preclude review of every aspect of this important branch of neurobiology, this volume provides one of the most complete treatments of neuronal membrane properties published to date. All of the chapters have been written with the specialist and nonspecialist in mind. We thus hope that in addition to neurobiologists, researchers from other disciplines who are interested in membrane function will also find the volume of interest.

We thank the contributors of this volume and express our appreciation of their willingness to accept editorial suggestions. We would like to thank Linda O'Shea, Paula DiLuigi, Debbie Steele and Adele Brodginski for their untiring help in the editing of manuscripts.

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CARL COTMAN
Irvine, California

GEORGE POSTE
Buffalo, New York

GARTH NICOLSON
Houston, Texas

List of contributors

The numbers in parentheses indicate the page on which the author's contribution begins.

Richard W. ALDRICH (49), Hopkins Marine Station, Stanford University, Pacific Grove, California 93950, U.S.A.

Phillip W. BERMAN (157), Neurobiology Department, The Salk Institute, P.O. Box 1809, San Diego, California 92112, U.S.A.

Michael CAHALAN (1), Department of Physiology, University of California, Irvine, California 92717, U.S.A.

Carl W. COTMAN (505), Department of Psychobiology, University of California, Irvine, California 92717, U.S.A.

Ian CREESE (261), Department of Neurosciences, M-008, University of California, San Diego, La Jolla, California 92093, U.S.A.

Glyn DAWSON (351), Departments of Pharmacological and Physiological Sciences, Pediatrics, Biochemistry, and the Joseph P. Kennedy, Jr. Mental Retardation Research Center, Pritzker School of Medicine, University of Chicago, Chicago, Illinois 60637, U.S.A.

F. FONNUM (455), Norwegian Defence Research Establishment, Division for Toxicology, N-2007 Kjeller, Norway.

Arthur KARLIN (191), Departments of Biochemistry and Neurology, College of Physicians and Surgeons, Columbia University, New York, New York 10032, U.S.A.

R. LUND KARLSEN (455), Norwegian Defence Research Establishment, Division for Toxicology, N-2007 Kjeller, Norway.

John W. KEBABIAN (303), National Institute of Neurological and Communicative Disorders and Stroke, National Institutes of Health, Bethesda, Maryland 20205, U.S.A.

Paul T. KELLY (505), Department of Psychobiology, University of California, Irvine, California 92717, U.S.A.

Bruce R. LESTER (405), Department of Cell Biology, Baylor College of Medicine, Texas Medical Center, Houston, Texas 77030, U.S.A.

R. LLINÁS (87), Department of Physiology and Biophysics, New York University Medical Center, 550 First Avenue, New York, New York 10016, U.S.A.

D. MALTHE-SORENSSEN (455), Norwegian Defence Research Establishment, Division for Toxicology, N-2007 Kjeller, Norway.

Richard J. MILLER (351), Departments of Pharmacological and Physiological Sciences, Pediatrics, Biochemistry, and the Joseph P. Kennedy, Jr. Mental Retardation Research Center, Pritzker School of Medicine, University of Chicago, Chicago, Illinois 60637, U.S.A.

Jim PATRICK (157), Neurobiology Department, The Salk Institute, P.O. Box 1809, San Diego, California 92112, U.S.A.

Ernest J. PECK, Jr. (405), Department of Cell Biology, Baylor College of Medicine, Texas Medical Center, Houston, Texas 77030, U.S.A.

Joe Henry STEINBACH (119), Neurobiology Department, The Salk Institute, P.O. Box 1809, San Diego, California 92112, U.S.A.

S. STERRI (455), Norwegian Defence Research Establishment, Division for Toxicology, N-2007 Kjeller, Norway.

Stuart H. THOMPSON (49), Hopkins Marine Station, Stanford University, Pacific Grove, California 93950, U.S.A.

I. WALAAS (455), Norwegian Defence Research Establishment, Division for Toxicology, N-2007 Kjeller, Norway.

K. WALTON (87), Department of Physiology and Biophysics, New York University Medical Center, 550 First Avenue, New York, New York 10016, U.S.A.

Martin ZATZ (303), National Institute of Mental Health, National Institutes of Health, Bethesda, Maryland 20205, U.S.A.

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