PREFACE

In the past decade we have witnessed a trend toward interdisciplinary research. This trend has stemmed from an awareness that the study of biological phenomena requires an increasingly sophisticated integration of the natural, physical, and mathematical sciences. The most impressive unions in this regard have been at either end of the hierarchial orders of organization, namely, in molecular biology and in bioengineering. The reasons why we have witnessed dramatic advances in these areas of research are not serendipitous. Molecular biology deals with systems, admittedly complex, whose numbers of interdependent variables are not excessive, thus the so-called microscopic, single-subunit approach can be developed. Bioengineering deals with large, so-called macroscopic systems sufficiently organized that they can be described by lumped parameters or of sufficiently disorganized complexity that statistical techniques can be used. Between these two ends of the organizational spectrum lies a vast middle ground of research where the numbers of subunits and coupling factors are too large or too small for either of the above analytical methods. This middle ground has recently been entitled the study of organized complexities or the study of structured continua. In 1666 Leibnitz wrote about this middle ground. He saw it from a purely mathematical viewpoint and wrote of a combinatorial art, the *Characteristica Universalis,* that could deal simultaneously with the same and the different, the specific and the nonspecific. The modern biologist is now beginning to venture in similar directions. For him, these intermediate hierarchial orders pose exciting challenges. The unit of life, the cell, must ultimately be viewed as an organized complexity, and we shall become increasingly involved in studying the relationships among structures and functions, energy transductions within cells, the development of subcellular fractions, and movements within cells.

This book focuses on the last example, namely, the processes of and mechanisms underlying intracellular transport. It contains contributions of an unusual grouping of scientists—cellular biologists, mathematicians, physiologists, physical chemists, electron microscopicists, engineers, and geneticists. These seemingly disparate scientists came together for a week in Frascati, Italy to discuss their research activities and concepts. Obvious semantic difficulties arose. Most, but not all, of these difficulties were resolved. It soon became apparent that the engineer concerned with the analysis and design of involved chemical processing plants has interests in common with the cellular biologist concerned with nature's evolved processing plants. The awareness of mutual concerns led to an exchange of concepts and methodologies of mutual benefit. Many of these ideas and techniques are described in the various chapters of this book.

The titles of the chapters may at times appear unrelated. For the reader who finds the diversity of titles confusing and formidable, I recommend patient and repetitious study. As a biologist or as a physical or engineering scientist he can acquire insight into both technological and biological methods and concepts which he might never encounter in his normal course of research. The engineering scientist might be appalled that the biologist often has to disrupt his system by procedures as drastic as homogenization. On the other hand, the biologist might be alarmed that the engineering scientist is satisfied with design characteristics that tell much about the response of a system to perturbations but little about the details of its structure and function. The reader can detect such feelings in several chapters of this book.

Among the chapters that can be called biological are those of Snell and Chowdhury on intracellular potentials, Rostgaard and Behnke on the localization of adenine nucleoside phosphatase activity, Marshall on pinocytosis in amoeba. Crane on the brush border of cells, and Varon and Wilbrandt on the transport of γ-aminobutyric acid. Among the chapters that can be called technological or mathematical are those of Gmitro and Scriven on pattern and rhythm, Toor on diffusion and reaction coupling, Aris on compartmental analysis and residence time distributions, and Wilhelm on parametric pumping. Among those chapters that bridge the two areas in a less well-defined category are those of Rosenberg on intracellular transport fluxes, Vaidhyanathan on theoretical aspects of permeability transport, Jarosch on rotating helices and contractile mechanisms, and Booij on the movements of membranes. Obviously, several topics of interest have not been included. These gaps will have to be filled by future conferences and contributions regarding intracellular transport. In the meantime, we hope that this work will catalyze further interest in the fascinating biological problem and encourage biological, physical, and engineering scientists to assess areas where interests overlap.

At the time this book was being prepared for publication, Dr. John Marshall met with a tragic, fatal accident. Several of us have known him for many years. He was a dedicated, gifted scientist and a wonderful person. He was adept in expressing ideas clearly and directly. His chapter on intracellular transport in the amoeba summarizes several aspects of his exemplary research. We shall miss him.

December, 1966 MURRAY D. ROSENBERG