Preface to the Second Edition

In its first edition, the Physical Basis of Biochemistry endeavored to connect the foundation principles of biology to the essential processes in physics and chemistry. The core purpose of the new edition remains that described in the first edition:

- *The Physical Basis of Biochemistry* is an introduction to the philosophy and practice of an interdisciplinary field in which biological systems are explored using the quantitative perspective of the physical scientist. I have three primary objectives in this volume: one, to provide a *unifying* picture of the interdisciplinary threads from which the tapestry of biophysical studies are woven; two, to provide an insight into the power of the *modeling* approach to scientific investigation; and three, to communicate a sense of *excitement* for the activity and wholesome argument that characterizes this field of study.
- The students in this course are likely to be a cross section of quantitatively oriented biologists as well as aspiring chemists, physicists, and engineers with an interest in biological systems. This leads to a mixing of interests and disciplines brought to both the classroom and the laboratory. A fundamental assumption of a physical approach to biology and especially to biophysical chemistry is that we can gain understanding of a biological phenomenon by describing and understanding its physical nature. Thus the tools of the physical scientist become available to the biologist in the exploration of the complexities of biological systems.

In the preface to the first edition of The Physical Basis of Biochemistry I wrote

> In recent years, the skills of the biophysical chemist have emerged as prized commodities in both academic and industrial circles. The need for these skills will intensify as the practice in biotechnology and bioindustry moves from gene identification to the manufacture of gene products that will need both proper structure and function to be useful.

Just 6 years after that preface was written, the human genome was decoded and in the last decade genomics has given way to proteomics and the apparent rediscovery of the biological system. There have been several “great surprises” such as the complexity of the protein-folding question, the massive diversity of form and function that arises from a much smaller number of genes than expected, and an explosion of biomathematical needs and expectations as the field of bioinformatics has become critical to application of these data to biological questions in fields as diverse as evolution, anthropology, linguistics, neurosciences, and biomedicine.

The idea that a fundamental understanding of the basic physical principles underlying chemical biological systems is vital remains the focus of this new edition. This new edition has been extensively reworked and reorganized to be more pedagogically friendly to the original goals as outlined above. The parallel construction of topics in the first edition was much more difficult to teach in classrooms than expected and a more traditional ordering has now been restored. There has been substantial new material added with respect to models at the simple molecular level—including van der Waals gases and virial treatments—which is tied to coverage of models of polymer thermodynamics. The methods for biophysical analysis have largely been reorganized and are now found in Part V.

The new edition is again partitioned into five parts:

Part I explores the central concept that science is a way of looking at the world. The role of scientific inquiry and its dependence on systems analysis and model making (the progression of inquiry) is once again emphasized with respect to building a background in biological content, an approach to systems science, and a review of probability and statistics.

Part II reviews the physical underpinnings of biophysical chemistry with an emphasis first on energy, work, and forces of biological importance. Then an introduction to quantum mechanics, chemical principles, and thermodynamics prepares the student with the tools necessary for constructing models in biological state space.

Part III uses the physical foundations developed in the first two parts to explore how models applicable to molecular biophysics are constructed. The overall system is that of aqueous biochemistry. The part starts with a consideration of the properties of water and then sequentially explores the interactions of water with the chemical components that make up biological systems. In the development of ion–solvent and ion–ion models, the Born, Kirkwood, and Debye–Hückel models instruct us on how these great physical scientists brought us to where we are today. There is a certain "classical" coverage of material but it is important for the modern student to see where the simplifications and abstractions originated in many of the ideas that have become our modern dogma. The part explores the interactions that lead to macromolecular (polymer) structure, the properties of the cell membrane, and the structure of the electrified regions near cells and colloidal surfaces.

Part IV takes the three-dimensional potential energy surface, which reflects the equilibrium state, and puts it into motion. This part explores the time-dependent actions of real-world processes. The major driving forces in biological systems are chemical and electrical gradients, and, diffusion and conduction are the focus of this part. It concludes with an examination of the electromechanical phenomena of electrokinetics and the kinetics of chemical and electrochemical systems of biological importance: enzymes and electron transfer in proteins.

Part V is a succinct discussion of the biophysical methods used to evaluate structure and function in biological systems. First the physics underlying the methods that use mechanical macroscopic properties to cause motion in a field such as centrifugation, electrophoresis, mass spectrometry, and chromatography are presented. Then the exploration of molecular structure with photons through spectroscopy and scattering techniques is presented. Finally the use of imaging techniques such as light, fluorescence, and atomic force microscopy is examined.

The *Appendices* continue to serve the purpose of presenting in detail some review information and certain topics that will be of interest to some readers, but might otherwise disrupt the flow of the textual story line.

The *question and problem* coverage in this volume has undergone some moderate expansion but a companion problems and solutions manual covering the material in this edition and much more extensively providing exercises to support learning these topics is currently being written and should be available concurrently with this text.

As always, projects like this never happen in a vacuum and I remain indebted to the help and support provided by colleagues and my family as this project now reaches into its third decade! This text has become an intergenerational family business. Like the first edition, in which I had the pleasure of working with my late father, Kaare Roald Bergethon, who contributed his scholarly and linquistic skills, in this edition I am pleased to have collaborated with my daughter, Kristin Elizabeth Bergethon, who has come into her own as a chemist and made substantial contributions to several of the chapters in Part 5. Unfortunately, this edition had to proceed without the encouragement of my colleague and friend Mary T. Walsh whose untimely death has left the community without a dedicated teacher and researcher. She is missed by all who knew her. In addition I would like to acknowledge the efforts to improve this edition hopefully will reflect well on those whose input has only helped to accomplish the goal. Any failures and errors that remain are entirely my responsibility.

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