

Preface

Because the study of the chemical reactions of living cells is a vast and complex field that touches almost every branch of chemistry and biology, writing an introductory textbook in this field is a difficult task. I would never have undertaken such a project if my goal had been merely to try to improve on the textbooks currently available, but I am convinced that a new approach to biochemistry will be useful to a broad range of students and teachers. Therefore, rather than dividing biochemistry into segments centered around specific chemical compounds such as proteins, nucleic acids, lipids, and carbohydrates, I treat chemical reactions of cells as a primary theme. While stressing biological concerns, I try to trace all physiological phenomena back to the underlying chemistry.

For the student, the study of biochemistry in all of its complexities and nuances may seem overwhelming. I have tried in various ways to make this task easier for students with diverse backgrounds. For instance, the main body of the text focuses on a clear and uncluttered presentation of biochemical principles. Ancillary information on vitamins, metallic elements, poisons, research techniques, and metabolic diseases may be fascinating to some students but of lesser interest to others. Therefore, such information is set off from the main text in special boxes, where it will not interrupt the flow of the fundamental material. (These boxes are noted on the detailed table of contents, and are also listed under eight subject headings on p. xxix.) In addition to trying to provide a clear and highly readable introduction to the basic principles of biochemistry, I have also attempted to provide the student with a book that can be used in the future as a reference source. Literature citations of three types have been included: (1) those to standard reference books such as "The Enzymes" (edited by Paul Boyer; Academic Press, New York; a treatise in 13 volumes); (2) references to especially important papers, some old and some recent; and (3) current references that should help the student become acquainted with the research literature. Study questions and problems accompany each chapter.

In brief, I hope this book will provide a readable, student-oriented introduction to the

chemical structures and reactions of living cells. The end result is not a radical departure from previous textbooks, but rather a distinctive perspective on the subject combined with some fresh approaches.

The first section of the book (Chapters 1–3) contains introductory material on cell structure, molecular architecture, and energetics. Chapter 1 provides quantitative information on sizes of cells and organelles and on the genetic complexity of organisms, and also describes characteristics of important species considered in later chapters. It is designed especially for students with a minimum of biological knowledge and will serve as a review for others. In this chapter, as well as throughout the book, the coverage includes bacteria, plants, and animals. In the second chapter a brief review of structural principles for molecules is followed by a systematic consideration of molecular structure and chemical properties of proteins, carbohydrates, nucleic acids, and lipids. A modern approach is followed whereby conformational properties as well as structures and reactivities are emphasized. A section on inorganic elements is followed by a review of methods of structure determination, including nmr techniques.

The third chapter, which starts with a review of thermodynamic equations, presents a practical approach to biochemical thermodynamics with a series of tabulated data. All of the free energy and enthalpy values cited later in the text are consistent with those in the tables. I chose to use the SI unit of kilojoules per mole throughout after I became convinced that this is the accepted norm in the international biochemical literature. The change from the more familiar kilocalories per mole is simple. An innovation is the use of free energies of combustion by NAD^+ which simplifies the arithmetic in evaluating free energy changes for metabolic processes.

Chapters 4 and 5 (the second major section of the book) deal with the ways in which biomolecules interact. From the quantitative treatment of binding to the structures of oligomeric enzymes, microtubules, viruses, and muscle, the treatment in Chapter 4 pursues a rigorous contemporary approach. Allosteric effects are considered quantitatively and systematically. Chapter 5 covers the structures and chemical properties of membranes and of the surrounding cell coats. A major aim of this and other chapters is to provide students with sufficient background so that they can begin to read the current research literature without immediately having to consult a variety of other background sources.

In the third major section of the book (Chapters 6–8) the general properties of enzymes, the kinetics of chemical reactions, and the various mechanisms employed in enzymatic catalysis are discussed. Chapter 6 presents enzyme kinetics in sufficient detail to satisfy the needs of most students and provides a description of the mechanisms by which enzymatic reactions are controlled within cells. In Chapter 7 a systematic and rational classification of enzymatic reactions is given, including information about a variety of enzymes and the techniques used to study them. Chapter 8 treats the chemistry and special functions of coenzymes, relating these functions to reaction types considered in preceding chapters. These chapters contain much reference material, and do not have to be read completely in sequence. However, it will be easy for the student or instructor to discern the principles emphasized and to apply them. Materials from these chapters may, if desired, be incorporated with material from Chapter 2 into units dealing with proteins, carbohydrates, nucleic acids, and lipids without difficulty.

The fourth major section (Chapters 9–14) of the book treats reaction sequences found in metabolism. Chapter 9 explores the “logic” of metabolic cycles and other pathways. Patterns are shown to arise as a natural result of the kind of chemistry needed to obtain a desired product from a given reactant. I hope that this presentation will be a distinct improvement over the conventional ones. Chapter 10 deals with electron transport and oxidative phosphorylation as well as with the energy-yielding reactions of chemiautotrophs. Many otherwise confusing aspects of metabolism are shown to be simple when it is understood (Chapter 11) that certain steps are needed to couple cleavage of ATP to biosynthesis. In the specialized chapter on carbohydrate and lipid metabolism (Chapter 12) most of the sequences are easy to understand in the light of preceding discussions.

A unique chapter, *Light in Biology* (Chapter 13), covers not only photosynthesis, vision, and other biological responses to light, but light absorption spectra, circular dichroism, and fluorescence. Chapter 14 provides details of the biosynthesis and catabolism of an enormous number of nitrogenous compounds. It can serve as a starting point for individual literature research projects by biochemistry students and could profitably be used in courses on natural products chemistry.

The last section (Chapters 15 and 16) deals with topics of genetic and hormonal control of metabolism, development, and brain function. Chapter 15 not only covers biosynthesis of nucleic acids and proteins but also includes a succinct summary of methods used in the study of biochemical genetics. Although this material has been placed near the end of the book, it is entirely possible to present part or all of it to a class at an earlier stage of the course. The final chapter (16) provides a brief introduction to the problems of cell communication, neurochemistry, differentiation, and ecological problems (metabolism in the environment).

I would like to acknowledge with thanks the many people who have helped me in the preparation of this text: among them my colleagues at Iowa State University, especially John Foss and Bernard White, and many scientists in other institutions. Special thanks are due the John Simon Guggenheim Foundation for a fellowship, Iowa State University for a faculty improvement leave, and the staff and students of the Department of Biochemistry of the University of California, Berkeley, for many helpful discussions and criticisms. Special thanks go to Peggy Johnston, Jeanne Peters, and Wilma Holdren for excellent and dedicated help in the preparation of the manuscript; to Carol Harris for computations, supervising the proofreading, and for checking every numerical value; and to the graduate students who checked every equation and reference. The members of the staff of Academic Press have my gratitude for their patience and encouragement. It has been a pleasure to work with them.

David E. Metzler