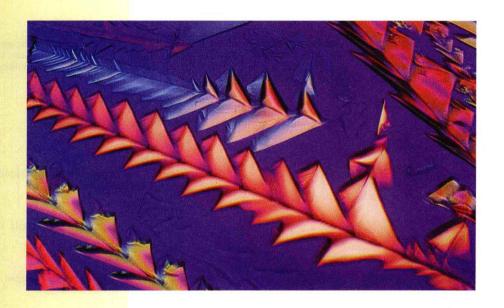


# Concepts

# **Biochemistry**



Rodney Boyer

Hope College



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#### PREFACE

#### To the Student

Biochemistry, the chemistry of life, is no longer just a part of biology or chemistry, but has matured into a major field of study. Colleges and universities now make available biochemistry courses at all levels including introductory, intermediate, and advanced. The courses at universities are usually taught in biochemistry departments, but in smaller colleges, biochemistry courses are offered by chemistry or biology departments. You are enrolled in this course probably because the academic preparation for your chosen career requires knowledge in the molecular life sciences. Professionals engaged in the biological sciences, health professions, food sciences, biotechnology, environmental sciences, bioengineering, agriculture, and related areas are increasingly using the concepts and tools of biochemistry. Many colleges and universities offer a one-semester, survey biochemistry course for students who require an introduction but have neither the time nor the more extensive chemistry background needed for an intermediate level, full-year course. This book was prepared especially for the brief survey course.

My goals in writing this book were:

- 1. To give you a view of modern biochemistry by identifying the most important biochemical concepts and theories and explaining them at an appropriate level.
- **2.** To develop a lively and clear presentation based on the proper balance of chemistry and biology.
- To present numerous biochemical applications that you can identify in your own career choices and your everyday lives.

My hope is that when you complete this course, you agree that these goals have been achieved and that using this book has enhanced your knowledge and appreciation of biochemistry.

#### To the Instructor

After nearly 25 years of teaching, researching, and living biochemistry, I have concluded that the discipline is undergoing a change of focus. Former biochemistry studies (and textbooks) have traditionally been based on the structure and function of proteins with emphasis on the biological processes of metabolism and bioenergetics. Topics that once were considered to be "molecular biology", and usually tucked into the ends of textbooks, are bringing a new perspective and a new excitement to biochemistry. Experimental design in biochemical research now tends to place increased emphasis on the nucleic acids. Genetic approaches are commonly

used to study all biological processes including the traditional core topics of biochemistry: structure, metabolism, and bioenergetics. To enhance student learning and understanding in the current and future era, we need to redirect the study of biochemistry with nucleic acids playing a more central role as fundamental molecules and treat other biomolecules and biological processes as direct or indirect products of the nucleic acids. For example, we must explain, using a molecular approach, how biological processes like metabolism are under the influence of genes. This text was designed and written to reflect these changes occurring in biochemistry. Students using the book will see the importance of the discipline in their careers and lives and can use that new information in their work.

#### A Balanced Approach with a Modern Perspective

Most colleges and universities offer a one-semester, introductory biochemistry course for which this book is intended. Brief, survey courses usually follow the same content order as the one-year, majors level, biochemistry courses except that there is much less detail and theory and more focus on applications. Students usually take the course during their sophomore or junior years after they have completed at least one semester each of introductory chemistry, organic chemistry, and introductory biology. The course at most institutions is a requirement for students in the applied sciences; however, I have found that all students, including non-science majors, are fascinated by current developments in the molecular life sciences. A text that presents a good balance of theory and applications, a modern view of the new directions of biochemistry, and an appropriate mixture of chemistry and biology should capture the interests of this diverse group of students. Even those students who had less than positive experiences in general and organic chemistry enjoy biochemistry because they see an application of the material they studied in prerequisite courses.

This text is organized around the theme of nucleic acids as central molecules of biochemistry. Proteins are treated as products of the nucleic acids; however, the important roles of the proteins are not diminished. Amino acids as well as nucleotides are considered as fundamental building blocks of cellular components. The importance of DNA and RNA in all aspects of biochemistry are integrated as much as possible throughout the text. This changes the focus from other biochemistry books that center on amino acids and proteins as the fundamental molecules. This new perspective is in line with the direction of research and represents the future trends in biochemistry and therefore enhances the educational value of the text.

#### Integration of Theory, Concepts, and Applications

This book is divided into four parts:

- I. Molecules and Life
- II. Dynamic Function of Biomolecules
- III. Storage and Transfer of Biological Information
- IV. Metabolism and Energy

Part I begins by setting the stage for future studies. Chapter 1, a discussion of organisms and cell structure, defines the environment in which biomolecules interact. A thread interlinking various aspects of biochemistry is developed in Chapter 2 and continues throughout the book. This thread describes DNA as the origin of all

information and introduces cellular communication as the "flow" of biological information:

The strong influence of water on the structure and interactions of biomolecules is described in Chapter 3. The simple and well known biomolecules, the amino acids, along with peptides and proteins, are introduced in Chapter 4.

Part II initiates a discussion of the conformational side of biochemistry and focuses on the structures and dynamic functions of the proteins, carbohydrates, and lipids. This section begins with a study of protein structure and function in Chapter 5 and continues with a detailed examination of enzymes in Chapters 6 and 7. Chapter 8 introduces the carbohydrates, including glycoprotein structure and function, and Chapter 9 concentrates on lipid biomolecules, membrane structure, and membrane transport.

Part III defines the informational side of biochemistry: the nucleic acids and their role in the storage and transfer of biological instructions. The various stages of information flow-replication, transcription, and translation-are examined. Details of genetic regulation are also included. Part III concludes by introducing topics in biotechnology and recombinant DNA. The topics of nucleic acids and molecular genetics covered in Chapters 10 to 13 have traditionally appeared in the final chapters of biochemistry books. In this text, these are brought forward to reinforce the idea that the latter topics of bioenergetics and metabolism are shaped by genetic information in the nucleic acids. It is important, however, for students to first understand protein structure and function because in other courses they often learn how to manipulate and rearrange a gene without taking time to comprehend the structure of the protein product and what it is doing in the cell. Therefore, an appropriate order and balance of molecular biology and biochemistry are essential so students see the complete picture. Because most students have a natural fascination for molecular biology, biotechnology, and related advances in medicine and agriculture, their interest is sparked by this approach. By introducing students earlier to the roles of nucleic acids, it is possible to present metabolism in a more contemporary manner, emphasizing regulation and integration. Students need to grasp the concept that genes exert their influence by controlling the hundreds of chemical reactions that take place in the cell.

Part IV focuses on bioenergetics and metabolism. The chemical reactions that result in degradation and synthesis of biomolecules are described along with details on regulation in Chapters 14 to 19. The two directions of metabolism, anabolism and catabolism, are combined to emphasize the flow of metabolism and the idea that synthesis and degradation of biomolecules are not separate processes but a continuum requiring energy transfer and complex regulation. A major stumbling block for students in the study of metabolism is the chemical understanding of the reactions. Early in this part on metabolism (Chapter 14), the general types of biochemical reactions are identified and their chemistries described. Many applications are included, covering the diverse areas of medicine, agriculture, nutrition, food processing, and ecology.

The book does not change the traditional topics covered in current biochemistry courses, only their order and balance. These modifications, which are driven by the new directions in biochemistry, will allow for valuable pedagogical changes in the use of class time. Students using this text will leave the course with a clear picture of current biochemistry and the background and enthusiasm to study future bio-

chemistry. The book is flexible so that instructors desiring the more traditional order of topics may choose the option of covering Part IV (Chapters 14 to 19) before Part III (Chapters 10 to 13).

#### **Pedagogical Aids**

Several pedagogical aids have been incorporated into the text to assist student and instructor use. These include the following:

- Study Problems help students apply theory and concepts from each chapter. A minimum of 30 problems is provided for each chapter, and answers for all problems are available in the back of the book. Several problems in each chapter contain → HINTS encouraging students to work on the problem rather than turning immediately to the end-of-text answers.
- WebWorks are Internet assignments listed at the end of each chapter to provide students with additional resources for review, study problems, images, and animations. At least one URL site is listed for each chapter. All the sites listed were available at the time of publication. An update of new listings and obsolete ones will be available to instructors on a web site maintained by the publisher and author.
- Summary text in each chapter assists students in their review and helps them
  make connections among concepts.
- Further Reading lists at the back of each chapter gives references for more detailed articles on specific topics. Emphasis is placed on references in educational journals such as Scientific American, Biochemical Education, Journal of Chemical Education, and Trends in Biochemical Sciences.
- A **Glossary** of biochemical terms gives clear and concise definitions for approximately 450 terms highlighted with bold print in the text.

#### Ancillaries for the Instructor

Separate publications will be available for instructor use:

- Printed Test Items featuring mostly multiple choice items, plus answers.
- Thomson World Class Testing Tools software packaging featuring electronic test generation, on-line testing, and class management capabilities. Available for Windows® and Macintosh®.
- Transparencies featuring over 100 four-color figures and tables from the text.
- Cross-platform PowerPoint® presentation package with transparency slides and animations for assistance in lecture preparation.

#### Acknowledgments

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Writing a textbook in a rapidly-evolving discipline like biochemistry requires the assistance of knowledgeable scientists and dedicated teachers. These qualities were present in reviewers of the manuscript including: Edward Behrman, Ohio State University; William Coleman, University of Hartford; Edward Funkhauser, Texas A & M University; Milton Gordon, University of Washington; John Gores, California Polytechnic State University–San Luis Obispo; John L. Hess, Virginia Polytechnic and State University; Roger Lewis, University of Nevada–Reno; Scott Mohr, Boston University; Richard Paselk, Humboldt State University; and Rachel Shireman, University of Florida-Gainesville.

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I encourage all users of this book to send comments that will assist in the preparation of future editions.

Rodney F. Boyer boyer@hope.edu

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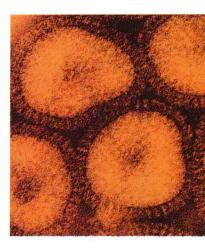
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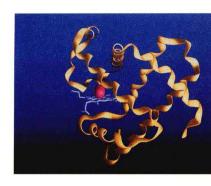
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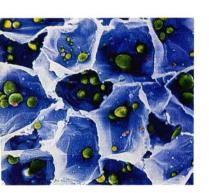
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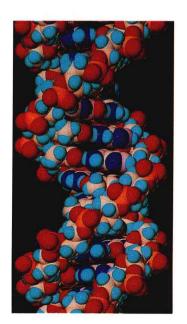
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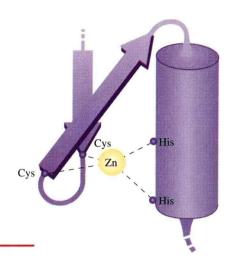
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