



INTRODUCTION TO

GENERAL,
ORGANIC
&
BIOCHEMISTRY

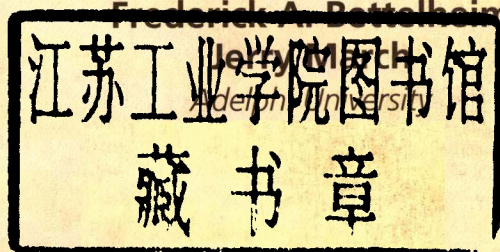
FOURTH EDITION

BETTELHEIM AND MARCH

INTRODUCTION TO
**GENERAL,
ORGANIC &
BIOCHEMISTRY**

FOURTH EDITION

Frederick A. Bettelheim



Saunders College Publishing

Harcourt Brace College Publishers

Fort Worth • Philadelphia • San Diego • New York

Orlando • Austin • San Antonio

Toronto • Montreal • London • Sydney • Tokyo

*To our wives:
Vera S. Bettelheim and Beverly March.*

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Permissions Department, Harcourt Brace & Company, 6277 Sea Harbor Drive, Orlando,
Florida 32887-6777.

Text Typeface: Caledonia
Compositor: Progressive Information Technologies
Vice President, Publisher: John Vondeling
Developmental Editor: Beth Rosato
Managing Editor: Carol Field
Project Editor: Beth Ahrens
Copy Editor: Janis Moore
Manager of Art and Design: Carol Bleistine
Art Director: Anne Muldrow
Art and Design Coordinator: Sue Kinney
Cover Designer: Lou Fuiano
Text Artwork: J & R Technical Services, Inc. and Rolin Graphics, Inc.
Layout Artist: Julie Anderson
Director of EDP: Tim Frelick
Production Manager: Charlene Squibb
Vice President, Marketing: Marjorie Waldron

Cover Credit: Uncompahgre National Forest, Colorado. © Willard Clay/FPG International
Frontispiece: California coast. Comstock, Inc., Mike and Carol Warner © 1991.

Printed in the United States of America

INTRODUCTION TO GENERAL, ORGANIC & BIOCHEMISTRY, Fourth Edition

0-03-001068-3

Library of Congress Catalog Card Number: 94-065433

67890123 032 10 987654

P R E F A C E



USDA

“... matter is matter, neither noble nor vile, infinitely transformable, and its proximate origin is of no importance whatsoever. Nitrogen is nitrogen, it passes miraculously from the air into plants, from these into animals and from animals to us; when its function in the body is exhausted, we eliminate it, but it still remains nitrogen, aseptic, innocent” so says Primo Levi in his book *The Periodic Table*. In transforming a life-long love affair toward his chosen profession, chemistry, into literature, he succeeded in expressing his enthusiasm for all to see.

In writing the Preface for this, the fourth edition of our textbook, we hope that somewhat similarly we manage to convey our delight in observing the chemical processes in the core of life sciences. The increasing use of our textbook enables this new edition, and we wish to thank our colleagues who adopted previous editions for their courses. Testimony from colleagues and students indicates that we have conveyed our enthusiasm to students who find this book a great help in studying difficult concepts.

Thus, this fourth edition intends to be even more readable and understandable than earlier editions. While maintaining the overall organization of the textbook, we strive to produce more integration of the three domains of the text: general, organic, and biochemistry. Chemistry, especially biochemistry, is a fast-developing discipline, and we include new relevant material in the text. This is done not just by upgrading information but also by enlarging the scope of the book, both in the text and in the boxes containing medical applications of chemical principles. At the same time, we are aware of the necessity to keep the

book to a manageable size and proportion. Twenty percent of the problems are new; there is an increase in the number of more challenging, thought-provoking problems (marked by asterisks).

AUDIENCE

As were the previous editions, this book is intended for nonchemistry majors, mainly those entering health science and related fields (such as nursing, medical technology, physical therapy, and nutrition). It also can be used by students in environmental studies. In its entirety it can be used for a one-year (two-semester or three-quarter) course in chemistry, or parts of the book can be used in a one-term chemistry course.

We assume that the students using the book have little or no chemistry background. Therefore, we introduce the basic concepts slowly at the beginning, increasing the tempo and the level of sophistication as we go on. We progress from the basic tenets of general chemistry to organic chemistry and finally to biochemistry. We consider this progression an ascent in terms of both practical importance and sophistication. However, the three parts are integrated by keeping a unified view of chemistry. We do not consider the general chemistry sections to be the exclusive domain of inorganic compounds, so we frequently use organic and biological substances to illustrate general principles.

While teaching the chemistry of the human body is our ultimate goal, we try to show that each subsection of chemistry is important in its own right, besides being required for future understanding.

BOXES (Medical and Other Applications of Chemical Principles)

The boxes contain applications of the principles discussed in the text. Comments from users of the earlier editions indicate that these are especially well received, providing a much requested relevance to the text. The large number of boxes deal mainly with health-related applications, including many also related to the environment. A list of these medically relevant applications follows the Contents. Five boxes from the third edition have been dropped. Two others have been incorporated into the text. Nine new boxes have been added dealing with diverse topics such as oncogenes, the indoor radon problem, taxol as an anticancer agent, nitric oxide and long term memory, sex hormones and old age, excess vitamins, hydrates and air pollution, rubber, sunglasses, and deodorants. Many boxes have been enlarged and updated. For example, boxes on Parkinson's disease, lipid storage disease, anesthetics, birth control, goiter, and AIDS now include recent material.

The presence of boxes allows a considerable degree of flexibility. If an instructor wants to assign only the main text, the boxes will not interrupt continuity and the essential material will be covered. However, most instructors will probably wish to assign at least some of the boxes, since they enhance the core material. In our experience, students are eager to read the relevant boxes even without assignments, and they do so with discrimination. From such a large number of boxes, the instructor can select those that best fit the particular needs of the course and of the students. Problems are provided for nearly all of the boxes.

ORGANIZATION

We have maintained the organization of the previous edition. Nine chapters deal with general chemistry, six with organic chemistry and eleven with biochemistry. The presentation of nuclear chemistry is in Chapter 9 at the end of the general chemistry sections. Some instructors think that this topic is better presented immediately after Chapter 2 on Atoms. There are no difficulties in moving up nuclear chemistry, if the instructor so desires. We think, however, that the complexity of this topic is better appreciated after the exploration of equilibrium and kinetics.

In organic chemistry, we concentrate on the structure and properties and only the most important reactions of each class of compounds. As for the mechanisms of the reactions, we provide only one example: carbocation intermediates in addition reactions. We do this deliberately because we think that in the relatively brief portion of the course devoted to organic chemistry, students do not have time to learn a large number of reactions or anything substantial about mechanisms. As stated before, we consider the progression from general to organic and to biochemistry an ascent. Therefore, we selected mainly organic compounds and reactions which have physiological activity and biological importance. In order to help students learn the reactions, we include summaries of reactions at the ends of the chapters.

Within the biochemistry chapters, we maintain the traditional order. We find this a pedagogical imperative. Even though most of the important new developments in biochemistry occur in molecular biology (Chapter 23 on Nucleic Acids and Protein Synthesis) and neurochemistry and immunology (Chapter 24 on Chemical Communication: Neurotransmitters, Hormones, and Immunoglobulins), these chapters come late in the book. We think that the appreciation of these topics requires a previous acquaintance with carbohydrate, lipid, and protein chemistry and metabolism. We hope that each instructor, to his or her taste, will judiciously appropriate time to discuss the exciting developments presented in the late chapters.

NEW MATERIAL

In addition to several new boxes, we include new material in the text. Some examples are

- We provide a new section on the basic types of reactions.
- We discuss environmental problems, such as the Clean Air Act and the oxygenation of gasoline as well as the threat to the ozone layer by CFCs.
- We include the fullerenes in the discussion of carbon.
- We enlarge the discussion on cis-trans isomerism.
- We add new material on the role of chaperones in protein folding and denaturation.
- We extend the discussions on transcription factors and gene therapy.
- We describe the important polymerase-chain-reaction (PCR) technique in molecular biology.

METABOLISM; COLOR CODE

The biological functions of chemical compounds are explained in each of the biochemistry chapters and in many of the organic chapters. The emphasis is on chemistry rather than physiology. We received much positive feedback regarding the way in which we organized the topic of metabolism (Chapters 20, 21, and 22). We maintained this organization.

First, we introduce the common metabolic pathway through which all food will be utilized (citric acid cycle; oxidative phosphorylation), and only after that do we discuss the specific pathways leading to the common pathway. We find this a useful pedagogical device, and it enables us to sum up the caloric values of each type of food because their utilization through the common pathway has already been learned. Finally, we separate the catabolic pathways from the anabolic pathways by treating them in different chapters, emphasizing the different ways the body breaks down and builds up different molecules.

The topic of metabolism is a difficult one for most students. We try to explain it as clearly as possible. As in the previous edition, we enhance the clarity of presentation by the use of a color code for the most important biological compounds discussed in Chapters 20, 21, and 22. Each type of compound is shown in a specific color, which remains the same throughout the three chapters. These colors are as follows:

ATP and other nucleoside triphosphates

ADP and other nucleoside diphosphates

The oxidized coenzymes NAD^+ and FAD

The reduced coenzymes NADH and FADH_2

Acetyl coenzyme A



The circled numbers in the figures showing the steps involved in the various metabolism pathways are always in yellow.

In addition to this main use of a color code, other figures in various parts of the text are color coded, so that the same color is used for the same entity throughout the text. For example, in Chapter 19, enzymes are always shown in blue and substrates in orange in all of the figures that show enzyme substrate interactions.

INTERVIEWS

Each of the three sections—general, organic, and biochemistry—opens with an interview with an individual who has made significant contributions in that particular field. Roald Hoffman, Nobel Laureate in 1981, not only enhanced our understanding of chemical bonding through his theoretical work but also regularly teaches general chemistry at Cornell University. Carl Djerassi of Stanford University is a master of steroid chemistry, both in synthesis and analyses of organic compounds, and he is often cited as the inventor of the birth control pill. Jacqueline K. Barton of the California Institute of Technology has made important discoveries relating to the structure and conformation of the DNA double helix.

These interviews are intended to give the student a human face of science and an insight of how science affects our lives.

FEATURES

One of the main features of this book, as in earlier editions, is the number of applications of chemical concepts presented in the boxes. Another important feature is the Glossary-Index. The definition of each term is given along with the index entry and the page number. Another feature is the list of key terms at the end of each chapter, with notation of the section number in which the term is introduced. Many students find these lists to be helpful study guides.

Other features are the summaries at the end of each chapter (including summaries of organic reactions in Chapters 11 to 15) and the substantial number of margin notes. We subsectioned the end-of-chapter problems, to guide students to the section of the chapter where they can find the relevant material.

STYLE

Feedback from colleagues and students alike indicates that the style of the book, which addresses the students directly in simple and clear phrasing, is one of its major assets. We continue to make special efforts to provide clear and concise writing. Our hope is that this eases the understanding and the absorption of the difficult concepts.

PROBLEMS

About one fifth of the problems are new in this fourth edition. The number of starred problems, which contain the more challenging, thought-provoking questions, has increased. The end-of-chapter problems are grouped and sub-headed in the order of topic coverage. The last group headed as Additional Problems is not arranged in any specific order. The answers to all the in-text problems and to the odd-numbered end-of-chapter problems are given at the end of the book. Answers to the even-numbered problems are included in the Instructor's Manual and the Study Guide.

ANCILLARIES

This textbook is accompanied by a number of ancillary publications to help support your teaching and your students' learning:

1. Flash Cards by Hugh Akers (Lamar University). 200 bi-directional cards provide handy and convenient reference to the important reactions, terms, structures, and classifications of general, organic, and biological chemistry.
2. Study Guide by W. Scovell (Bowling Green State University). Includes review of chapter objectives, important terms and comparisons, focused review of concepts, self tests, and answers to the even-numbered problems in the text.
3. Instructor's Manual and Test Bank by F. A. Bettelheim and J. March. Contains suggested course outlines, 90% newly revised exam questions organized chapter by chapter, answers to the exam questions, and answers to the even-numbered problems.

4. Computerized Test Bank available in IBM and Macintosh versions. The format permits modification of questions in the test bank and the addition of new ones.
5. Approximately 160 overhead transparencies in full color. Figures and tables are taken from the text.
6. Laboratory Experiments for *Introduction to General, Organic & Biochemistry*, 2e by F. A. Bettelheim and J. Landesberg. Forty-six experiments illustrate important concepts or principles in general, organic, and biochemistry. Simple equipment and inexpensive, common, and environmentally safe chemicals are used. The large number of experiments allows sufficient flexibility for the instructor to select the usual 24 experiments the students can perform in a two-semester course.
7. Instructor's Manual to accompany Laboratory Experiments for *Introduction to General, Organic & Biochemistry*, 2e by F. A. Bettelheim and J. Landesberg. This will help instructors in grading the answers to the questions as well as in assessing the range of the experimental results obtained by the students.
8. Saunders Chemistry of Life Videodisc. Includes nearly all the still images from *Introduction to General, Organic & Biochemistry*, 4e, with large type for better classroom viewing, and contains live-action footage of chemical demonstrations.
9. Chemistry of Life LectureActive™ Software. This outstanding, convenient package is noted for its ease of use and economy of time because all video clip and still frame data from the videodisc are entered and listed on the software. This unique program for both IBM Windows and Macintosh formats enables the instructor to swiftly access every image and film clip on the videodisc and to easily prepare a customized presentation of disc images.

ACKNOWLEDGMENTS

The publication of a book such as this requires the efforts of many more people than merely the authors. A number of reviewers have read all or significant portions of the manuscript in various stages. We thank the following for their constructive criticism and helpful suggestions in revising the text for this fourth edition:

Hugh Akers, Lamar University
Karen Eichstadt, Ohio University
Leland Harris, University of Arizona
James T. Johnson, Sinclair Community College
Margaret G. Kimble, Indiana-Purdue Universities at Fort Wayne
Kenneth E. Miller, Milwaukee Area Technical College
Thomas Pynadath, Kent State University
Guy Rosenthal, The University of Vermont
Robert VanLanen, Saint Xavier University

Reviewers of the first three editions:

David Adams, North Shore Community College
Michael Bobrick, North Virginia Community College
Lorraine Brewer, University of Arkansas
Ana A. Cierieszko, Miami-Dade Community College South Campus
William D. Covey, Los Angeles Pierce College
Charles Cowell, Rancho Santiago College
Adrienne Curtis, Orange Coast College
Andrew Dachauer, University of San Francisco
Jane Dant, Florida Community College
Bruce Dunlap, University of South Carolina
Stanley Grenda, University of Nevada
John Griswold, Cedar Crest College
Marvin Hackert, University of Texas at Austin
Leland Harris, University of Arizona
Robert Harris, University of Nebraska
Larry Jackson, Montana State University
Eugene Kline, Tennessee Technological University
Herman Knoche, University of Nebraska
Joseph Landesberg, Adelphi University
Jessie Lee, Philadelphia Community College
William Masterton, University of Connecticut
Melvin Merken, Worcester State College
Norman Meyers, Bowling Green State University
Robert Midden, Bowling Green State University
Paul O'Brien, West Valley College
Pat O'Day, Pasadena City College
Alan Price, University of Michigan
Jacqueline Scholar, Bellevue College
Ronald M. Scott, Eastern Michigan University
William Scovell, Bowling Green State University
Brahama Sharma, Los Angeles Pierce College
David Tuleen, Vanderbilt University
William H. Voige, James Madison University
Shan Wong, University of Lowell
Albert Zabady, Montclair State College
William Zuber, Memphis State University

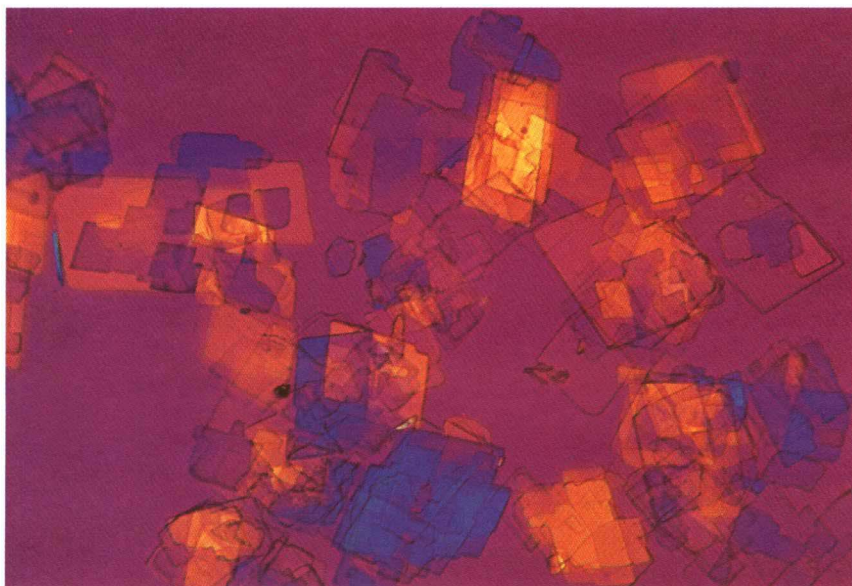
We wish to also thank the many respondents to a survey of questions on our text and the market that Saunders commissioned for our consideration as we made plans for the fourth edition: Hugh Akers, Lamar University; Kim Caluo, University of Akron; Thomas Cogdell, University of Texas at Arlington; Carolyn T. Connelly, Waynesburg College; Thomas D. Crute, Augusta College; James Deavor, College of Charleston; Lawrence K. Duffy, University of Alaska, Fairbanks; Amal Girgis, Pierce College; Marie Hankins, University of Southern Indiana; Lillian M. Hansen, Tarrant County Junior College Northeast; Karen Harding, Pierce College; Chu-ngi Ho, East Tennessee State University; Vanessa Hull, Tarrant County Junior College South; Eric Johnson, Ball State University; Warren Johnson, University of Wisconsin-Green Bay; M. G. Kimble, Indiana Purdue University at Ft. Wayne; Richard Kletsch, Centralia College; M. L. Morris, North Dakota State University; Don Naschert, Illinois Central College; Mary O'Sullivan, Indiana State University; Helen Place, Washington State University; Bruce P. Ronald, Idaho State University; L. Rosenhein, Indiana State University; J. Scholar, Bellevue College; Daniel R. Tauber, Villa Julie College; Chris Vogel, Sacramento City College; Craig Weaver, Brevard Community College; Jack Wolf, El Banuaru College.

Many of our reviewers pointed out inadvertent errors or certain weaknesses in the previous editions. We attempted to correct these, and thus we hope that the fourth edition will prove even more useful than the earlier editions.

We also wish to thank several of our colleagues at Adelphi University for their useful advice. These include Stephen Goldberg, Joseph Landesberg, Sung Moon, Donald Opalecky, Reuben Rudman, Charles Shopsis, Kevin Terrance, and Stanley Windwer. We are grateful for the support of John Vondeling, Vice President and Publisher, Saunders College Publishing. We thank Beth Rosato, Developmental Editor, and Beth Ahrens, Project Editor, for their congenial steady assistance. We would like to express our appreciation to Charlene Squibb for supervising the production of this edition and to Anne Muldrow for supervising the art. Rolin Graphics, Inc. transformed our crude drawings into pieces of art. Last but not least we want to thank Beverly March and Charles D. Winters for their many excellent photographs.

Frederick A. Bettelheim and Jerry March
Adelphi University
June 1994

HEALTH-RELATED TOPICS



Drs. Dieppe, Bacon, Bamji, and Watt; Gower Medical Publishing Co.

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