The background of the cover is a photograph of a person running along the top edge of a dark, silhouetted cliff. The person is in mid-stride, facing right. The sky behind them is a gradient of colors, from deep blue at the top to a bright orange and yellow at the bottom, suggesting a sunset or sunrise. The overall mood is one of pursuit and achievement.

Fundamentals of

General, Organic, and Biological Chemistry

Second Edition

John McMurry / Mary E. Castellion

FUNDAMENTALS OF GENERAL, ORGANIC, AND BIOLOGICAL CHEMISTRY

SECOND EDITION

John McMurry

Cornell University

Mary E. Castellion

Norwalk, Connecticut



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Editorial director: Tim Bozik
Vice president of production and manufacturing: David W. Riccardi
Executive managing editor: Kathleen Schiaparelli
Assistant managing editors: Margaret Antonini and Shari Toron
Art director: Heather Scott
Creative director: Paula Maylahn
Marketing manager: Linda Taft
Marketing assistant: Amy Reed
Editorial assistant: Ashley Scattergood
Cover design: Lee Goldstein
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Preface

To provide an introduction to chemistry in general and to the chemistry of living things in particular—the goal of the second edition of this textbook remains the same as that of the first edition. The writing style, content, and organization are directed toward students with career goals in the allied health sciences and other disciplines in which understanding the fundamentals of biological chemistry is valuable.

To teach chemistry all the way from, “What is an atom?” to “How do we get energy from glucose?” is a challenging activity. Our experience with the first edition confirms our premise that there is a wide variety of approaches to presenting this course, possibly more than for any other introductory chemistry course. Thus, *flexibility* is of primary importance.

The material in this book is ample for a thorough, two-semester introduction to general, organic, and biological chemistry. By varying the topics covered and the time devoted to them, however, each teacher can change the focus of the course to meet individual needs (including the one-semester course). This edition retains our unique and well-received integrated biological chemistry sequence (described in greater detail below), which allows for an unusual degree of flexibility.

Another matter of primary importance is *student accessibility*. Students in this course have their sights set well beyond academic concerns and the laboratory bench. They want to know why: Why must I study the gas laws? Why are molecular shapes important to me as a nurse, or a soil scientist, or a nutritionist? We have therefore endeavored at every step along the way to place chemistry in the context of applications relevant to these students’ needs and interests. We have written in a clear and simple style that assists in engaging students in the subject matter.

ORGANIZATION

General chemistry: Chapters 1–11 The introduction to elements, atoms, the periodic table, and the quantitative nature of chemistry (Chapters 1–3) is followed by chapters that individually highlight the nature of ionic and molecular compounds (Chapters 4 and 5). The next two chapters

discuss chemical reactions and their stoichiometry, energies, rates, and equilibria (Chapters 6 and 7). Specific topics essential to applied chemistry follow: Gases, Liquids, and Solids (Chapter 8); Solutions (Chapter 9); and Acids and Bases (Chapter 10). Nuclear Chemistry (Chapter 11) closes the general chemistry sequence.

New to this edition:

- Increased emphasis on the periodicity of properties
- Combination and condensation of appropriate sections, designed to simplify the discussion
- Movement of nuclear chemistry from Chapter 4 to Chapter 11.
- A decrease in the number of classes of chemical reactions covered in Chapter 6 to include only precipitation, acid-base reactions, and redox reactions

Organic chemistry: Chapters 12–17 These chapters concisely focus on what students must know in order to get on with biochemistry. Nomenclature rules are included with the introduction to hydrocarbons (Chapters 12, 13) and thereafter are kept to a minimum. Discussion of functional groups with single bonds to oxygen, sulfur, or a halogen (Chapter 14) is followed by a short chapter on amines (Chapter 15) that emphasizes their numerous biological roles. After introducing aldehydes and ketones (Chapter 16), the chemistry of carboxylic acids and their derivatives (including amides) is covered with a focus on similarities among the reactions of the derivatives (Chapter 17).

New to this edition:

- Summaries of organic reactions at the ends of chapters
- Integration into text and Applications of new information on the roles of certain organic compounds in health and physiology
- Combined rather than separate discussion of hemiacetals and acetals, allowing for better understanding of their relationships (Chapter 16)
- Similar combination of discussions of ester and amide formation and hydrolysis (Chapter 17)
- Presentation of amide formation via acyl group transfer; elimination of the Claisen condensation (Chapter 17)

Biological chemistry: Chapters 18–27 Rather than proceed through the complexities of protein, carbohydrate, lipid, and nucleic acid molecular structures before getting to the roles of these compounds in the body, *structure and function are integrated*. Protein structure (Chapter 18) is followed by enzyme and neurotransmitter chemistry (Chapter 19). With enzymes introduced, the central pathways of biochemical energy generation can be described (Chapter 20). If your time for biochemistry is limited, stop with Chapter 20 and your students will have an excellent preparation in the essentials of metabolism. Integration next proceeds with carbohydrates (Chapter 21) and carbohydrate metabolism (Chapter

22), and then lipids (Chapter 23) and lipid metabolism (Chapter 24). A brief discussion of protein and amino acid metabolism follows (Chapter 25). Throughout, the emphasis is on the role in the overall functions of biochemical pathways rather than on details of the individual steps in the pathways. In the last two chapters are topics that are an essential part of the course to many instructors, but optional to others—Nucleic Acids and Protein Synthesis (Chapter 26) and Body Fluids (Chapter 27). Nutrition is not treated as yet another separate subject, but is integrated with the discussion of each type of biomolecule.

New to this edition:

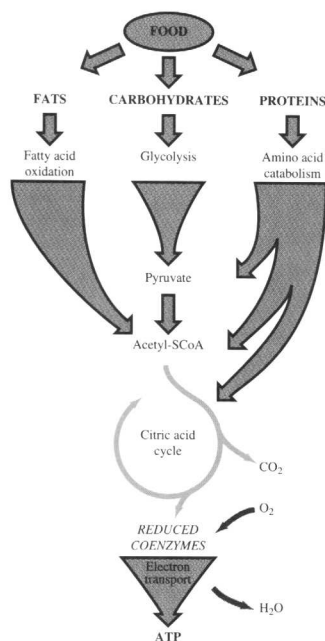
- Introduction to biochemistry, functional groups of importance in biochemistry, and the importance of molecular shape (Chapter 18)
- Reorganized and clarified description of shape-determining interactions in proteins (Chapter 18)
- Updating of all nutrition information in accord with the new Dietary Guidelines and Nutrition Facts food labels
- New computer-generated biomolecule models and new or revised flow diagrams
- Combined rather than separate discussion of electron transport and ATP production, with simplified presentation of electron transport (Chapter 20)
- Updated, expanded, or new topics such as neurotransmitters and their receptors; the fading distinction between hormones and neurotransmitters; reactive oxygen by-products; glycoproteins as receptors; ATP yield per glucose molecule; transport across cell membranes (now in a text section rather than an Application box); recombinant DNA (also now in a text section); the relationships among dietary fats, lipoproteins, and heart disease (Interlude, Chapter 24)

KEY FEATURES

Applications and Interludes are set off from the text and cover a wide variety of special topics. As in the first edition, each provides sufficient information for reasonable understanding. Some favorites retained from the first edition (with their chapter numbers) are Powers of 10 (2), Polymers: How Big Can a Molecule Be? (5), Medical Uses of Radioactivity (11), Chemical Information (15), Chemical Warfare among the Insects (16), and Biochemistry of Running (22). Topics *new to this edition* include Photography (6), Timed-Release Medications (9), Nitrate Esters for Treating Angina (17), A Drug Family (19), Plants and Photosynthesis (20), Tooth Decay (21), and Biotechnology and Agriculture (26).

Computer-generated molecular models are used extensively in the organic and biological chemistry chapters to enhance student understanding of spatial relationships and their importance.

Color highlights have been used meaningfully as in the first edition for molecular structures, chemical and math equations, and charts and diagrams. Many topics become clearer when the parts of molecules under



discussion or that are undergoing reaction are highlighted with color. In biochemistry equations, energy-rich ATP and reduced coenzymes are set in red and their lower-energy counterparts are set in blue.

Graphics and flow charts for biochemical pathways are based on those found to be outstandingly clear and useful by users of the first edition. Our catabolism summary diagram is repeated as a marginal logo where each new segment of catabolism is discussed.

Problem solving skills essential to this course are illustrated with clearly explained and worked out Solved Problems. The analysis of mathematical problems for known and unknown information and the factor-label method are introduced in Chapter 2 and applied in all mathematical Solved Problems. Students are encouraged to evaluate answers by finding approximate solutions, and *the use of such Ballpark Solutions has been expanded.*

Practice Problems follow all worked Examples and additional Practice Problems are included throughout to provide immediate tests of understanding. All Practice Problems are answered in an Appendix.

Learning and Study Aids

Introduction and Goals Each chapter begins with a brief introductory overview, followed by a list of goals for the student to keep in mind while studying.

Marginal Definitions Key terms are boldfaced in the text and each is accompanied by a marginal definition, a feature cited by users of the first edition as of great assistance to students. *New to this edition* is an alphabetical list of key terms at the end of each chapter with citations of the page where each definition is given.

Glossary The definitions of key terms are collected in alphabetical order in the Glossary at the back of the book.

Summaries Complex and important topics are summarized by bulleted statement lists, another valuable aid to student understanding. *New summary lists have been added.* Also, each chapter ends with a few summary paragraphs that clearly and concisely review key information.

Additional Problems These sections at the end of each chapter provide a review of topics covered, practice with skills to be mastered, and thought-provoking questions of broader scope. There are groups of problems organized by topics, questions based on the Applications and Interludes, and, finally, uncategorized General Questions and Problems. All even-numbered Additional Problems are answered in an Appendix.

Appendixes Reviews of scientific notation and useful conversion factors are provided. *New to this edition* is the inclusion of a discussion of scientific notation and electronic calculators, and of problems with answers for students who need practice with scientific notation. *Also new to this edition* is the discussion in an Appendix rather than in the text of the application of the Henderson-Hasselbalch equation to amino acids.

Index The index is designed to be especially useful by including both general and specific citations and by the absence of cross reference entries without page numbers.

SUPPLEMENTS

For the Instructor

Instructor's Resource Manual with Tests. Developed by Theodore Sakano, Rockland Community College, and Barbara Mowery, Thomas Nelson Community College, this manual features lecture outlines with presentation suggestions and topics for classroom discussion. Also included are tests to accompany the text with approximately 1250 true-false, multiple-choice, matching, and fill-in questions. (0-13-378712-5, 37871-1)

Transparencies. This set of four-color transparencies includes 125 acetates. (0-13-378761-3, 37876-0)

Prentice Hall Test Managers. Based on the powerful testing technology developed by Engineering Software Associates, Inc. (ESA), this supplement allows instructors to tailor exams to their own needs. With the On-line Testing option, exams can be administered on-line, so data can be automatically transferred for evaluation. A comprehensive desk reference guide is included, along with on-line assistance. (IBM: 0-13-378779-6, 37877-8) (Mac: 0-13-378787-7, 37878-6)

Instructor's Manual to *Chemistry and Life in the Laboratory*, 3/e. This Instructor's Manual provides a list of chemicals and supplies required for each experiment; suggestions and precautions for optimum class results; and answers to all pre-laboratory questions, selected conclusions in the Observations and Results section, and all Questions and Problems. (0-02-352846-X, U3002-5)

For the Student

Study Guide and Solutions Manual. Developed by Susan McMurry, the study guide and solutions manual explains in detail how the answers to in-text and end-of-chapter problems are obtained. This supplement is available in two versions, one with solutions and answers to all problems and the other with solutions only to those problems with short answers given in the Selected Answers appendix in the text. Chapter summaries, study hints, and self-test materials for each chapter are included. (0-13-378753-2, 37875-2)

***Chemistry and Life in the Laboratory*, 3/e.** Developed by Victor L. Heasley, Point Loma Nazarene College, Val J. Christensen, Point Loma Nazarene College, and Gene E. Heasley, Southern Nazarene University, this text-independent laboratory manual includes 35 self-contained, easy-to-understand experiments that blend traditional experiments with new investigative exercises. An instructor's guide is available separately. (0-02-352845-1, U3001-7)

Prentice/HallThe New York Times Contemporary View Program. Through this unique program, adopters of McMurry/Castellion's *Fundamentals of General, Organic, and Biological Chemistry* are eligible to receive Prentice Hall's innovative *New York Times* supplement for students. This newspaper-format resource brings together current chemistry-related articles from the award-winning pages of *The New York Times*—perfect for generating in-class discussion and for additional writing assignments. Free in quantity to qualified adopters through your local representative.

How to Study Chemistry. This unique chemistry supplement contains problems solving strategies, suggestions, and helpful hints for learning and achieving success in chemistry. This student tool also provides a mathematical review for the course. One copy of this supplement is provided free for every new student copy of the text purchased. (0-13-234329-2, 23432-8)

Allied Health Chemistry: A Companion. Developed by Jim Smith and Diane Vukovich, both of the University of Akron, this exciting new student tool provides a friendly, hands-on approach to GOB. This guide contains 16 chapters that help students with calculator usage, measurements, algebra, logarithmic equations, and stoichiometry. *The Companion* helps students overcome the mathematical stumbling blocks in chemistry.

Multimedia Development Tools

Director Academic (Mac 0-13-315771-7, 31577-0) (Windows 0-13-315797-0, 31579-6) **Authorware Academic** (Mac 0-13-289802-0, 29890-1) (Windows 0-13-289794-6, 28979-3) by Prentice Hall and Macromedia, these educational adaptations of the leading multimedia authoring tools provide instructors with high-power multimedia at a minimal cost. Distributed exclusively by Prentice Hall, both products contain templates designed specifically for academic uses. For further information, contact the Prentice Hall Multimedia Group at (800) 887-9998. For sale only (\$150 for Authorware Academic, \$99 for Director Academic).

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First Edition Reviewers

James N. Beck, *McNeese State University*

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John McMurry
Mary E. Castellion

A Note to the Student

Here you are, about to study chemistry, perhaps for the first time. The topics you are about to study will be useful in all health-related professions and in many business endeavors. The chemistry you are introduced to in this book will also be useful in exercising judgment in everyday life. Newspapers and magazines are filled with chemistry-related stories about protecting the environment, about new materials designed to improve the quality of life, and about drugs that promise to revolutionize medical care. The better you understand such matters, the better you will be able to function in today's society.

The following suggestions should prove helpful in your study:

Don't read the text immediately. As you begin each new chapter, look it over first. Read the introductory paragraphs and familiarize yourself with the chapter goals. Find out what topics are covered, and take a look at the illustrations—to get a feel for the topics at hand. Then turn to the end of the chapter and read the summary. You'll be in a much better position to learn new material if you first have a general idea of where you're going.

Work the problems. The problems are designed to give you practice in the skills necessary to understand and use chemistry. There are no shortcuts here. The sample problems illustrate the skills, the in chapter practice problems provide immediate practice, and the end-of-chapter problems provide additional opportunities to test your understanding. Brief answers to in-chapter practice problems and most even-numbered review problems are given at the end of this book.

Use the study guide. Complete answers and explanations for all problems, along with chapter outlines, additional study hints, and self-tests, are given in the *Study Guide and Solutions Manual* that accompanies this text. The *Study Guide* can be extremely useful when you're working problems and when you're studying for an exam. Investigate what's there now so you'll know where to find help when you need it.

Ask questions. Faculty members and teaching assistants are there to help you learn. Don't hesitate because you think a question might be stupid or silly. If it's something you need to know to get on with understanding chemistry, it's always a good question.

Many of the words and symbols that lie ahead in this book may at first seem strange to you. We urge you not to let their unfamiliarity cause you to lose sight of your goals: to learn about the amazing kinds of chemistry that keep us all alive and well, and to understand the impact of chemistry on everyday life.

John McMurry
Mary E. Castellion

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