



Pearson International Edition

conceptual chemistry

THIRD EDITION

John Suchocki

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conceptual chemistry

UNDERSTANDING OUR WORLD
OF ATOMS AND
MOLECULES

JOHN SUCHOCKI

Saint Michael's College



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Production Management and Composition: GGS Book Services

Cover Design/Illustration and Text Design: Seventeenth Street Studios

Cover Photo: Michael Salas/The Image Bank/Getty Images

Photo Research: Laura Murray Productions

Artists: Emiko-Rose Koike, J. B. Woolsey and Associates, and GGS Book Services

Director, Image Resource Center: Melinda Patelli

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ISBN 0-321-45649-1

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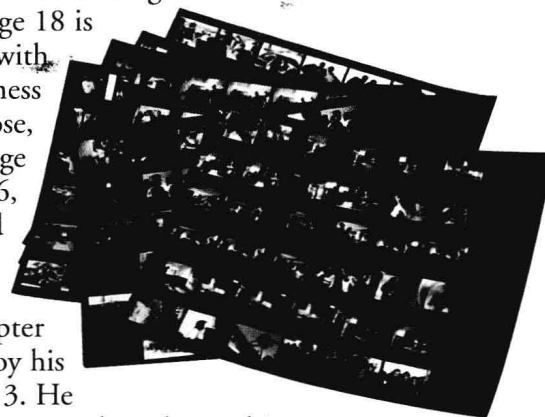
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CONCEPTUAL CHEMISTRY PHOTO ALBUM

Conceptual Chemistry is personalized with photographs of my family and friends. A photo of my uncle and mentor Paul Hewitt, author of *Conceptual Physics*, appears on page xxxi. On Uncle Paul's lap is my son Evan Suchocki (pronounced Su-HOCK-ee, with a silent *c*), who, as a toddler, sums up the book with his optimistic message.

Taking advantage of water's high heat of vaporization is my wife, Tracy, who is seen fearlessly walking over hot coals on page 280. Demonstrating the potential energy of a drawn bow and arrow on page 18 is our precious oldest son, Ian, who is also seen as a baby with his mom on page 92 letting us know that the closeness between us is in the heart. Our third child, Maitreya Rose, is proudly showcased both as a fetus and as a baby on page 473, as one of the models of Figure 13.18, on page 446, highlighting the value of proteins, and as a two-year-old holding the cellulose and color-rich Vermont autumn leaves on page 439. She appears yet again within the Chapter 12 opening photograph and within the Chapter 10 Spotlight essay on hair and skin care. About to enjoy his favorite beverage—by the liter—is son Evan on page 13. He appears again on page 585 using balloons to demonstrate the relationship between the volume of a gas and its temperature. The inverted image of Evan and his mom enjoying the balmy beaches of Hawaii can be seen on page 366 in the discussion on the chemistry of photography. Evan, his mom, and brother Ian are seen huddled together at Evan's ceramic art show in the middle figure on page 628. Those are Ian's hands holding the mineral fluorite on page 192 and my fingers on page 160 lightly touching the strings of Betsy, my guitar since childhood. I still use Betsy in producing music for my alter ego, John Andrew (see www.JohnAndrew.net). Also of our immediate family is Rusty Cat, whom you will find on page 646 helping provide perspective for the propane tank at the side of our home. Our dog Sam demonstrates his panting skills on page 269.

A few members of our extended family have also made their way into *Conceptual Chemistry*. My nephew Graham Orr, lead singer for the emo-rock group Burlington, is seen on page 53 drinking water both as a kid and as a grown-up college student. Exploring the microscopic realm with the uncanny resolution of electron waves is my cousin George Webster, who is seen on page 155 alongside his own scanning electron microscope. George's son, Christian, is the cute kid in the Chapter 3 opening photo. Friend and former housemate Rinchen Trashy is seen looking through the spectroscope on page 149. Cousin Gretchen Hewitt demonstrates her taste for chips on page 446. Tracy's brother, Peter Elias, is found on page 614 smelling the camphorous odor of a freshly cut Ping-Pong ball. Look carefully on page 630 and you will see my father-in-law,



David Hopwood, sailing with his wife Hedi on their boat *Dogs of Sabbatt*. On the same page appears my brother-in-law Peter Elias along with his mom (my mother-in-law), Sharon Hopwood, as they perch on the branch of a tree made strong by its composite nature. Both Peter and Sharon were key players in the development of *Conceptual Chemistry Alive!* Also key to *CCAlive!* are my dear former students Kai Dodge and Maile Ventura who appear on page 345. Watch for Kai and Maile's popular student-oriented video lessons with *CCAlive!* Key to my being accepted into the chemistry department family at St. Michael's College is Alayne Scholl, shown on page 316 tending to an entropy-driven exothermic reaction.

In addition to family photographs, the photographs of many of our friends' children grace this book. Ayano Jeffers-Fabro is the adorable girl hugging the tree on page 11. Jill Rabinov and her daughter Michaela appear on page 47 demonstrating the chemical nature of biological growth. Cole Stevens, who is seen on page 256, helps us to be amazed by what happens to the volume of water as it freezes. Helping us to understand the nature of DNA in the Chapter 13 opener are Daniel and Jacob Glassman-Vinci. Makani Nelson, on page 432, provides us with a fine example of a human body full of cells and biomolecules. Look also for Makani's cameo appearance on the opening montage video of *Conceptual Chemistry Alive!* We are born with the desire to learn about our environment and our place in it. Let the sparkle of curiosity in the eyes of the many kids portrayed in this textbook serve as a reminder of this important fact.

TO THE STUDENT

Welcome to the world of chemistry—a world where everything around you can be traced to these incredibly tiny particles called atoms. Chemistry is the study of how atoms combine to form materials. By learning chemistry, you gain a unique perspective on what things are made of and why they behave as they do.

Chemistry is a science with a very practical outlook. By understanding and controlling the behavior of atoms, chemists have been able to produce a broad range of new and useful materials—alloys, fertilizers, pharmaceuticals, polymers, computer chips, recombinant DNA, and more. These materials have raised our standards of living to unprecedented levels. Learning chemistry, therefore, is worthwhile simply because of the impact this field has on society. More important, with a background in chemistry you can judge for yourself whether or not available technologies are in harmony with the environment and with what you believe to be right.

This book presents chemistry conceptually, focusing on the concepts of chemistry with little emphasis on calculations. Though sometimes wildly bizarre, the concepts of chemistry are straightforward and accessible—all it takes is the desire to learn. What you will gain from your efforts, however, may be

more than new knowledge about your environment and your personal relation to it—you may improve your learning skills and become a better thinker! But remember, just as with any other form of training, you'll get out of your study of chemistry only as much as you put in.

I enjoy chemistry, and I know you can, too. So put on your boots and let's go explore this world from the perspective of its fundamental building blocks.

Good chemistry to you!





TO THE INSTRUCTOR



As instructors, we share a common desire for our teaching efforts to have a long-lasting positive impact on our students. We focus, therefore, on what we think is most important for the student to learn. For students taking liberal arts chemistry courses, certain learning goals are clear. They should become familiar with and, perhaps, even interested in the basic concepts of chemistry, especially the ones that apply to their daily lives. They should understand, for example, how soap works and why ice floats on water. They should be able to distinguish between stratospheric ozone depletion and global warming, and also know what it takes to ensure a safe drinking water supply. Along the way, they should learn how to think about matter from the perspective of atoms and molecules. Furthermore, by studying chemistry, students should come to understand the methods of scientific inquiry and become better equipped to pass this knowledge along to future generations. In short, these students should become citizens of above-average scientific literacy.

These are noble goals, and it is crucial that we do our best to achieve them. Judging from encounters with my former liberal arts students in the midst of their daily lives, however, I have come to conclude that this is not what they usually cherish most from having taken a course in chemistry. Rather, it is the personal development they experienced through the process.

As all science educators know, chemistry—with its many abstract concepts—is fertile ground for the development of higher-thinking skills. Thus, it seems reasonable for us to share this valuable scientific offering—tempered to an appropriate level—with all students. Liberal arts students, like all other students, come to college not just to learn about scientific subjects but for personal growth as well. This growth should include improvements in their analytical and verbal-reasoning skills along with a boost in self-confidence from having successfully met well-placed challenges. The value of our teaching, therefore, rests not only on our ability to help students learn chemistry but also on our ability to help them learn about themselves.

These are the premises upon which *Conceptual Chemistry* was written. You will find the standard discussions of the applications of chemistry, as shown in the table of contents. True to its title, this textbook also builds a conceptual base from which nonscience students may view nature more perceptively by helping them visualize the behavior of atoms and molecules and showing them how this behavior gives rise to our macroscopic environment. Numerical problem-solving skills and memorization are not stressed. Instead, chemistry concepts are developed in a story-telling fashion with the frequent use of analogies and tightly integrated illustrations and photographs. Follow-up end-of-chapter questions are designed to challenge the students' understanding of concepts and their ability to synthesize and articulate conclusions. Concurrent with helping

students learn chemistry, *Conceptual Chemistry* aims to be a tool by which students can learn how to become better thinkers and reach their personal goals of self-discovery.

ORGANIZATION

The basic concepts of chemistry are developed in the first 12 chapters of *Conceptual Chemistry*. Threaded into the development, real-life applications facilitate the understanding and appreciation of chemistry concepts. In the remaining 7 chapters, students have the opportunity to exercise their understanding of earlier material as they explore numerous chemistry-related topics such as nutrition, genetic engineering, pharmaceuticals, agriculture, water treatment facilities, air pollution, modern materials, and energy sources.

FEATURES

Key features of *Conceptual Chemistry* include the following:

- A conversational and clear writing style aimed at engaging student interest.
- In-text **Concept Checks** that pose a question followed by an immediate answer. These questions reinforce ideas just presented before the student moves on to new concepts.
- **Hands-On Chemistry** activities that allow students to experience chemistry outside a formal laboratory setting. These activities can be performed using common household ingredients and equipment. Most chapters have two or three Hands-On features, which lend themselves well to distance learning or to in-class activities.
- **Calculation Corners** appear in selected chapters. They are included so that students can practice the quantitative-reasoning skills needed to perform chemical calculations. In each Calculation Corner, an example problem and answer show students how to perform a specific calculation; then their understanding is tested in a Your Turn section. None of the calculations involves skills beyond fractions, percentages, or basic algebra.
- Each chapter includes four to six **FYI** margin features that highlight interesting information relating to the adjacent chapter content. An accompanying web reference points the student in the direction of additional interesting tid-bits.
- **In the Spotlight** essays appear after each of the first 12 chapters. These essays focus on chemistry-related issues that lend themselves to controversy. A Spotlight essay can serve as a starting point for a student project or as a centerpiece for in-class student discussion groups.
- **Conceptual Chemistry Alive!** is a student tutorial presented by the author on a single DVD-ROM found in every textbook. This extensive tutorial features over 200 minilectures, demonstrations, animations, home chemistry projects, and explorations of chemistry in the community. Students browse through over 24 hours of Quicktime movies in an interactive environment that follows the *Conceptual Chemistry* table of contents. After viewing a segment, students answer Concept Checks that encourage them to test their understanding of key material before progressing further. A student's answer to these Concept Checks are recorded in an electronic notebook that can be submitted to an instructor for assessment. More than a study supplement, *Conceptual Chemistry Alive!* is a textbook companion suitable for distance-learning programs and for instructors seeking to free up class time for student-centered curricula.

Extensive end-of-chapter material includes:

- **Key Terms** A short summary of important terms that appear boldfaced in the text.
- **Chapter Highlights** A set of 30 easy-to-answer questions that highlight the essentials of the chapter. Designed as a quick review, these questions are grouped by chapter section to help the student in finding the answer.
- **Concept Building** An extensive set of questions designed to challenge student understanding of the chapter material and to emphasize critical thinking rather than mere recall. In many cases, a “concept builder” links chemistry concepts to familiar situations.
- **Supporting Calculations** A set of questions featuring concepts that are more clearly understood with numerical values and straightforward calculations. They are based on information presented in the Calculation Corners and therefore appear only in chapters containing this feature.
- **Difficulty Ratings** All Concept Builders and Supporting Calculations are rated by their level of difficulty to assist you and the student in selecting among the numerous questions. The solutions to all odd-numbered Concept Builders and Supporting Calculations appear in Appendix C. The solutions to all end-of-chapter questions appear within the Instructor Manual.
- **Discussion Questions** In the topical chapters (13–19), students are prompted to express their opinions on issues that have no definitive answers. This is similar to the discussion questions found within the interchapter Spotlight essays. These questions promote student debate about controversial ideas.
- **Hands-On Chemistry Insights** The “insights” are a follow-up to the Hands-On Chemistry activities. These insights are designed to ensure that the student is getting the most out of performing the Hands-On activities and also to clear up any misconceptions that may have developed.
- **Exploring Further** The references provided here serve as a bibliography allowing the student to research the ideas of the chapter for him or herself.

NEW TO THE THIRD EDITION

Conceptual Chemistry's Third Edition is a major revision of the textbook as well as its many supplements. In all of these revisions, the main focus has been on creating tools that support the instructor seeking to emphasize student-centered learning in the classroom and beyond.

For the textbook, this has meant the creation of new interchapter In the Spotlight essays and marginal FYIs as described above. The aim of such features is to help reveal how the concepts of chemistry are central to students' lives, especially in these modern times. Also, the end-of-chapter questions have been extensively reworked to provide ample opportunity for student assessment. Notably, select Concept Builders and Supporting Calculations appear within the Instructor Resource CD-ROM in a multiple-choice format amenable to “Think-Pair-Share” teaching techniques as described in the Instructor Manual. Most significant is the inclusion of the full version of *Conceptual Chemistry Alive!* now housed on a single DVD-ROM. This DVD-ROM, found in every textbook, contains minilecture presentations organized around the Third Edition's table of contents. Using this DVD-ROM, students can access chemistry lectures whenever and wherever they have access to a computer. Class sessions can then

become a time more dedicated to various student-centered learning techniques, such as Process Oriented Guided Inquiry Learning (POGIL). In other words, students can “go home for their lectures,” but they come to class to study under the expert supervision of their course instructor.

Accompanying the Third Edition are two new student supplements; this includes the *Study Guide*, consisting of detailed chapter summaries, numerous POGIL oriented worksheets, study group questions, and RATS, which are Readiness Assurance Tests designed to help the student gauge how prepared he or she may be for an exam. RATS are particularly popular with students, which is why I have my students perform their RATS in class during the period preceding an exam.

In contrast to the minds-on approach of the study guide is *Explorations in Conceptual Chemistry: A Student Activity Manual* written by Jeff Paradis of California State University–Sacramento. Unlike the laboratories of a traditional lab manual, these activities are short and relatively easy to set up. They can be scheduled directly into the course syllabus or alternatively pulled together “on the fly” based upon student need as the semester progresses. The majority of these activities can be performed by students during class, which is a surefire way to maintain student interest. Many can also be performed by students outside of class as prescribed by the instructor. The primary goal of this booklet is to allow the student to learn chemistry by doing chemistry.

As can be expected, the creation of the Third Edition allowed for further improvements in the readability of the text and for the correction of inaccuracies appearing in earlier editions. Content changes were also made. The most significant of these changes include a reworking of the presentation of the scientific method as found in Chapter 1. For Chapter 9, the section on entropy was greatly revised. For Chapter 10, Lewis acids and bases are now discussed, and for Chapter 17 a new section on gas laws was added. The topical chapters of this textbook, Chapters 13–19, were also updated to reflect current events.

SUPPORT PACKAGE

The *Conceptual Chemistry* instructional package provides complete support materials for both students and faculty.

FOR THE STUDENT

- *Conceptual Chemistry Alive!* is a student tutorial presented by the author on a single DVD-ROM included with every Third Edition textbook. Students obtaining a used DVD-ROM can renew the *CCAlive!* registration on-line at www.ConceptChem.com, which is the technical support website for all *Conceptual Chemistry Alive!* users.
- *Study Guide for Conceptual Chemistry* features engaging minds-on, pencil-pushing, concept-review activities designed to help students working collaboratively to prepare for exams and learn chemistry through that process. Available for purchase (ISBN 0-8053-1789-9).
- *Explorations in Conceptual Chemistry: A Student Activity Manual* features hands-on activities that help students learn chemistry by doing chemistry in a discovery-based team environment. Available for purchase (ISBN 0-8053-8289-5).
- *The Chemistry Place* website (www.aw-bc.com/chemplace) is a unique study tool that offers detailed learning objectives, practice quizzes, flash cards, and web links for each chapter of the text. *The Chemistry Place* also includes inter-

active tutorials featuring simulations, animations, and 3-D visualization tools.

- *Student Laboratory Manual for Conceptual Chemistry*, coauthored with Donna Gibson, Chabot College, features laboratory activities tightly correlated to the chapter content. Available for purchase (ISBN 0-8053-8232-1).

FOR THE INSTRUCTOR

- Written by the author, the *Instructor Manual* is an important resource for the instructor seeking to implement student-centered learning techniques, such as “think-pair-share,” “student-centered circles,” “minute quizzes,” “student mini-presentations with activity intervals,” “muddiest points,” “readiness-assurance tests,” “collaborative exams,” and more. In addition to discussions on student-centered learning, the *Instructor Manual* contains sample syllabi, teaching tips, suggested demonstrations, and answers to all end-of-chapter questions. Also included are answers to all questions and worksheets appearing in the *Study Guide*, *Explorations in Conceptual Chemistry: A Student Activity Manual*, and the *Lab Manual*. Discussions on how to prep for guided inquiry activities and laboratories are also included (ISBN 0-8053-8228-3).
- The *Instructor Resource CD-ROM* contains the extensive PowerPoint presentations developed by the author in making *Conceptual Chemistry Alive!* Instructors using *Conceptual Chemistry* may adapt these PowerPoints for their own electronic presentations. To further support such electronic presentations, these CDs also contain all of the figures and tables from the textbook in JPG format. Also included are the author’s favorite Test Bank and end-of-chapter Concept Builder questions in multiple-choice format. These are the same questions that appear in the student *Study Guide* as short-answer “study group exercises” and as RATS. Presented as “clicker” PowerPoints, these multiple-choice questions serve as useful in-class concept checks tightly integrated with the *Study Guide*. The CD also contains the Test Bank and *Instructor Manual* in Word and PDF format (ISBN 0-8053-8223-X).
- *The Chemistry Place* website (www.aw-bc.com/chemplace) provides learning objectives, quizzes, interactive tutorials, and a link to downloadable supplements.
- A set of 250 four-color acetates of figures and tables from the text is available (ISBN 0-8053-8227-5).
- An extensive test bank comes in both printed format (ISBN 0-8053-8225-9) and on a cross-platform CD-ROM (ISBN 0-8053-8226-7). A special section of this test bank contains multiple-choice versions of odd Concept Builders and Supporting Calculations. These multiple-choice questions are provided as a reward to students who have studied these questions at the end of each chapter where they appear in a short-answer format.
- Course management technologies available to qualified college adopters:
Blackboard: <http://cms.aw.com/blackboard>
CourseCompass™: www.coursecompass.com

In addition to offering Blackboard, we also offer CourseCompass—a nationally hosted on-line course management system. All CourseCompass and Blackboard courses offer preloaded content, including testing and assessment, interactive web-based activities, animations, web links, illustrations, and photos. To view a demonstration of any course, go to www.coursecompass.com.



ACKNOWLEDGMENTS



I am grateful for the love and support I have received over the years from my father, John Marion Suchocki, and his wife, Susan Suchocki. To them this Third Edition is dedicated. To my wife, Tracy, I remain deeply thankful for her endless patience and for the love and time she gives to me daily. To Ian, Evan, and Maitreya, who have grown up knowing only a dad who pores hours over his computer, thank you for reminding me of the important things in life.

There are numerous other individuals I am grateful and indebted to for their assistance in the development of *Conceptual Chemistry*. Standing at the head of this crowd is my uncle and mentor, Paul G. Hewitt. He planted the seed for this book in the early 1980s and has lovingly nurtured its growth ever since. Thanks also to Uncle Paul and cousin Leslie Hewitt Abrams for allowing me to use their material from our *Conceptual Physical Science* textbooks. Thanks to my pharmacist sister, Joan Lucas, for helping with the early drafts of Chapter 14, and to my chemical engineer brother-in-law, Rick Lucas, for consultations regarding the petroleum industry. To Bill Candler, rock collector and husband to my dear sister Cathy, thank you for supplying various minerals for photographing. I would like to thank my molecular geneticist step-brother, Nicholas Kellar, for assistance in the Chapter 13 laboratory for isolating DNA from plant material. Thanks also to my electron microscopist cousin, George Webster, and his wife, Lolita, for supplying photos of their SEM.

Special thanks are extended to my mother, Majorie Hewitt Suchocki, for her love and for instilling in me a positive attitude about life's work. Personal thanks are also extended to all my friends and other relatives for their support throughout the years, most notably to my mother-in-law, Sharon Hopwood, for photo research and for being a wonderful grandmother. Personal thanks also go to my past mentors, Professors Everette May and Albert Sneden of Virginia Commonwealth University.

I am particularly grateful for the past support of the faculty and staff of Leeward Community College, notably Michael Reese, Bob Asato, the late George Shiroma, Pearl Takachi, Patricia Domingo, Manny Cabral, Mike Lee, Kakkala Mohanan, Irwin Yamamoto, Stacy Thomas, Sharon Narimatsu, and Mark Silliman. Extra, extra thanks are extended to Michael Reese, a first-rate chemistry professor as well as computer programmer. Michael single-handedly created the programming that allows *CCAlive!* to run on computers. After four years of smooth running, there has been no technical support issue that Michael has not been able to solve. His recent efforts have made it possible to have *CCAlive!* in a DVD-ROM format, which has allowed us to include a copy of *CCAlive!* with every textbook.

I send a big *mahalo* to the crew that helped in the filming of *CCAlive!* including Michael Reese, Peter Elias, Camden Barruga, Ed Nartatez, Kelly Sato, Sharon Hopwood, Patrick Garcia, Irwin Yamamoto, Stacy Thomas, Kai

Dodge, and Maile Ventura. Another Hawaiian *mahalo* to Julia Myers and Michael Niederer for designing and maintaining the ConceptChem.com website. To Alayne Schroll and the other faculty of the chemistry and physics departments at St. Michael's College, thank you for your continued support. Special thanks are extended to Frank L. Lambert, Professor Emeritus Occidental College, for his much-appreciated assistance in the development of *Conceptual Chemistry's* presentation of the second law of thermodynamics.

To Jeff Paradis of CSU–Sacramento, I am thankful for his efforts in creating his activities manual, which complements this textbook so well. For developing the *Conceptual Chemistry Laboratory Manual*, I am forever grateful to Donna Gibson of Chabot College. For developing the *Conceptual Chemistry Test Bank*, I am deeply indebted to Bill Centobene of Cypress College as well as Dan Stasko of the University of Southern Maine.

The first chapter of this textbook is graced by the research efforts of Professors Jim McClintock of the University of Alabama, Birmingham, and Bill Baker of the University of South Florida, who were quick to provide not only their permissions but some beautiful photographs of the Antarctic. A big Hawaiian *mahalo* to them both. Jim and Bill's scientific work is outlined using the "Wheel of Scientific Inquiry" shown in Figure 1.5. This model was developed by William Harwood and his graduate students at Indiana University. I am indebted to Professor Harwood for his permission to incorporate this model into *Conceptual Chemistry*.

I am grateful for the continued support and guidance of my chemistry editor, Jim Smith. The editorial services of Lisa Leung, Cinnamon Hearst, and Kate Brayton have also been invaluable. Continued thanks are also due to my earlier editors, Ben Roberts, Hilair Chism, and Irene Nunes.

For overseeing the production of this Third Edition, I send a heartfelt thanks to Beth Masse as well as Corinne Benson. For managing the design of the book, I thank Mark Ong, Marilyn Perry, and Randall Goodall. For producing this edition's cover, I am grateful to Randall Goodall as well as Steve and Janet Simonson for providing their brilliant photography. This edition is graced by many new photographs due to the research efforts of Laura Murray—thank you, Laura. To Kristin Rose I am grateful for her work on the *Conceptual Chemistry* website and *Instructor Resource CD-ROM*. Thanks also are due to Grace Joo for producing an extensive set of transparency acetates. My thanks are also extended to Scott Dustan, our very capable marketing manager, and to Emily Autumn of GGS Book Services for overseeing the actual piecing together of this textbook. Thanks to Terri Miller for her great page-layout skills, and to Pam Rockwell for her keen copyediting, followed by Denne Wesolowski for his vigilant proofreading. Thanks to you all. An author couldn't possibly ask for more support than this.

The development of *Conceptual Chemistry* relied heavily on the comments and criticisms of numerous reviewers. These people should know that their input was carefully considered and most often incorporated. A tremendous thanks go to the reviewers listed here, who contributed immeasurably to the development of this and earlier editions of this book:

Pamela M. Aker, University of Pittsburgh
Edward Alexander, San Diego Mesa College
Sandra Allen, Indiana State University
Susan Bangasser, San Bernardino Valley College
Ronald Baumgarten, University of Illinois, Chicago
Stacey Bent, New York University
Richard Bretz, University of Toledo

Benjamin Bruckner, University of Maryland, Baltimore County
 Kerry Bruns, Southwestern University
 Patrick E. Buick, Florida Atlantic University
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 Frank Lambert, Occidental College
 Carol Lasko, Humboldt State University
 Joseph Lechner, Mount Vernon Nazarene College
 Robley Light, Florida State University
 Maria Longas, Purdue University
 David Lygre, Central Washington University
 Art Maret, University of Central Florida
 Vahe Marganian, Bridgewater State College
 Irene Matusz, Community College of Baltimore County—Essex
 Robert Metzger, San Diego State University
 Luis Muga, University of Florida

B. I. Naddy, Columbia State Community College
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 George Wahl, North Carolina State University
 M. Rachel Wang, Spokane Community College
 Karen Weichelman, University of Southwestern Louisiana
 Bob Widing, University of Illinois at Chicago
 Ted Wood, Pierce University
 Sheldon York, University of Denver

To the struggling student, thank you for your learning efforts—you are on the road to making this world a better place.

Much effort has gone into keeping this textbook error-free and accurate. It is possible, however, that some errors or inaccuracies may have escaped our notice. Your forwarding such errors or inaccuracies to me would be greatly appreciated. Your questions, general comments, and criticisms are also welcome. I look forward to hearing from you.

John Suchocki
John@ConceptChem.com



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