CONCEPTUAL Integrated Science

SECOND EDITION

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This book is dedicated to the inquiring minds devoted to protecting the beautiful planet we call home.

Brief Contents

Detailed Contents

PART TWO

Chemistry 213

Special Features

MATH CONNECTION

SCIENCE AND SOCIETY

HISTORY OF SCIENCE

TECHNOLOGY

The *Conceptual Integrated Science* Photo Album

THIS BOOK IS VERY PERSONAL to the authors, family undertakings shown in the many photographs throughout. Author Paul is seen with wife Lillian on page 58, and Lil again on pages 176, and 210. Lil's dad, Wai Tsan Lee, is on page 176. Paul's grown children begin with son Paul with his mother Millie on page 138, and daughter Leslie in her student days on page 240. Paul's sister (and John's mom) Marjorie Hewitt Suchocki (pronounced Su-hock-ee, with a silent *c*), a leading process theologian, is shown reflectively on page 188. Paul's brother Steve shows Newton's third law with his daughter Gretchen on page 67. Paul's grandchild Emily Abrams opens Part One on page 17. Paul's friends include Tenny Lim pages 1 and 79, Will Maynez on page 77, Burl Grey on page 25, Dan Johnson on page 146 and Bay Johnson (Dan's grandson) on page 185, John Hubisz on page 128, Mike and Jane Jukes on pages 34 and 68, Cassy Cosme on page 73. Little kids that Paul loves include Carlos Vasquez on page 195, Miriam Dijamco and Michelle Anna Wong on page 178, Francesco Ming Giovannuzzi on page 125, and Andrea Wu on pages 94 and 191.

Chemistry author John, who in his "other life" is John Andrew, singer and songwriter walks barefoot on red-hot coals on page 137. John's wife, Tracy, is seen again with oldest son Ian on page 216 and with their second son Evan on page 283. Their third child, Maitreya Rose, is featured in the Chapter 14 opening photograph on page 376. Exploring the microscopic realm with the uncanny resolution of electron waves is cousin George Webster, who is seen on page 234. Friend Rinchen Trashi looks through the spectroscope on page 230. John's former students and co-stars of the Kai and Maile Show from *Conceptual Chemistry Alive!* appear on page 370. Coauthor Leslie Hewitt is seen as a 16 year old inspecting a molecular model on page 240. Nephews and niece Liam, Bo, and Neve Hopwood are seen together in the chemistry part opener of page 213.

Paul's granddaughter Grace Hewitt is featured in the astronomy part opener on page 819. The left two photographs on page 842 show our lab manual author Dean Baird surrounded by crescent shaped images of the Sun during the 2012 solar eclipse. Colleague Paul Doherty, on the far right on page 842, reveals the rarely seen sun circles that formed during same eclipse at the time and place of annular totality.

Biology author Jennifer's daughter Daphne and her prized sunflower open up Biology on page 409. A special thank you to Daphne's aunt Anita Sherman for bringing Daphne the sunflower all the way from her Baltimore garden! Jennifer's kids Io and Pico show off their sunscreen and sun hats on page 472. Io also appears on page 552, where she engages in her favorite pastime. Jennifer's husband Nils shoots a basket on page 591. And Jennifer's sister Pam, who is also a biologist, shows a specimen she caught (and later released) during an ecological study in Nepal on page 609.

Earth-Science author Suzanne Lyons with her children Simone and Tristan are shown on page 211. Tristan is on page 32 demonstrating friction and Simone is on page 192 pondering the color of a rose. Suzanne's husband Pete demonstrates thermodynamics in everyday life on page 126.

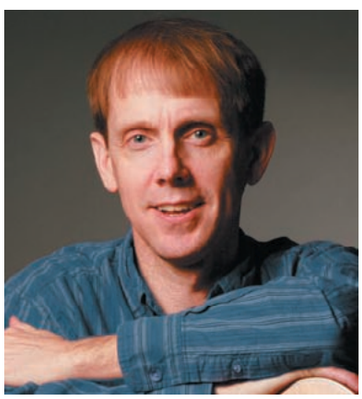
These photographs are of people very dear to the authors, which makes *Conceptual Integrated Science* all the more our labor of love.

Paul G. Hewitt

Former silver-medal boxing champion, sign painter, uranium prospector, and soldier, Paul began college at the age of 27, with the help of the GI Bill. He pioneered the conceptual approach to teaching physics at the City College of San Francisco. He has taught as a guest teacher at various middle schools and high schools, the University of California at both the Berkeley and Santa Cruz campuses, and the University of Hawaii at both the Manoa and Hilo campuses. He also taught for 20 years at the Exploratorium in San Francisco, which honored him with its Outstanding Educator Award in 2000. He is the author of *Conceptual Physics* and a co-author of *Conceptual Physical Science* and *Conceptual Physical Science Explorations* (with John Suchocki and Leslie Hewitt Abrams).

Suzanne Lyons

Suzanne received her B.A. in physics from the University of California, Berkeley. She earned her M.A. in education and her California teaching credential both from Stanford University. She earned another M.A. degree in Integrated Earth Sciences from California State University Sacramento. Suzanne was editor of *Conceptual Physics* and other books in the Conceptual series for 16 years and has authored 7 books on physics, hands-on science activities, and other topics in science and education. She has taught science and education courses to students of diverse ages and ability levels, from elementary school through college. She is always interested in developing new ways to teach and to that end, she founded the small business CooperativeGames.com.



John A. Suchocki

John is the author of *Conceptual Chemistry* and coauthor of *Conceptual Physical Science* and *Conceptual Physical Science Explorations*. John obtained his Ph.D. in organic chemistry from Virginia Commonwealth University. He worked as a pharmacology postdoctoral fellow at the Medical College of Virginia before becoming a tenured professor at Leeward Community College in Hawaii, where his interests turned to science education, the development of distance learning programs, and student-centered learning curricula. Currently an adjunct professor at Saint Michael's College in Vermont, John also produces science multimedia through his company Conceptual Productions. His popular tutorial video lessons, as well as those of his coauthors, are freely available at ConceptualAcademy.com.

Jennifer Yeh

Jennifer earned a Ph.D. in integrative biology from the University of Texas, Austin, for her work on frog skeleton evolution. She obtained her B.A. in physics and astronomy from Harvard University. Following her graduate work, Jennifer was a postdoctoral fellow at the University of California, San Francisco, where she studied the genetics of breast cancer. Jennifer has taught courses in physics, cell biology, human embryology, vertebrate anatomy, and ecology and evolution. She is the author of various scientific papers as well as the book *Endangered Species: Must They Disappear?* (Thomson/Gale, © 2002, 2004). Jennifer continues to work on a wide variety of introductory biology materials, including various ancillaries and online tutorials.

To the Student

Welcome to *Conceptual Integrated Science*. The science you'll learn here is INTEGRATED. That means we'll explore the individual science disciplines of physics, chemistry, biology, Earth science, and astronomy PLUS the areas where these disciplines overlap. Most of the scientific questions you're curious about, or need to know about, involve not just one discipline, but several of them in an overlapping way. How did the universe originate? That's astronomy + physics. How are our bodies altered by the foods we eat, the medicines we take, and the way we exercise? That's chemistry + biology. What's the greenhouse effect? Will it trigger irreversible global warming, threatening life on our planet? Physics, chemistry, biology, and Earth science are all needed to understand the answers.

We're convinced that the CONCEPTUAL orientation of this book is the way in which students best learn science. That means that we emphasize concepts *before* computation. Although much of science is mathematical, a firm qualitative grasp of concepts is also important. Too much emphasis on mathematical problem solving early in your science studies can actually distract you from the concepts and prevent you from fully comprehending them. If you continue in science, you may follow up with classes requiring advanced mathematical methods. Whether you do or don't, we think you'll be glad you learned the concepts first with just enough math to make them clearer.

This course provides plenty of resources beyond the text as well. For example, the interactive figures, interactive tutorials, and demonstration videos on www.masteringphysics.com will help you visualize science concepts, particularly processes that vary over time, such as the velocity of an object in free fall, the phases of the Moon, or the formation of chemical bonds. The activities in the *Laboratory Manual* will build your gut-level feeling for concepts and your analytical skills. Ponder the puzzlers in the *Conceptual Integrated Science Practice Book* and work through the simple review questions—all this will increase your confidence and mastery of science.

As with all things, what you get out of this class depends on what you put into it. So study hard, ask all the questions you need to, and most of all enjoy your scientific tour of the amazing natural world!

To the Instructor

This second edition of *Conceptual Integrated Science* with its important ancillaries provides your students an enjoyable and readable introductory coverage of the natural sciences. As with the previous edition, the 29 chapters are divided into five main parts—Physics, Chemistry, Biology, Earth Science, and Astronomy. We begin with physics, the basic science that provides a foundation for chemistry, which in turn underlies biology, which extends to Earth science and astronomy.

For the nonscience student, this book affords a means of viewing nature perceptively. One can see that a surprisingly few relationships make up its rules, most of which are the laws of physics presented in Part One. Physics laws are nature's secret codes. Here they are expressed both in words and in equation form. We view equations as *guides to thinking*. Even students who shy away from mathematics can learn to read equations to guide their thinking—to see how concepts connect. The symbols in equations are akin to musical notes that guide musicians.

For the science student, this same foundation affords a springboard to further study. For quantitatively oriented students, ample end-of-chapter material provides problem-solving activity through the *Think and Solve* problems.

Physics begins with static equilibrium so that students can start with forces before studying velocity and acceleration. After success with simple forces, the coverage touches lightly on kinematics, enough preparation for Newton's laws of motion. The pace picks up with the conventional order of mechanics topics followed by heat, thermodynamics, electricity and magnetism, sound, and light. Physics chapters lead to the realm of the atom—a bridge to chemistry.

The chemistry chapters begin with a look at the submicroscopic world of the atom, which is described in terms of subatomic particles and the periodic table. Students are then introduced to the atomic nucleus and its relevance to radioactivity, nuclear power, as well as astronomy. Subsequent chemistry chapters follow a traditional approach covering chemical changes, bonding, molecular interactions, and the formation of mixtures. With this foundation students are then set to learn the mechanics of chemical reactions and the behavior of organic compounds. As with previous editions, chemistry is related to the student's familiar world—the fluorine in their toothpaste, the Teflon on their frying pans, and the flavors produced by various organic molecules. The environmental aspects of chemistry are also highlighted—from how our drinking water is purified to how atmospheric carbon dioxide influences the pH of rainwater and our oceans.

The biology section begins by asking—what constitutes life? Each of the first three chapters focuses on a key feature of living things. We begin with a discussion of cells, move on to genes, and finally, tackle evolution and the origin of life. From here, we proceed to an overview of the different kinds of living things found on Earth. This overview is followed by two chapters on humans, our own species. In these chapters, we study the human body and how it works. Finally, we look at ecology, the study of how living organisms interact with their environments.

The Earth science chapters begin with plate tectonics, the theory that establishes the underlying framework of the geosciences. The next chapter is about rocks and

minerals, the principal materials that make up the solid Earth. Then comes a tour of Earth's landforms, surface features, and geography followed by a chapter on surficial processes—those processes of weathering, erosion, and deposition that originate at Earth's surface and shape the planet's contours. Plate tectonics is about Earth's interior, and the chapters on rock, landforms, and surficial processes describe Earth's surface. The next chapter in the sequence rises higher still—into the atmosphere—with weather. The subject of weather is broken down into elements from atmospheric pressure to wind to precipitation that can be learned separately but then applied to complex phenomena such as weather systems. The Earth science unit concludes with a chapter on environmental geology, which is new to the second edition. It provides an updated review of earthquakes, tsunami, hurricanes, volcanic eruptions, and other geologic hazards. Most importantly, it features expanded coverage of our changing climate including extensive discussion of natural and anthropogenic climate change.

The applications of physics, chemistry, biology, and the Earth sciences applied to other massive bodies in the universe culminate in Part Five—astronomy. This unit introduces the basic structure of the universe from our local solar system and the stars we see at night to galaxies and superclusters of galaxies. Focus is given to modern theories describing how this structure evolved and is continuing to evolve. Many recent discoveries are featured in this edition, illustrating that science is more than a growing body of knowledge; it is an arena in which humans actively and systematically reach out to learn more about our place in the universe.

What's New to This Edition

Conceptual Integrated Science now comes with a powerful media package including **MasteringPhysics®**, the most widely used, educationally proven, and technologically advanced tutorial and homework system available.

MasteringPhysics®
www.masteringphysics.com

MasteringPhysics contains:

- A **library of assignable and automatically graded content** , including tutorials, visual activities, end-of-chapter problems, and test bank questions so instructors can create the most effective homework assignments with just a few clicks. A **color-coded gradebook** instantly identifies vulnerable students or topic areas that are challenging for students in the class.
- **A student study area** with practice quizzes, Interactive Figures, self-guided tutorials, flashcards, videos, access to the Pearson eText version of the book, and more.
- An **instructor resources section** with PowerPoint lectures, clicker questions, Instructor Manual files and more.

Another significant revision for this second edition lies with the development of the end-of-chapter review. New questions were added while older ones were either discarded or reworded for improved quality. All questions were then organized following Bloom's taxonomy of learning as follows:

Summary of Terms (Knowledge)
These key terms match the definitions given within the chapter and are now listed in alphabetical order so that they appear as a mini-glossary for the chapter.

Reading Check Questions (Comprehension)

These questions frame the important ideas of each section in the chapter. They are for review and a check of reading comprehension. They are simple questions and all answers can easily be discovered in the chapter.

Think Integrated Science

Questions pertaining to the Integrated Science sections of each chapter are contained in this section. Questions range from straightforward, reading-check type questions to critical-thinking exercises.

Think and Do (Hands-On Application)

The Think and Do items are easy-to-perform hands-on activities designed to help students experience physical science concepts for themselves.

Think and Solve (Mathematical Application)

The *Think and Solve* questions blend simple mathematics with concepts. They allow students to apply problem-solving techniques, many of which are featured in the Math Connection boxed features.

Think and Rank (Analysis)

The *Think and Rank* questions ask students to make comparisons of quantities. For example, when asked to rank quantities such as momentum or kinetic energy, appreciably more judgment is called for than in providing numerical answers. Some *Think and Rank* analyze trends, as in ranking atoms in order of increasing size based upon student understanding of the periodic table. This feature elicits critical thinking that goes beyond *Think and Solve*.

Think and Explain (Synthesis)

The *Think and Explain* questions, by a notch or two, are the more challenging questions at the end of each chapter. Many require critical thinking while others are designed to prompt the application of science to everyday situations. All students wanting to perform well on exams should be directed to the *Exercises* because these are the questions that directly assess student understanding. Accordingly, many of the *Exercises* have been adapted to a multiple-choice format and integrated into the *Conceptual Integrated Science, 2e* test bank. This will hopefully allow the instructor to reward those students who put time and effort into the *Exercises*.

Think and Discuss (Evaluation)

The *Think and Discuss* topics provide students the opportunity to apply science concepts to real-life situations, such as whether a cup of hot coffee served to you in a restaurant cools faster when cream is added promptly or a few minutes later. Other discussion questions allow students to present their educated opinions on a number of science-related hot topics, such as the appearance of pharmaceuticals in drinking water.

Readiness Assurance Test

Each chapter review concludes with a set of 10 multiple choice questions that students can take for self-assessment. They are advised to study further if they score less than 7 correct answers.

Also new to this edition, are the solutions to the odd-numbered end-of-chapter questions in the back of this book. As before, solutions to all end-of-chapter questions are available to instructors through the Instructor Manual for *Conceptual Integrated Science*, which is found in the Instructor Resource Center and in the Instructor Resource area of MasteringPhysics.

This second edition features a new and, we think, refreshing page layout design. Integrated into this design are **learning objectives** that appear alongside each chapter section head. Each learning objective begins with an active verb that specifies what the student should be able to do after studying that section, such as "Calculate the energy released by a chemical reaction." These section-specific learning objectives are further integrated into the new MasteringPhysics online tutorial/assessment tool.

Also within the design, appearing beneath each section head is another new feature, which we call an **"Explain This"** question. An ET question would be fairly difficult for the student to answer without having read the chapter section. Some require that the student recall earlier material. Others reveal interesting applications of concepts. In all cases the ET question should serve well as a launching point for classroom discussions. The answers to these ET questions appear only within the Instructor Manual.

The text of all chapters has been edited for accuracy, better readability and also updated to reflect current events, such as the nuclear power plant disaster following the 2011 Japanese earthquake and tsunami, and the discovery of Fermi clouds arising from the center of our Milky Way galaxy.

The scope and sequence of chapters is revised for this second edition. The material on the atom has been folded into the chemistry unit so that the atomic theory is explained at the point of use. The Earth science material has been reorganized such that the geography material is now separated from the discussion of surficial processes, allowing for more discussion of the oceans. A chapter on Historical Geology was eliminated with the most important concepts (such as the geologic time scale, Cretaceous extinction, and the nature of the rock record) being integrated into other chapters. The elimination of Historical Geology allowed the new chapter on Environmental Geology to be added with in-depth coverage of climate change. In Part Four—Astronomy, aside from updates from recent discoveries, the first section of Chapter 28 has been heavily revised in its presentation of nebular theory and the second chapter of this unit is expanded greatly to include discussions of cosmology.

Ancillary Materials

MasteringPhysics®
www.masteringphysics.com

Most significantly, *Conceptual Integrated Science* is now available with MasteringPhysics—a homework, tutorial, and assessment system based on years of research into how students work problems and precisely where they need help. Studies show that students who use MasteringPhysics significantly increase their scores compared to hand-written homework. MasteringPhysics achieves this improvement by providing students with instantaneous feedback specific to their wrong answers and simpler sub-problems upon request when they get stuck. Instructors can also assign End-of-Chapter (EOC) problems from every chapter including multiple-choice questions, section-specific exercises, and general problems. Quantitative problems can be assigned with numerical answers and randomized values or solutions.

The Pearson eText of *Conceptual Integrated Science* is available through MasteringPhysics. Allowing students access to the text wherever they have access to the Internet, the Pearson eText comprises the full text, including figures that can be enlarged for better viewing, popup definitions and terms, a note-taking feature, and more.

Tutorial video lessons and screencasts featuring the authors are now freely available to students at ConceptualAcademy.org. This is a must-visit website for any student who needs a bit of extra help and it is also a great tool for the online component of any course. Many author-created resources for the instructor are also available on this website, which is a great place to communicate directly with the authors as well as other instructors using *Conceptual Integrated Science*.

The ***Instructor Manual for Conceptual Integrated Science*** (ISBN 0-321-82743-0), which you'll find to be different from most instructors' manuals, allows for a variety of course designs to fit your taste. It contains many lecture ideas and topics not treated in the textbook as well as teaching tips and suggested step-by-step lectures and demonstrations. It has full-page answers to all the end of chapter material in the text.

The ***Conceptual Integrated Science Practice Book*** (ISBN 0-321-82298-6), our most creative work, guides your students to a sometimes computational way of developing concepts. It spans a wide use of analogies and intriguing situations, all with a user-friendly tone.

The ***Test Bank for Conceptual Integrated Science*** (ISBN 0-321-82276-5) has more than 2400 multiple choice questions as well as short answer and essay questions. The questions are categorized according to level of difficulty. The Test Bank allows you to edit questions, add questions, and create multiple test versions.

The ***Laboratory Manual for Conceptual Integrated Science*** (ISBN 0-321-82297-8) is written by the authors and Dean Baird. In addition to interesting laboratory experiments, it includes a range of activities similar to the activities in the textbook. These guide students to experience phenomena before they quantify the same phenomena in a follow-up laboratory experiment. Answers to the lab manual questions are in the Instructor Manual.

Another valuable media resource available to you is the ***Instructor Resource DVD for Conceptual Integrated Science*** (ISBN 0-321-82744-9). This cross-platform DVD set provides instructors with the largest library available of purpose-built, in-class presentation materials, including all the images from the book in high-resolution JPEG format; interactive figures™ and videos; PowerPoint® lecture outlines and clicker questions in PRS-enabled format for each chapter, all of which are written by the authors; and Hewitt's acclaimed Next-Time Questions in PDF format. The *Instructor Resource DVD* provides you with everything you need to prepare for dynamic, engaging lectures in no time.

Go to it! Your conceptual integrated science course really can be the most interesting, informative, and worthwhile science course your students will ever take.

Acknowledgments

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We thank all the contributors to the first and second editions of *Conceptual Integrated Science*, as well as the many people who contributed to the other books in the *Conceptual* series: *Conceptual Physics*, *Conceptual Chemistry*, *Conceptual Physical Science*, and *Conceptual Integrated Science—Explorations*. For helping to shape the physics content over the years, in the student editions as well as our many supplements, we thank: Dean Baird, Tsing Bardin, Howie Brand, Alexi Cogan, Paul Doherty, Marshall Ellenstein, Ken Ford, Lillian Lee Hewitt, Jim Hicks, David Housden, John Hubisz, Will Maynez, Fred Myers, Bruce Novak, Ron Perkins, Diane Reindeau, David Williamson, Larry Weinstein, Phil Wolf, and Dean Zollman.

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The *Conceptual Integrated Science* authors are fortunate to have helpful and loving spouses who have supported us through the long hours and contributed to our efforts. Thanks go to Lillian Lee Hewitt, Pete Lang (Suzanne's husband), Tracy Suchocki, and Nils Gilman (Jennifer's husband). And to our kids, ranging now from preschool to high school, we send our love and gratitude: Tristan and Simone Lyons Lang; Ian, Evan, and Maitreya Suchocki; and Io, Pico, and Daphne Yeh Gilman.

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