

A person wearing a light blue cap and a red life vest is seen from behind, paddling a red and yellow kayak on a calm lake. The water reflects the surrounding landscape, which includes dark, forested hills and distant, snow-capped mountains under a pale sky. The overall mood is peaceful and scenic.

JOHN W. HILL
DORIS K. KOLB

CHEMISTRY

for Changing Times

NINTH EDITION

Chemistry for Changing Times

NINTH EDITION

John W. Hill

University of Wisconsin–River Falls

Doris K. Kolb

Bradley University



PRENTICE HALL
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Preface

Chemistry for Changing Times is now in its ninth edition. Times have indeed changed since the first edition appeared in 1972, and the book has changed accordingly. Our knowledge base has expanded enormously since that first edition, yet we have resisted the pressure to increase the size of the book. This has forced us to make some tough choices in deciding what to include and what to leave out. We live in what has been called the “information age.” Our main focus, therefore, is not so much on providing information as it is on helping students evaluate that information.

We believe that a chemistry course for students who are not majoring in science should be quite different from the course we offer our science majors. It should present basic chemical concepts with intellectual honesty, but it should not focus on esoteric theories or rigorous mathematics. It should include lots of modern everyday applications. The textbook should be appealing to look at, easy to understand, and interesting to read.

Three-fourths of the legislation considered by the U. S. Congress involves questions having to do with science or technology, yet only rarely does a scientist or engineer enter politics. Most of the people who make important decisions regarding our health and our environment are not trained in science, but it is critical that these decision makers are scientifically literate. A chemistry course for students who are not science majors should emphasize practical applications of chemistry to problems involving such things as environmental pollution, radioactivity, energy sources, and human health. The students who take our liberal arts chemistry courses include future teachers, lawyers, accountants, journalists, and judges. There are probably some future legislators, too.

Objectives

Our main objectives in a chemistry course for students who are not majoring in science are as follows:

- To attract as many students as possible. If students are not enrolled in the course, we can't teach them.
- To use topics of current interest to illustrate chemical principles. We want students to appreciate the importance of chemistry in the real world.
- To relate chemical problems to the everyday lives of our students. Chemical problems seem more significant to students if they can see a personal connection.
- To instill in students an appreciation for chemistry as an open-ended learning experience. We hope that our students will want to continue learning throughout their lives.
- To acquaint students with scientific methods. We want students to be able to read about science and technology with some degree of critical judgment.
- To help students become literate in science. We want our students to develop a comfortable knowledge of science so that they find news articles relating to science interesting rather than intimidating.

New Features in the Ninth Edition

In response to suggestions from users and reviewers of the eighth edition, as well as using our own writing and teaching experience, we have thoroughly updated all the text to reflect the latest scientific knowledge. The organization of the 20 chapters remains much the same as in the eighth edition. The major exception lies within Chapters 5 and 6.

Changes in Content

Some of the more important changes are as follows:

- Chapter 6 was substantially revised and has a new title, “Chemical Accounting: Mass and Volume Relationships.” We have concentrated much of the quantitative material in this one chapter.
- We moved the sections on naming chemical compounds from Chapter 6 to Chapter 5.
- We moved the kinetic-molecular theory from Chapter 5 to Chapter 6.
- At the request of several users and reviewers, we have added a new section (Section 6.7) on solutions. This addition includes new worked-out examples, exercises, and end-of-chapter problems.
- We revised much of the early treatment of acid-base chemistry (Chapter 7), making the Brønsted–Lowry treatment more explicit.
- We added a discussion of half-reactions in Chapter 7, with new worked-out examples, exercises, and end-of-chapter problems.
- We added a brief discussion of IUPAC naming in Chapter 9.
- In Chapter 13 we added a brief subsection, “Calculations of Parts per Billion,” including a new worked-out example and end-of-chapter problems.
- We have added new tables and reorganized others. New tables include Physical Properties, Chemical Properties, Potential Energy, and Kinetic Energy (Chapter 1); Mendeleev’s Original Periodic Table (Chapter 2); Types of Radiation, Differences Between Chemical and Nuclear Reactions, and Symbols for Subatomic Particles (Chapter 4).

Additions to Pedagogy

The following changes have been made to strengthen and improve the pedagogy in this edition.

- We follow worked-out examples by A and B exercises in some cases. The B exercise is intended to be a bit more challenging, often requiring a knowledge of material from earlier in the book.
- To improve the organization of the text, we use superheads in some chapters.
- We use voice balloons in problem solving to carefully guide the student through the process and thus improve the pedagogy.
- Focusing on the importance of providing interesting, relevant applications, we have added several new box features: Cost-Benefit Analysis and Health Care and Body Temperature, Hypothermia, and Hyperthermia (Fever) (Chapter 1); What a Difference an O Makes, and Recycling (Chapter 2); What Makes for Nuclear Stability? (Chapter 4); Who’s Number Is It Anyway? (Chapter 6); Conducting Polymers: Polyacetylene (Chapter 10); Asbestos: Risks and Benefits (Chapter 11); Air Pollution in China, An Air Pollution Episode: London, England, and Wood Smoke (Chapter 12); and Entropy (Chapter 14).

- We have updated the References and Readings at the end of each chapter.
- We continue to include Critical Thinking exercises at the end of each chapter.
- We have chosen several new photographs and produced new diagrams to improve the pedagogy and the visual appeal of the book.

Web-Related Activities

- For this ninth edition, we have added 12 MediaLabs, which are spread throughout the text and placed appropriately after the chapter to which they relate. Examples include: Chapter 9 MediaLab—Fragrances: Stop and Smell the Roses, Chapter 15 MediaLab—Genetic Recombination—Promise or Peril?, and Chapter 18 MediaLab—Keeping Fit or Overexerting? These MediaLabs help tie the chapter topics to current events and use the power of the internet to explore those events.
- For this ninth edition, a major change is that we have added web references with brief descriptions as margin notes within each chapter. They can be accessed through the *Chemistry for Changing Times World Wide Web Center* (<http://www.prenhall.com/hillkolb>).
- We have also added interesting Online Projects at the end of each chapter that may be assigned as a collaborative group or individual activity.

Use of Color

New color photographs and diagrams have been added. Visual material adds greatly to the general appeal of a textbook. Color diagrams can also be highly instructive, and colorful photographs relating to descriptive chemistry do much to enhance the learning process.

Readability

Over the years, students have told us that they have found this textbook easy to read. The language is simple, and the style is conversational. Explanations are clear and easy to understand. The friendly tone of the book has been maintained in this edition.

Units of Measurement

The United States continues to cling to the traditional English system for many kinds of measurement even though the metric system has long been used internationally. A modern version of the metric system, the *Système International* (SI), is now widely used, especially by scientists. So what units should be used in a text for liberal arts students? In presenting chemical principles, we use primarily metric units. In other parts of the book we use those units that the students are most likely to encounter elsewhere in the same context.

Chemical Structures

The structures of many complicated molecules are presented in the text, especially in the later chapters. These structures are presented mainly to emphasize that they are actually known and to illustrate the fact that substances with similar properties often have similar structures. Students should not feel that they must learn all these structures, but they should take the time to look at them. We hope that they will come to recognize familiar features in these molecules.

Glossary

The Glossary (Appendix B) gives definitions of terms that appear in boldface throughout the text. These terms include all key terms listed at the end of each chapter.

Questions and Problems

The end-of-chapter exercises include review questions, a set of matched-pair problems, and suggested projects and online projects. Answers to many review questions and to all the odd-numbered problems are given in Appendix C. Problems are given within some of the chapters, with worked-out examples followed by similar exercises. Answers to all the in-chapter exercises are also given in Appendix C.

References and Suggested Readings

An updated list of recommended books and articles appears at the end of each chapter. A student whose interest has been sparked by a topic can delve more deeply into the subject in the library. Instructors might also find these lists useful.

Supplementary Materials

The most important learning aid is the teacher. In order to make the instructor's job easier and enrich the education of students, we have provided a variety of supplementary materials.

Print Resources for Students

Student Study Guide (0-13-087497-3) by John W. Hill of University of Wisconsin–River Falls and Richard Jones of Sinclair Community College. This book assists students through the text material and contains learning objectives, chapter outlines, key terms, and additional problems along with self-tests and answers.

Chemical Investigations for Changing Times, Ninth Edition (0-13-087499-X) by Alton C. Hassell and Paula Marshall. Contains 44 laboratory experiments and is specifically referenced to *Chemistry for Changing Times*. An *Instructor's Manual* (0-13-087491-4) prepared by Paula Marshall is also available.

New York Times Themes of the Times. This newspaper-format offprint uses current chemistry-related articles to emphasize the importance and relevance of chemistry in our lives. (Free in quantity to qualified adopters.)

Print Resources for Instructors

Instructor's Resource Manual (0-13-087480-9) by Paul Karr of Wayne State College. This useful guide describes all the different resources available to instructors and shows how to integrate them into your course. Organized by chapter, this manual offers lecture outlines, answers and solutions to all questions and problems that are not answered by the authors in the answer appendix, suggested in-class demonstrations recommended by Doris Kolb, and other suggested resources. The lecture outline is also available in an electronic format.

Instructor's Manual for Chemical Investigations for Changing Times (0-13-087491-4) by Paula Marshall. This laboratory manual reference includes notes for experiments, safety regulations, procedural instructions, and specifications for equipment and supplies.

Transparencies (0-13-087492-2) This set contains 150 full-color acetates.

Test Item File (0-13-089605-5) by William D. Scott, III, University of Mississippi. Contains over 1800 multiple-choice questions that are referenced to the text.

Media Resources for Students

Chemistry for Changing Times World Wide Web Center (<http://www.prenhall.com/hillkolb>). This user-friendly site emphasizes that chemistry is an open-ended learning experience, with both interesting applications in our daily lives and exciting new developments. The site features the online versions of MediaLabs in this book, where students are encouraged to do web-based investigations on a topic and then communicate their results in a report. In addition, the links featured in the margins of the text are maintained on this site. Finally, the site also features interactive quizzes with carefully crafted hints and specific feedback that can be assigned in an online syllabus and submitted directly to the student's professor or a teaching assistant via e-mail.

Media Resources for Instructors

Matter 2001: Instructor Presentation CD (coming late fall 2000). This dual-platform presentation CD includes art from the textbook, as well as animations and video clips selected to be appropriate for each chapter. Build a presentation in your office, carry the CD and a small presentation file to your classroom, and use our high-quality images to enhance your lecture.

Course Management Options. Prentice Hall offers a variety of online course management options to suit your needs. The Companion Website comes also in a *Companion Website Plus* version, which includes online tracking of the performance by the students in your class on their online assignments, plus broadcast messaging, all tied to a calendar-driven syllabus. For schools interested in using *WebCT* or *Blackboard*, we offer complete, enhanced website content for use in these powerful course management tools (available late fall 2000).

Computerized Prentice Hall Custom Test. This computerized version of the *Test Item File*, available for both Windows and Macintosh, includes electronic versions of all 1800 test questions as well as the latest Prentice Hall Test Manager Software. Test Manager allows you to create and tailor exams to your own needs and includes tools for course management, algorithmic question generation, and offering tests over a local network. *Windows* (0-13-087498-1); *Macintosh* (0-13-087496-5)

Acknowledgments

Through the last quarter century we have greatly benefited from hundreds of helpful reviews. It would take far too many pages to list all of those reviewers here. Many of you have contributed to the flavor of the book and helped us minimize our errors. Please know that your contributions are deeply appreciated. For the eighth and ninth editions, we are grateful for challenging reviews from:

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Cynthia S. Hill prepared much of the original material on biochemistry, food, and health and fitness.

Four of the verses that appear in this volume were first published in the *Journal of Chemical Education*. We acknowledge, with thanks, the permission to reprint them here. Doris Kolb wrote those verses plus all of the others, including the chapter openers.

We also want to thank our colleagues at the University of Wisconsin–River Falls and Bradley University for all their help and support.

We have been blessed with a team of careful and considerate editors. We especially appreciate all the help we have received from our senior editor, Kent Porter-Hamann. Mary Ginsburg, our development editor, has been a marvelous help in so many ways. Our outstanding production editor, Nicole Bush, has been especially helpful in guiding the book through the putting-it-together process.

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Finally, we also thank all those many students whose enthusiasm has made teaching such a joy. It is gratifying to have students learn what you are trying to teach them, but it is a supreme pleasure to find that they want to learn even more. Finally, we want to thank all of you who have made so many helpful suggestions. We welcome and appreciate all your comments, corrections, and criticisms.

J. W. H.

D. K. K.

To the Student

Welcome to Our Chemical World!

Chemistry is fun. Through this book, we would like to share with you some of the excitement of chemistry and some of the joy of learning about it. We hope to convince you that chemistry does not need to be excluded from your learning experiences. Learning chemistry will enrich your life—now and long after this course is over—through a better understanding of the natural world, the technological questions now confronting us, and the choices we must face as citizens within a scientific and technological society.

Chemistry Directly Affects Our Lives

How does the human body work? How does aspirin cure our headaches? Do steroids enhance athletic ability? Is table salt poisonous? Can scientists cure genetic diseases? Why do most weight-loss diets seem to work in the short run but fail in the long run? Does fasting cleanse the body? Why do our moods swing from happy to sad? Can a chemical test on urine predict possible suicide attempts? How does penicillin kill bacteria without harming our healthy body cells? Chemists have found answers to questions such as these and continue to seek the knowledge that will unlock still other secrets of our universe. As these mysteries are resolved, the direction of our lives often changes—sometimes dramatically. We live in a chemical world—a world of drugs, biocides, food additives, fertilizers, detergents, cosmetics, and plastics. We live in a world with toxic wastes, polluted air and water, and dwindling petroleum reserves. Knowledge of chemistry will help to better understand the benefits and hazards of this world and will enable you to make intelligent decisions in the future.

Chemical Dependency

We are all chemically dependent. Even in the womb we depend on a constant supply of oxygen, water, glucose, and a multitude of other chemicals.

Our bodies are intricate chemical factories. They are durable but delicate systems. Innumerable chemical reactions that allow our bodies to function properly are constantly taking place within us. Thinking, learning, exercising, feeling happy or sad, putting on too much weight or not gaining enough, and virtually all life processes are made possible by these chemical reactions. Everything that we ingest is part of a complex process that determines whether our bodies work effectively or not. The consumption of some substances can initiate chemical reactions that will stop body functions altogether. Other substances, if consumed, can cause permanent handicaps, and still others can make living less comfortable. A proper balance of the right foods provides the chemicals and generates the reactions we need in order to function at our best. The knowledge of chemistry that you will soon be gaining will help you better understand how your body works so that you will be able to take proper care of it.

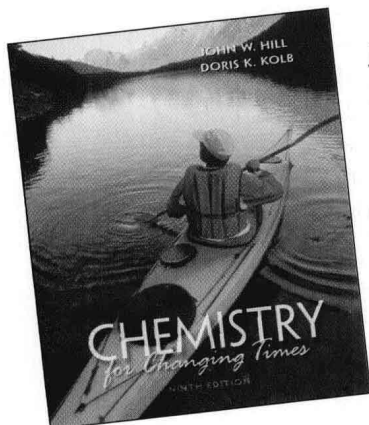
Changing Times

We live in a world of increasingly rapid change. It has been said that the only constant is change itself. At present, we are facing some of the greatest problems that humans have ever encountered, and the dilemmas with which we are now confronted seem to have no perfect solutions. We are sometimes forced to make a best choice among only bad alternatives, and our decisions often provide only temporary solutions to our problems. Nevertheless, if we are to choose properly, we must understand what our choices are. Mistakes can be costly, and they cannot always be rectified. It is easy to pollute, but cleaning up pollution once it is there is enormously expensive. We can best avoid mistakes by collecting as much information as possible before making critical decisions. Science is a means of gathering and evaluating information, and chemistry is central to all the sciences.

Chemistry and the Human Condition

Above all else, our hope is that you will learn that the study of chemistry need not be dull and difficult. Rather, it can enrich your life in so many ways—through a better understanding of your body, your mind, your environment, and the world in which you live. After all, the search to understand the universe is an essential part of what it means to be human.

Student Media Resources

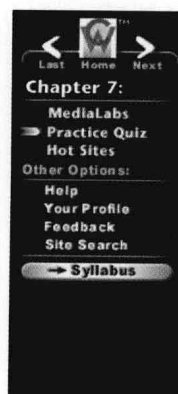


John Hill and Doris Kolb have written *Chemistry for Changing Times* with an emphasis on connecting our world to the chemistry that is all around us. In doing so, they have made chemistry exciting and interesting for thousands of students.

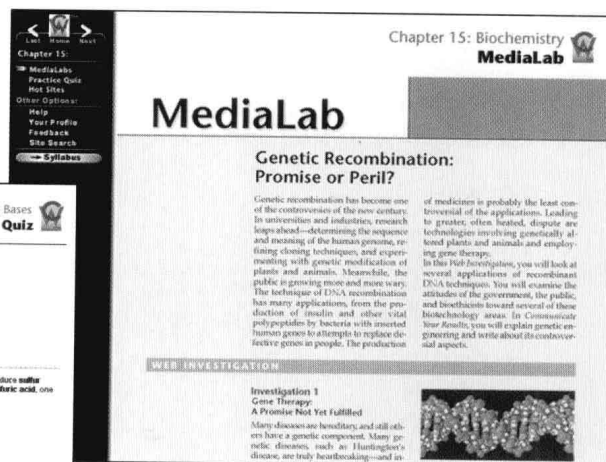
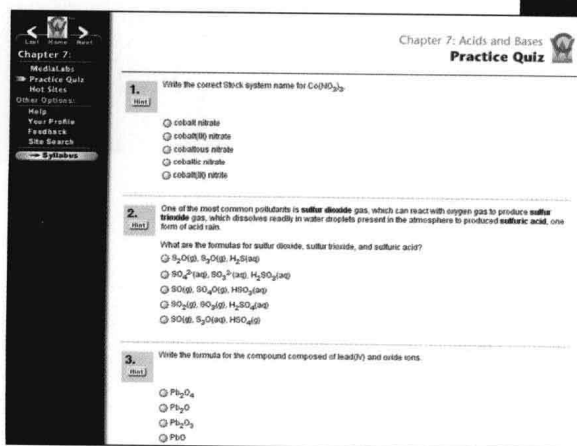
The advantages of media present innumerable educational opportunities. By using Prentice Hall's *Companion Website* technology and in-text MediaLabs, the authors link key chapter concepts to websites and other Internet resources that will expand your study. The next two pages explain how to use these integrated, innovative resources to enhance your understanding of chemistry.

How to Access the Companion Website

You can access the Companion Website (CW) for *Chemistry for Changing Times*, ninth edition by using a standard web browser such as Internet Explorer or Netscape, by typing in the URL www.prenhall.com/hillkolb. No password is needed and you may use this site for free with the purchase of the ninth edition.



◀ The MediaLabs in the ninth edition are live on the **Companion Website** and provide current and maintained links for your investigations. Web References and Online Projects are also made live in the Hot Sites sections. Also, you can test your understanding by using the Practice Quiz for each chapter.



MediaLab

Genetic Recombination: Promise or Peril?

Genetic recombination has become one of the controversies of the new century. In universities and industries, research leaps ahead—determining the sequence and meaning of the human genome, refining cloning techniques, and experimenting with genetic modification of plants and animals. Meanwhile, the public is growing more and more wary. The technique of DNA recombination has many applications, from the production of insulin and other vital polypeptides by bacteria with inserted human genes to attempts to replace defective genes in people. The production

of medicines is probably the least controversial of the applications. Leading to greater, often heated, dispute are technologies involving genetically altered plants and animals and employing gene therapy. In this *Web Investigation*, you will look at several applications of recombinant DNA techniques. You will examine the attitudes of the government, the public, and bioethicists toward several of these biotechnology areas. In *Communicate Your Results*, you will explain genetic engineering and write about its controversial aspects.

WEB INVESTIGATION

Investigation 1 Gene Therapy: A Promise Not Yet Fulfilled

Many diseases are hereditary, and still others have a genetic component. Many genetic diseases, such as Huntington's disease, are truly heartbreaking—and inescapable for the person inheriting the gene. Thus, great excitement has accompanied each report of apparently successful gene therapy trials. However, though the concept of injecting replacement genes seems straightforward, many obstacles lie in the way, including the body's own defenses against intruders. Select Keyword **THERAPY** for a look at early successes and disappointments. This site also has a nice animated illustration of the technique. Select Keyword **NEWS** for current news and bioethical debates. (Read what seems interesting and relevant at this site.)

Investigation 2 A New Gene in My Food?

Some of the fiercest reactions from the public, particularly in Europe, have



arisen in response to genetic engineering of various foods. For centuries, people have improved plants and animals by selective breeding. Sometimes, however, breeding for one trait has diminished another desirable attribute. Genetic engineering, however, speeds up the process and enables the insertion of totally new genes, such as genes for selective pest resistance. Select Keyword **FARMING** to read about the benefits of biotechnology in farming and to explore the concerns some people have about it. For an interesting account of the use of gene transfer to protect plants against pests, select Keyword **PLANTS**.

MediaLabs

Throughout the ninth edition, the authors have included **MediaLabs**. These pages cover interesting topics and tie the text discussion to the CW, where a more detailed discussion of the topic can be found. Students are prompted when to access a given website and are given questions to answers. By reading the MediaLabs and completing the exercises provided, students learn chemistry by discovering the answers for themselves, not by just reading about them.

Investigation 3 Cloning: Techniques and Ethics

Among the most controversial topics in genetic engineering is that of cloning. Since Dolly the sheep was created in 1997 by the nuclear replacement technique, interest has focused on the possibility of cloning human beings, and governments around the world have attempted to legislate limits. For a clear but lengthy description of the cloning technique, select Keyword **CLONING**. This British document discusses potential benefits and perils of cloning and related genetic research and technology. It also includes a glossary of genetic engineering terms and a brief overview of national laws concerning



Dolly and Her Surrogate Mother

human cloning. If you wish to see a list of U.S. federal bills, with links to transcripts, select Keyword **BILLS**.

COMMUNICATE YOUR RESULTS

Exercise 1 Risk-Benefit Ratio

Little controversy exists over the use of recombinant methods to produce human insulin, growth hormone, and other essential medications. Is this because people realize that in these cases the benefits of the drugs are worth any perceived risk from genetic engineering? List some benefits of current recombinant DNA techniques, primarily as used in human medicine, and discuss any accompanying risks in terms of these benefits.

Exercise 2 Cloning: Benefits and Pitfalls

Looking at *Web Investigation 3*, discuss the potential benefits and ethical pitfalls of genetic engineering in general and vertebrate cloning in particular. For this discussion, concentrate on techniques used in animals. What are some potential benefits to agriculture? Are these worth less risk than medical applications? Should the risks dictate a "go slow" approach, or lead to an outright ban of some applications?

Exercise 3 Bioethics and the Law

In the not-so-distant past, scientists generally regulated themselves, enforcing intellectual integrity by the peer review process. Sometimes they seem to have given little thought to the impact of their findings on society. With an accelerated pace of research and development, including genetic recombination, is this sufficient? Drawing on the *Web Investigations* and any other resources you wish to use, discuss the role of law in regulating the course of biotechnical endeavors. (You might evaluate the degree to which scientific research has moved from academic laboratories into the realm of big business. Does this make federal controls more essential?)

Exercise 4 It's in the Genes

To what degree is the fear of genetic engineering due to the fact that it involves the *genes*—the "stuff of life"—and the concern that any changes will be passed on to future generations? How much concern is due to the fact that many technological advances in the past (DDT, for example) had hidden costs? Write an op-ed article on this topic.

MediaLab Features

- The MediaLabs start with an introduction to the topic under discussion.
- The *Web Investigation* sections provide thought-provoking issues and questions that you can explore by using the text's Companion Website.
- The *Communicate Your Results* sections give you the opportunity to answer questions about the topics you have investigated.

[Web Reference 1]
www.Friedrich-Wöhler's 1828 report on his synthesis of urea from inorganic materials can be read.

◀ **Web References** in the margin of the book prompt you to research specific key concepts using the Companion Website.

Online Projects at the end of the chapters provide you the opportunity to further investigate and answer questions on a high-interest topic using the web address provided.

Online Projects

71. The theory that organic chemistry was the chemistry of living organisms, which was overturned by Wöhler's discovery in 1828, was known as vitalism. What was the effect of this philosophy on areas outside chemistry. You

might begin your research at <http://www.rit.edu/~flw-stv/biology.html>, which has a long but interesting history of vitalism, biology, and the origin of life.

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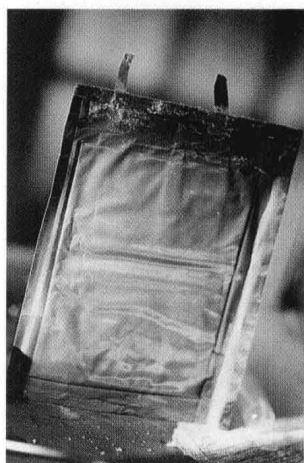
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MediaLabs

Each of the twelve MediaLabs is introduced to the student in a two-page spread after appropriate chapters throughout the textbook. The topics have been carefully chosen not only to interest students but also to focus on information that is timely and relevant in daily life. All of the necessary background information is included in the text. Once the student accesses the Companion Website, the static investigations and exercises become a dynamic and exciting discovery activity for students to actively participate in and report on individually or in groups.

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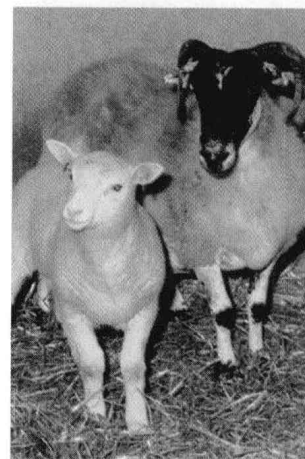
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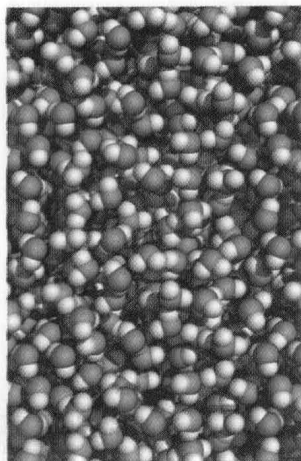
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