



**HOLT  
SCIENCE &  
TECHNOLOGY**

# Physical Science



**Includes Student  
LabBook**





**HOLT  
SCIENCE &  
TECHNOLOGY**

Physical  
Science



**HOLT, RINEHART AND WINSTON**

A Harcourt Classroom Education Company

Austin • New York • Orlando • Atlanta • San Francisco • Boston • Dallas • Toronto • London



# Staff Credits

## Editorial

Robert W. Todd, Executive Editor  
David F. Bowman, Managing Editor  
Anne Engelking, Senior Editor  
Michael Mazza, Editor  
Amy James, Ken Shepardson,  
Robin Goodman (Feature Articles)

## ANNOTATED TEACHER'S EDITION

Ken Shepardson, Amy James,  
Michael Mazza, Kelly Rizk,  
Bill Burnside

## ANCILLARIES

Jennifer Childers, Senior Editor  
Chris Colby, Kristen Falk, Molly  
Frohlich, Robin Goodman,  
Shari Husain, Monique Mayer,  
Kristen McCardel, Sabelyn  
Pussman, Erin Roberson

## COPYEDITORS

Dawn Spinozza, Copyediting  
Supervisor  
Brooke Fugitt, Kathryn  
O'Shields, Cindy Foreman

## EDITORIAL SUPPORT STAFF

Jeanne Graham, Rose Segrest,  
Tanu'e White

## EDITORIAL PERMISSIONS

Cathy Paré, Permissions Manager  
Jan Harrington, Permissions  
Editor

## Art, Design, and Photo

### BOOK DESIGN

Richard Metzger, Design Director  
Marc Cooper, Senior Designer  
Ron Bowdoin, Designer  
Alicia Sullivan, Designer (ATE),  
Cristina Bowerman, Design  
Associate (ATE), Eric Rupprath,  
Designer (Ancillaries)

### IMAGE ACQUISITIONS

Joe London, Director  
Elaine Tate, Art Buyer Supervisor  
Sean Moynihan, Art Buyer  
Tim Taylor, Photo Research  
Supervisor  
Stephanie Morris, Assistant  
Photo Researcher

### PHOTO STUDIO

Sam Dudgeon, Senior Staff  
Photographer  
Victoria Smith, Photo Specialist  
Lauren Eischen, Photo  
Coordinator

### DESIGN NEW MEDIA

Susan Michael, Design Director

### DESIGN MEDIA

Joe Melomo, Design Director

## Production

Mimi Stockdell, Senior  
Production Manager  
Beth Sample, Production  
Coordinator  
Suzanne Brooks, Sara Carroll-  
Downs

## Media Production

Kim A. Scott, Senior Production  
Manager  
Nancy Hargis, Production  
Supervisor  
Adriana Bardin, Production  
Coordinator

## New Media

Jim Bruno, Senior Project  
Manager II  
Lydia Doty, Senior Project  
Manager  
Jessica Bega, Project Manager  
Armin Gutzmer, Manager  
Training and Technical Support  
Cathy Kuhles, Nina Degollado,  
Technical Assistants

## Design Implementation and Production

Preface, Inc.

Copyright © 2001 by Holt, Rinehart and Winston

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher.

Requests for permission to make copies of any part of the work should be mailed to the following address: Permissions Department, Holt, Rinehart and Winston, 1120 South Capital of Texas Highway, Austin, Texas 78746-6487.

For permission to reprint copyrighted material, grateful acknowledgment is made to the following source: *sciLINKS* is owned and provided by the National Science Teachers Association. All rights reserved.

Printed in the United States of America  
ISBN 0-03-051957-8  
4 5 6 7 048 05 04 03 02 01



# Acknowledgments

## Chapter Writers

### Christie Borgford, Ph.D.

*Professor of Chemistry*  
University of Alabama  
Birmingham, Alabama

### Andrew Champagne

*Former Physics Teacher*  
Ashland High School  
Ashland, Massachusetts

### Mapi Cuevas, Ph.D.

*Professor of Chemistry*  
Santa Fe Community College  
Gainesville, Florida

### Leila Dumas

*Former Physics Teacher*  
LBJ Science Academy  
Austin, Texas

### William G. Lamb, Ph.D.

*Science Teacher and Dept. Chair*  
Oregon Episcopal School  
Portland, Oregon

### Sally Ann Vonderbrink, Ph.D.

*Chemistry Teacher*  
St. Xavier High School  
Cincinnati, Ohio

## Lab Writers

### Phillip G. Bunce

*Former Physics Teacher*  
Bowie High School  
Austin, Texas

### Kenneth E. Creese

*Science Teacher*  
White Mountain Junior High  
School  
Rock Springs, Wyoming

### William G. Lamb, Ph.D.

*Science Teacher and Dept. Chair*  
Oregon Episcopal School  
Portland, Oregon

### Alyson Mike

*Science Teacher*  
East Valley Middle School  
East Helena, Montana

### Joseph W. Price

*Science Teacher and Dept. Chair*  
H. M. Browne Junior High  
School  
Washington, D.C.

### Denice Lee Sandefur

*Science Teacher and Dept. Chair*  
Nucla High School  
Nucla, Colorado

### John Spadafino

*Mathematics and Physics  
Teacher*  
Hackensack High School  
Hackensack, New Jersey

### Walter Woolbaugh

*Science Teacher*  
Manhattan Junior High School  
Manhattan, Montana

## Academic Reviewers

### Paul R. Berman, Ph.D.

*Professor of Physics*  
University of Michigan  
Ann Arbor, Michigan

### Russell M. Brengelman, Ph.D.

*Professor of Physics*  
Morehead State University  
Morehead, Kentucky

### John A. Brockhaus, Ph.D.

*Director, Mapping, Charting and  
Geodesy Program*  
Department of Geography and  
Environmental Engineering  
United States Military Academy  
West Point, New York

### Walter Bron, Ph.D.

*Professor of Physics*  
University of California  
Irvine, California

### Andrew J. Davis, Ph.D.

*Manager, ACE Science Center*  
Department of Physics  
California Institute of  
Technology  
Pasadena, California

### Peter E. Demmin, Ed.D.

*Former Science Teacher and  
Department Chair*  
Amherst Central High School  
Amherst, New York

### Roger Falcone, Ph.D.

*Professor of Physics and  
Department Chair*  
University of California  
Berkeley, California

### Cassandra A. Fraser, Ph.D.

*Assistant Professor of Chemistry*  
University of Virginia  
Charlottesville, Virginia

### L. John Gagliardi, Ph.D.

*Associate Professor of Physics  
and Department Chair*  
Rutgers University  
Camden, New Jersey

### Gabriele F. Giuliani, Ph.D.

*Professor of Physics*  
Purdue University  
West Lafayette, Indiana

### Roy W. Hann, Jr., Ph.D.

*Professor of Civil Engineering*  
Texas A&M University  
College Station, Texas

### John L. Hubisz, Ph.D.

*Professor of Physics*  
North Carolina State  
University  
Raleigh, North Carolina

### Samuel P. Kounaves, Ph.D.

*Professor of Chemistry*  
Tufts University  
Medford, Massachusetts

### Karol Lang, Ph.D.

*Associate Professor of Physics*  
The University of Texas  
Austin, Texas

### Gloria Langer, Ph.D.

*Professor of Physics*  
University of Colorado  
Boulder, Colorado

### Phillip LaRoe

*Professor*  
Helena College of Technology  
Helena, Montana

### Joseph A. McClure, Ph.D.

*Associate Professor of Physics*  
Georgetown University  
Washington, D.C.

### LaMoine L. Motz, Ph.D.

*Coordinator of Science Education*  
Department of Learning  
Services  
Oakland County Schools  
Waterford, Michigan

### R. Thomas Myers, Ph.D.

*Professor of Chemistry, Emeritus*  
Kent State University  
Kent, Ohio

### Hillary Clement Olson, Ph.D.

*Research Associate  
and Department Chair*  
Institute for Geophysics  
The University of Texas  
Austin, Texas

### David P. Richardson, Ph.D.

*Professor of Chemistry*  
Thompson Chemical  
Laboratory  
Williams College  
Williamstown, Massachusetts

### John Rigden, Ph.D.

*Director of Special Projects*  
American Institute of Physics  
Colchester, Vermont

### Peter Sheridan, Ph.D.

*Professor of Chemistry*  
Colgate University  
Hamilton, New York

### Vederaman Sriraman, Ph.D.

*Associate Professor of Technology*  
Southwest Texas State  
University  
San Marcos, Texas

### Jack B. Swift, Ph.D.

*Professor of Physics*  
The University of Texas  
Austin, Texas

### Atiq Syed, Ph.D.

*Master Instructor of Mathematics  
and Science*  
Texas State Technical College  
Harlingen, Texas

### Leonard Taylor, Ph.D.

*Professor Emeritus*  
Department of Electrical  
Engineering  
University of Maryland  
College Park, Maryland

### Virginia L. Trimble, Ph.D.

*Professor of Physics and  
Astronomy*  
University of California  
Irvine, California



# Acknowledgments (cont.)

**Martin VanDyke, Ph.D.**  
*Professor of Chemistry Emeritus*  
Front Range Community  
College  
Westminster, Colorado

**Gabriela Waschewsky,  
Ph.D.**  
*Science and Math Teacher*  
Emery High School  
Emeryville, California

## Safety Reviewer

**Jack A. Gerlovich, Ph.D.**  
*Associate Professor*  
School of Education  
Drake University  
Des Moines, Iowa

## Teacher Reviewers

**Barry L. Bishop**  
*Science Teacher and Dept. Chair*  
San Rafael Junior High School  
Ferron, Utah

**Paul Boyle**  
*Science Teacher*  
Perry Heights Middle School  
Evansville, Indiana

**Kenneth Creese**  
*Science Teacher*  
White Mountain Junior High  
School  
Rock Springs, Wyoming

**Vicky Farland**  
*Science Teacher and Dept. Chair*  
Centennial Middle School  
Yuma, Arizona

**Rebecca Ferguson**  
*Science Teacher*  
North Ridge Middle School  
North Richland Hills, Texas

**Laura Fleet**  
*Science Teacher*  
Alice B. Landrum Middle  
School  
Ponte Vedra Beach, Florida

**Jennifer Ford**  
*Science Teacher and Dept. Chair*  
North Ridge Middle School  
North Richland Hills, Texas

**Susan Gorman**  
*Science Teacher*  
North Ridge Middle School  
North Richland Hills, Texas

**C. John Graves**  
*Science Teacher*  
Monforton Middle School  
Bozeman, Montana

**Dennis Hanson**  
*Science Teacher and Dept. Chair*  
Big Bear Middle School  
Big Bear Lake, California

**David A. Harris**  
*Science Teacher and Dept. Chair*  
The Thacher School  
Ojai, California

**Norman E. Holcomb**  
*Science Teacher*  
Marion Local Schools  
Maria Stein, Ohio

**Kenneth J. Horn**  
*Science Teacher and Dept. Chair*  
Fallston Middle School  
Fallston, Maryland

**Tracy Jahn**  
*Science Teacher*  
Berkshire Junior-Senior High  
School  
Canaan, New York

**Kerry A. Johnson**  
*Science Teacher*  
Isbell Middle School  
Santa Paula, California

**Drew E. Kirian**  
*Science Teacher*  
Solon Middle School  
Solon, Ohio

**Harriet Knops**  
*Science Teacher and Dept. Chair*  
Rolling Hills Middle School  
El Dorado, California

**Scott Mandel, Ph.D.**  
*Director and Educational  
Consultant*  
Teachers Helping Teachers  
Los Angeles, California

**Thomas Manerchia**  
*Former Science Teacher*  
Archmere Academy  
Claymont, Delaware

**Edith McAlanis**  
*Science Teacher and Dept. Chair*  
Socorro Middle School  
El Paso, Texas

**Kevin McCurdy, Ph.D.**  
*Science Teacher*  
Elmwood Junior High School  
Rogers, Arkansas

**Alyson Mike**  
*Science Teacher*  
East Valley Middle School  
East Helena, Montana

**Donna Norwood**  
*Science Teacher and Dept. Chair*  
Monroe Middle School  
Charlotte, North Carolina

**Joseph W. Price**  
*Science Teacher and Dept. Chair*  
H. M. Browne Junior High  
School  
Washington, D.C.

**Terry J. Rakes**  
*Science Teacher*  
Elmwood Junior High School  
Rogers, Arkansas

**Beth Richards**  
*Science Teacher*  
North Middle School  
Crystal Lake, Illinois

**Elizabeth J. Rustad**  
*Science Teacher*  
Crane Middle School  
Yuma, Arizona

**Rodney A. Sandefur**  
*Science Teacher*  
Naturita Middle School  
Naturita, Colorado

**Helen Schiller**  
*Science Teacher*  
Northwood Middle School  
Taylors, South Carolina

**Bert J. Sherwood**  
*Science Teacher*  
Socorro Middle School  
El Paso, Texas

**Patricia McFarlane Soto**  
*Science Teacher and Dept. Chair*  
G. W. Carver Middle School  
Miami, Florida

**David M. Sparks**  
*Science Teacher*  
Redwater Junior High School  
Redwater, Texas

**Larry Tackett**  
*Science Teacher and Dept. Chair*  
Andrew Jackson Middle School  
Cross Lanes, West Virginia

**Elsie N. Waynes**  
*Science Teacher and Dept. Chair*  
R. H. Terrell Junior High School  
Washington, D.C.

**Sharon L. Woolf**  
*Science Teacher*  
Langston Hughes Middle  
School  
Reston, Virginia

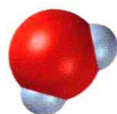
**Alexis S. Wright**  
*Middle School Science  
Coordinator*  
Rye Country Day School  
Rye, New York

**Lee Yassinski**  
*Science Teacher*  
Sun Valley Middle School  
Sun Valley, California

**John Zambo**  
*Science Teacher*  
Elizabeth Ustach Middle School  
Modesto, California

# Contents in Brief

<b>Unit 1</b>	<b>Introduction to Matter</b>	<b>2</b>
Chapter 1	The World of Physical Science . . . . .	4
Chapter 2	The Properties of Matter . . . . .	34
Chapter 3	States of Matter . . . . .	58
Chapter 4	Elements, Compounds, and Mixtures . . . . .	80
<b>Unit 2</b>	<b>Motion and Forces</b>	<b>104</b>
Chapter 5	Matter in Motion . . . . .	106
Chapter 6	Forces in Motion . . . . .	136
Chapter 7	Forces in Fluids . . . . .	160
<b>Unit 3</b>	<b>Work, Machines, and Energy</b>	<b>184</b>
Chapter 8	Work and Machines . . . . .	186
Chapter 9	Energy and Energy Resources . . . . .	212
Chapter 10	Heat and Heat Technology . . . . .	244
<b>Unit 4</b>	<b>The Atom</b>	<b>276</b>
Chapter 11	Introduction to Atoms . . . . .	278
Chapter 12	The Periodic Table . . . . .	300
<b>Unit 5</b>	<b>Interactions of Matter</b>	<b>324</b>
Chapter 13	Chemical Bonding . . . . .	326
Chapter 14	Chemical Reactions . . . . .	348
Chapter 15	Chemical Compounds . . . . .	372
Chapter 16	Atomic Energy . . . . .	396
<b>Unit 6</b>	<b>Electricity</b>	<b>418</b>
Chapter 17	Introduction to Electricity . . . . .	420
Chapter 18	Electromagnetism . . . . .	452
Chapter 19	Electronic Technology . . . . .	480
<b>Unit 7</b>	<b>Waves, Sound, and Light</b>	<b>506</b>
Chapter 20	The Energy of Waves . . . . .	508
Chapter 21	The Nature of Sound . . . . .	532
Chapter 22	The Nature of Light . . . . .	562
Chapter 23	Light and Our World . . . . .	592
<b>LabBook</b>	. . . . .	<b>620</b>





# Contents



**Unit 1** ... **Introduction to Matter**  
: **Timeline** ..... 2

## CHAPTER

**1**

### **The World of Physical Science** ..... 4

**Section 1** Exploring Physical Science ..... 6  
**Section 2** Using the Scientific Method ..... 11  
**Section 3** Using Models in Physical Science ..... 20  
**Section 4** Measurement and Safety in Physical Science . 24

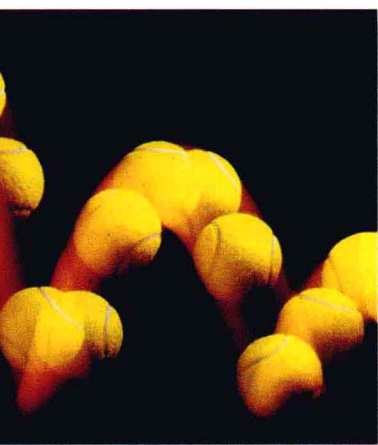
### **Chapter Highlights/Review** ..... 28

#### **Feature Articles**

**Careers:** Electronics Engineer ..... 32  
**Science Fiction:** “Inspiration” ..... 33

#### **LabBook**

■ Safety First! 622   ■ Exploring the Unseen 626  
■ Off to the Races! 627   ■ Measuring Liquid Volume 628  
■ Coin Operated 629



## CHAPTER

**2**

### **The Properties of Matter** ..... 34

**Section 1** What Is Matter? ..... 36  
**Section 2** Describing Matter ..... 43

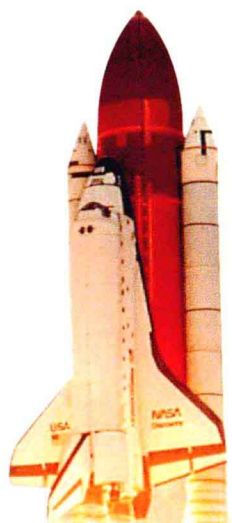
### **Chapter Highlights/Review** ..... 52

#### **Feature Articles**

**Across the Sciences:** In the Dark About Dark Matter . 56  
**Health Watch:** Building a Better Body ..... 57

#### **LabBook**

■ Volumania! 630   ■ Determining Density 632  
■ Layering Liquids 633   ■ White Before Your Eyes 634





**CHAPTER 3**

**States of Matter . . . . . 58**

**Section 1** Four States of Matter . . . . . 60

**Section 2** Changes of State . . . . . 68

**Chapter Highlights/Review . . . . . 74**

**Feature Articles**

**Science, Technology, and Society:** Guiding Lightning . 78

**Eureka!:** Full Steam Ahead! . . . . . 79

**LabBook**

■ Full of Hot Air! 636    ■ Can Crusher 637

■ A Hot and Cool Lab 638



**CHAPTER 4**

**Elements, Compounds, and Mixtures . . . . . 80**

**Section 1** Elements . . . . . 82

**Section 2** Compounds . . . . . 86

**Section 3** Mixtures . . . . . 90

**Chapter Highlights/Review . . . . . 98**

**Feature Articles**

**Science, Technology, and Society:**

Perfume: Fragrant Solutions . . . . . 102

**Science Fiction:**

“The Strange Case of Dr. Jekyll and Mr. Hyde” . . . 103

**LabBook**

■ Flame Tests 640

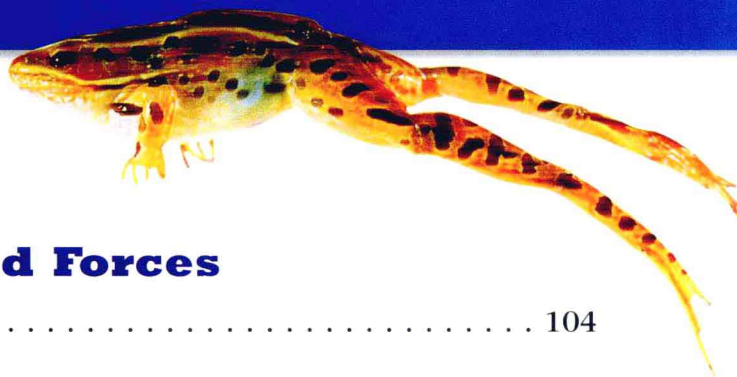
■ A Sugar Cube Race! 642

■ Making Butter 643

■ Unpolluting Water 644







**Unit 2**

**... Motion and Forces**

**: Timeline** ..... 104

**CHAPTER 5**



**Matter in Motion** ..... 106

Section 1 Measuring Motion ..... 108

Section 2 What Is a Force? ..... 115

Section 3 Friction: A Force That Opposes Motion .. 119

Section 4 Gravity: A Force of Attraction ..... 125

**Chapter Highlights/Review** ..... 130

**Feature Articles**

**Science, Technology, and Society:**

Is It Real . . . or Is It Virtual? ..... 134

**Across the Sciences: The Golden Gate Bridge** ..... 135

**LabBook**

- Built for Speed 646
- Detecting Acceleration 647
- Science Friction 650
- Relating Mass and Weight 651

**CHAPTER 6**



**Forces in Motion** ..... 136

Section 1 Gravity and Motion ..... 138

Section 2 Newton's Laws of Motion ..... 145

**Chapter Highlights/Review** ..... 154

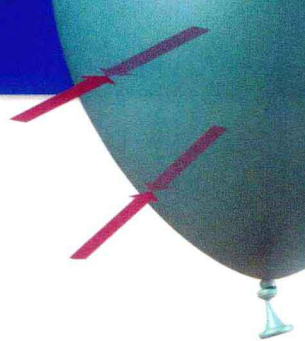
**Feature Articles**

**Eureka!: A Bat with Dimples** ..... 158

**Careers: Roller Coaster Designer** ..... 159

**LabBook**

- A Marshmallow Catapult 652
- Blast Off! 653
- Inertia-Rama! 654
- Quite a Reaction 656



**CHAPTER 7**

**Forces in Fluids** ..... 160

Section 1 Fluids and Pressure ..... 162

Section 2 Buoyant Force ..... 168

Section 3 Bernoulli's Principle ..... 173

**Chapter Highlights/Review** ..... 178

**Feature Articles**

Eureka!: Stayin' Aloft—The Story of the Frisbee® .. 182

Science Fiction: "Wet Behind the Ears" ..... 183

**LabBook**

■ Fluids, Force, and Floating 658 ■ Density Diver 660

■ Taking Flight 661



**Unit 3 ... Work, Machines, and Energy**

■ Timeline ..... 184

**CHAPTER 8**

**Work and Machines** ..... 186

Section 1 Work and Power ..... 188

Section 2 What Is a Machine? ..... 192

Section 3 Types of Machines ..... 198

**Chapter Highlights/Review** ..... 206

**Feature Articles**

Science, Technology, and Society: Micromachines ... 210

Eureka!: Wheelchair Innovators ..... 211

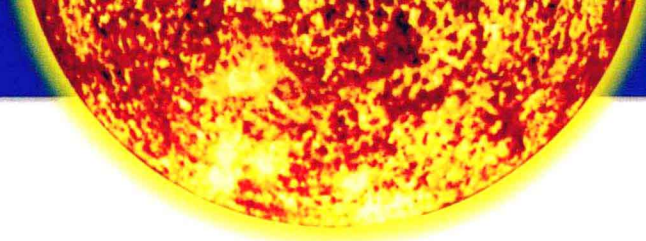
**LabBook**

■ A Powerful Workout 662 ■ Inclined to Move 664

■ Building Machines 665 ■ Wheeling and Dealing 666







**CHAPTER 9**



**Energy and Energy Resources** ..... 212

Section 1 What Is Energy? ..... 214

Section 2 Energy Conversions ..... 222

Section 3 Conservation of Energy ..... 229

Section 4 Energy Resources ..... 232

**Chapter Highlights/Review** ..... 238

**Feature Articles**

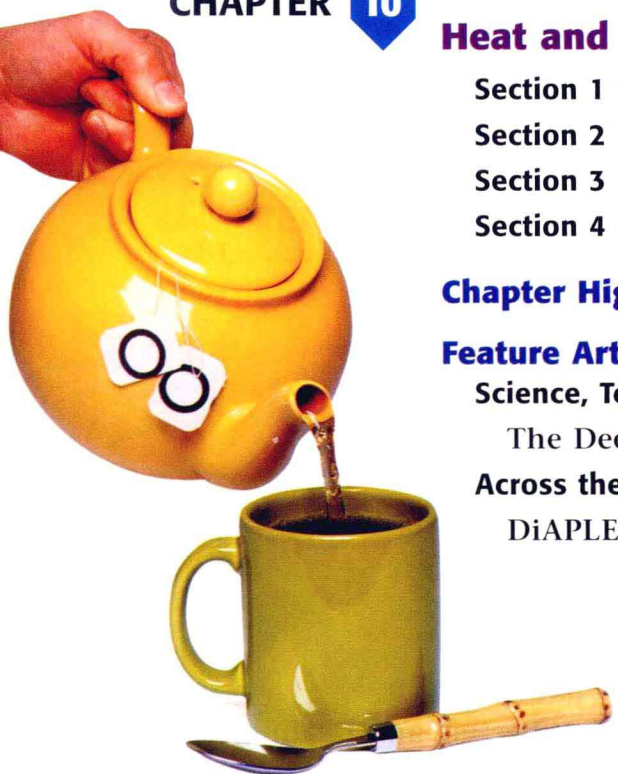
Across the Sciences: Green Buildings ..... 242

Careers: Power-Plant Manager ..... 243



- Finding Energy 668
- Energy of a Pendulum 670
- Eggstremely Fragile 671

**CHAPTER 10**



**Heat and Heat Technology** ..... 244

Section 1 Temperature ..... 246

Section 2 What Is Heat? ..... 251

Section 3 Matter and Heat ..... 260

Section 4 Heat Technology ..... 263

**Chapter Highlights/Review** ..... 270

**Feature Articles**

Science, Technology, and Society:

The Deep Freeze ..... 274

Across the Sciences:

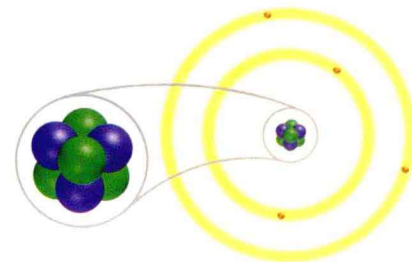
DiAPLEX®: The Intelligent Fabric ..... 275



- Feel the Heat 672
- Save the Cube! 674
- Counting Calories 675

## Unit 4 ... The Atom

Timeline ..... 276



### CHAPTER 11

**Introduction to Atoms** ..... 278

Section 1 Development of the Atomic Theory .... 280

Section 2 The Atom ..... 287

**Chapter Highlights/Review** ..... 294

#### Feature Articles

Across the Sciences: Water on the Moon? ..... 298

Careers: Experimental Physicist ..... 299



■ Made to Order 676



### CHAPTER 12

**The Periodic Table** ..... 300

Section 1 Arranging the Elements ..... 302

Section 2 Grouping the Elements ..... 310

**Chapter Highlights/Review** ..... 318

#### Feature Articles

Science, Technology, and Society:

The Science of Fireworks ..... 322

Weird Science: Buckyballs ..... 323



■ Create a Periodic Table 678

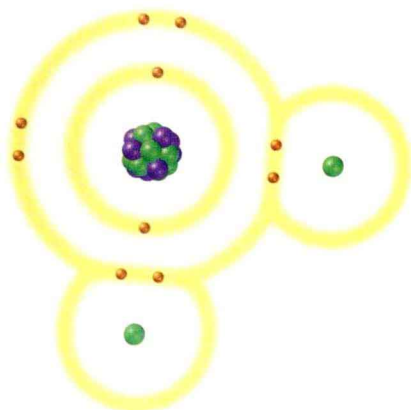




## Unit 5 ... Interactions of Matter

Timeline	324
----------	-----

### CHAPTER 13



#### Chemical Bonding

Section 1 Electrons and Chemical Bonding	328
--	-----

Section 2 Types of Chemical Bonds	332
-----------------------------------	-----

#### Chapter Highlights/Review

#### Feature Articles

Across the Sciences: Left-Handed Molecules	346
--	-----

Eureka!: Here's Looking at Ya'!	347
---------------------------------	-----

#### LabBook

Covalent Marshmallows	680
-----------------------	-----

### CHAPTER 14



#### Chemical Reactions

Section 1 Forming New Substances	350
----------------------------------	-----

Section 2 Types of Chemical Reactions	358
---------------------------------------	-----

Section 3 Energy and Rates of Chemical Reactions	361
--	-----

#### Chapter Highlights/Review

#### Feature Articles

Eye on the Environment: Slime That Fire!	370
--	-----

Careers: Arson Investigator	371
-----------------------------	-----

#### LabBook

Finding a Balance	682
Cata-what? Catalyst!	683
Putting Elements Together	684
Speed Control	686



## CHAPTER 15



<b>Chemical Compounds</b> .....	372
Section 1 Ionic and Covalent Compounds .....	374
Section 2 Acids, Bases, and Salts .....	377
Section 3 Organic Compounds .....	383
<b>Chapter Highlights/Review</b> .....	390
<b>Feature Articles</b>	
Across the Sciences: Unique Compounds .....	394
Weird Science: The Secrets of Spider Silk .....	395

### LabBook

- Cabbage Patch Indicators 688
- Making Salt 690

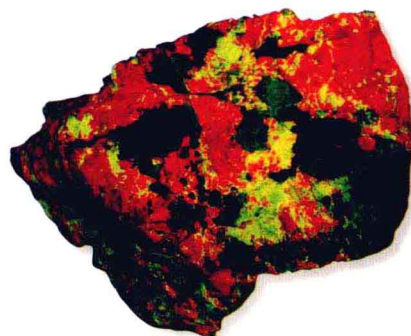
## CHAPTER 16



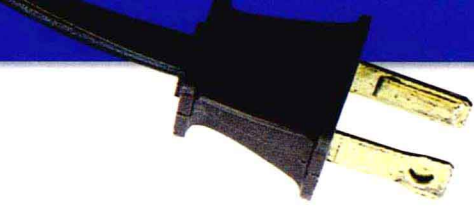
<b>Atomic Energy</b> .....	396
Section 1 Radioactivity .....	398
Section 2 Energy from the Nucleus .....	406
<b>Chapter Highlights/Review</b> .....	412
<b>Feature Articles</b>	
Scientific Debate: Wasting Yucca Mountain? .....	416
Careers: Materials Scientist .....	417

### LabBook

- Domino Chain Reactions 692







**Unit 6**

**Electricity**

**Timeline** ..... 418

**CHAPTER 17**

**Introduction to Electricity** ..... 420

**Section 1** Electric Charge and Static Electricity . . . 422  
**Section 2** Electrical Energy ..... 430  
**Section 3** Electric Current ..... 433  
**Section 4** Electric Circuits ..... 440

**Chapter Highlights/Review** ..... 446

**Feature Articles**

**Science, Technology, and Society:**  
Riding the Electric Rails ..... 450  
**Across the Sciences: Sprites and Elves** ..... 451

**LabBook**

- Stop the Static Electricity! 694
- Potato Power 695
- Circuitry 101 696



**CHAPTER 18**

**Electromagnetism** ..... 452

**Section 1** Magnets and Magnetism ..... 454  
**Section 2** Magnetism from Electricity ..... 462  
**Section 3** Electricity from Magnetism ..... 468

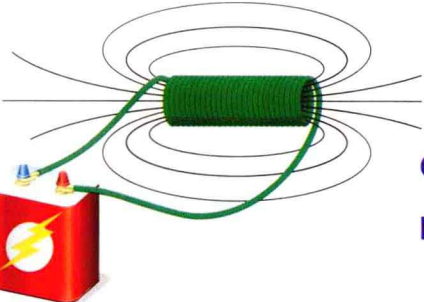
**Chapter Highlights/Review** ..... 474

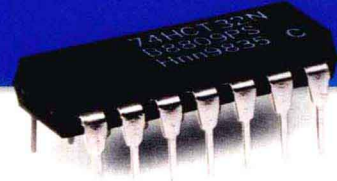
**Feature Articles**

**Across the Sciences: Geomagnetic Storms** ..... 478  
**Health Watch: Magnets in Medicine** ..... 479

**LabBook**

- Magnetic Mystery 698
- Build a DC Motor 700
- Electricity from Magnetism 699





**CHAPTER 19**



**Electronic Technology** . . . . . 480

**Section 1** Electronic Components . . . . . 482

**Section 2** Communication Technology . . . . . 488

**Section 3** Computers . . . . . 494

**Chapter Highlights/Review** . . . . . 500

**Feature Articles**

**Health Watch:** Listening Lower . . . . . 504

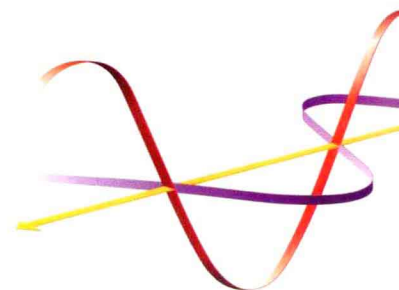
**Science Fiction:** “There Will Come Soft Rains” . . . . 505

**LabBook**

    ■ Tune In! 702

**Unit 7** . . . **Waves, Sound, and Light**

**Timeline** . . . . . 506



**CHAPTER 20**



**The Energy of Waves** . . . . . 508

**Section 1** The Nature of Waves . . . . . 510

**Section 2** Properties of Waves . . . . . 516

**Section 3** Wave Interactions . . . . . 520

**Chapter Highlights/Review** . . . . . 526

**Feature Articles**

**Science, Technology, and Society:**

        The Ultimate Telescope . . . . . 530

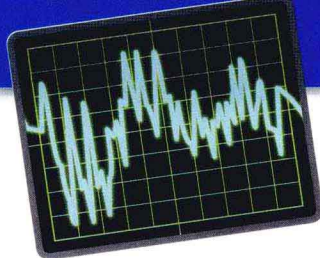
**Across the Sciences:** Sounds of Silence . . . . . 531

**LabBook**

    ■ Wave Energy and Speed 706

    ■ Wave Speed, Frequency, and Wavelength 708





**CHAPTER 21**

**The Nature of Sound** . . . . . 532

**Section 1** What Is Sound? . . . . . 534

**Section 2** Properties of Sound . . . . . 539

**Section 3** Interactions of Sound Waves . . . . . 545

**Section 4** Sound Quality . . . . . 552

**Chapter Highlights/Review** . . . . . 556

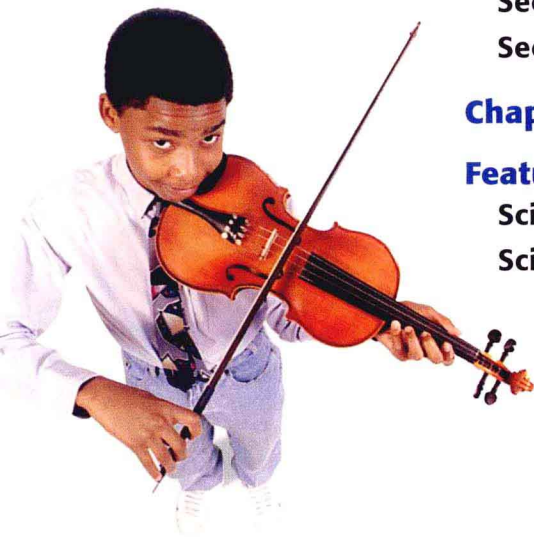
**Feature Articles**

**Science, Technology, and Society: Jurassic Bark** . . . . 560

**Science Fiction: “Ear”** . . . . . 561



- Easy Listening 710    ■ The Speed of Sound 712
- Tuneful Tube 713    ■ The Energy of Sound 714



**CHAPTER 22**

**The Nature of Light** . . . . . 562

**Section 1** What Is Light? . . . . . 564

**Section 2** The Electromagnetic Spectrum . . . . . 567

**Section 3** Interactions of Light Waves . . . . . 575

**Section 4** Light and Color . . . . . 581

**Chapter Highlights/Review** . . . . . 586

**Feature Articles**

**Science, Technology, and Society:**

Fireflies Light the Way . . . . . 590

Eureka!: It’s a Heat Wave! . . . . . 591



- What Color of Light Is Best for Green Plants? 716
- Which Color Is Hottest? 717    ■ Mixing Colors 718

