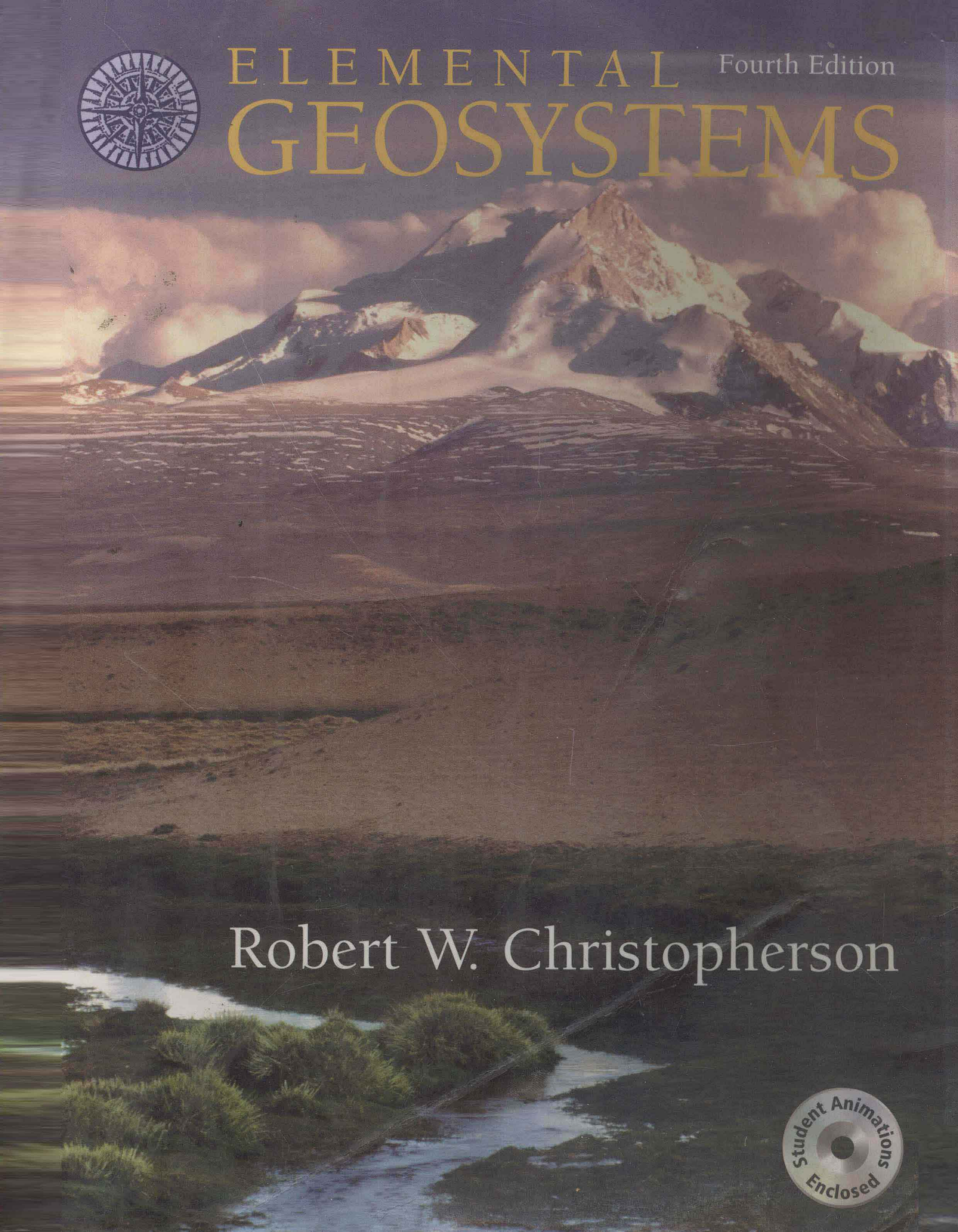
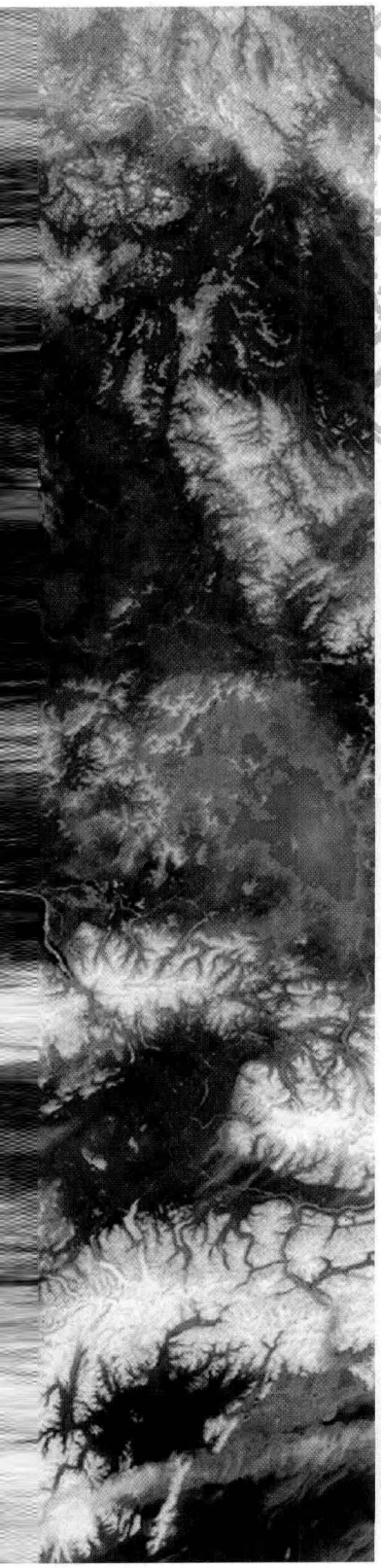

ELEMENTAL
Fourth Edition
GEOSYSTEMS
Robert W. Christopherson
Student Animations
Enclosed



Elemental Geosystems

Fourth Edition

Robert W. Christopherson

PEARSON
Prentice Hall

Pearson Education, Inc.
Upper Saddle River, New Jersey 07458

Library of Congress Cataloging-in-Publication Data

Christopherson, Robert W.
Elemental Geosystems / Robert W. Christopherson.—4th ed.
p. cm.
Includes bibliographical references (p.).
ISBN 0-13-101553-2 (pbk.)
1. Physical geography. I. Title.

GB54.5.C47 2004
910'.02—dc21 2003042993

Geoscience Executive Editor: *Daniel E. Kaveney*
Associate Editor: *Amanda Grifffith*
Editor in Chief, Life and Geosciences: *Sheri L. Snavely*
Vice President of Production and Manufacturing: *David W. Riccardi*
Executive Managing Editor: *Kathleen Schiaparelli*
Assistant Managing Editor: *Beth Sweeten*
Production Editor: *Kim Dellas*
Copy Editor: *Marcia Youngman*
Manager of Formatting: *Jim Sullivan*
Electronic Production Specialist/ Electronic Page Makeup: *Joanne Del Ben*
Production Assistant: *Nancy Bauer*
Production Assistant to the Author: *Bobbé Christopherson*
Manufacturing Buyer: *Alan Fischer*
Manufacturing Manager: *Trudy Pisciotti*
Senior Marketing Manager: *Christine Henry*
Media Editor: *Chris Rapp*
Assistant Managing Editor, Science Media: *Nicole Bush*
Editorial Assistant: *Margaret Ziegler*
Art Director: *Kenny Beck*
Interior Designer: *Joseph Sengotta*
Cover Designer: *Bruce Kenselaar*
AV Editor: *Adam Velthaus*
Art Studio: *Precision Graphics*
Director of Creative Services: *Paul Belfanti*
Director of Design: *Carole Anson*
Front Cover Photo: Tibetan landscape, Mount Kangbochen (7295 m, 23,933 ft). [Galen Rowell/Mountain Light Photography, Inc.]
Inside Front-Cover Image: [MODIS Science Team, Goddard Space Flight Center, NASA and NOAA.]
Title Page Image: *Terra* MODIS image, May 21, 2002, courtesy of MODIS Land Rapid Response Team NASA/GSFC; see http://terra.nasa.gov/.
Dedication page quote: B. Kingsolver, *Small Wonder* (New York: Harper Collins Publishers, 2002), p. 39.

Pearson Education, Inc.
Upper Saddle River, New Jersey 07458

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

ISBN 0-13-101553-2

Pearson Education LTD., *London*
Pearson Education Australia PTY, Limited, *Sydney*
Pearson Education Singapore, Pte. Ltd
Pearson Education North Asia Ltd, *Hong Kong*
Pearson Education Canada, Ltd., *Toronto*
Pearson Educación de Mexico, S.A. de C.V.
Pearson Education—Japan, *Tokyo*
Pearson Education Malaysia, Pte. Ltd

To all the students and teachers of Earth,
our home planet, and a sustainable future.

And to the late Galen and Barbara Cushman Rowell
for their vision of the world in photographs and words.

The land still provides our genesis, however we
might like to forget that our food comes from dank,
muddy earth, that the oxygen in our lungs was
recently inside a leaf, and that every newspaper or
book we may pick up is made from the hearts of
trees that died for the sake of our imagined lives.
What you hold in your hands right now,
beneath these words,
is consecrated air and time and sunlight. . . .

—Barbara Kingsolver

Preface

Welcome to physical geography and the fourth edition of *Elemental Geosystems*. This book builds on the previous three editions and on the five editions of its companion text *Geosystems, An Introduction to Physical Geography*. Students and teachers alike continue to express appreciation for the systems organization, readability, scientific accuracy, up-to-date coverage and relevancy, clarity of the summary and review sections, the functional beauty of the photographs, art, cartography, and the many integrated figures in the text that combine media.

The world community is responding to global concerns over the condition of Earth's physical, biological, and chemical systems. The globalization of the world economies seems paralleled by a global scientific inquiry into the state of the environment.

Armed with the spatial analysis tools of geographic science, physical geographers are well equipped to participate in a planetary understanding of environmental conditions. U.N. Secretary General Kofi Annan, recipient of the 2001 Nobel Peace Prize, spoke to the Association of American Geographers annual meeting, stating,

> As you know only too well the signs of severe environmental distress are all around us.... The idea of interdependence is old hat to geographers, but for most people it is a new garment they are only now trying on for size.... I look forward to working with you in that all-important journey.

Elemental Geosystems Communicates the Science of Physical Geography

The goal of physical geography is to explain the spatial dimension of Earth's dynamic systems—its energy, air, water, weather, climate, tectonics, landforms, rocks, soils, plants, ecosystems, and biomes. Understanding human-Earth relations is part of the challenge of physical geography—to create a holistic (or complete) view of the planet and its inhabitants.

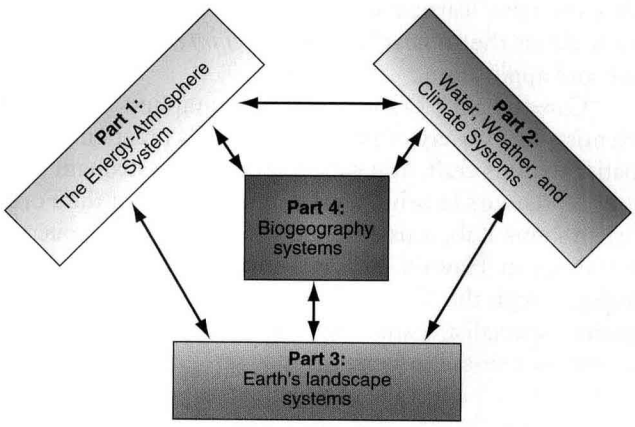
Elemental Geosystems analyzes the worldwide impact of environmental events, bringing together many physical factors to create a complete picture of Earth system operations. A good example is the 1991 eruption of Mount Pinatubo in the Philippines. The global implications of this major event (one of the largest eruptions in the 20th century) are woven through several chapters of the book (see Figure 1.5 for a summary). Global climate change and its related potential effects are part of the fabric in six chapters. These content threads, among many, weave together diverse topics crucial to an understanding of physical geography.

This edition of *Elemental Geosystems* features more than 450 photographs from across the globe and 90 remote-sensing images from a wide variety of orbital platforms. To assist with spatial analysis and location, more than 100 maps are utilized, and more than 250 illustrations explain concepts. New compound arts help you see the concepts you are studying. Here are two examples: Focus Study 13.1, art and 7 photos look at coastal planning; Figure 16.19, satellite image, map, and 10 photos examine succession in the area blasted by Mount St. Helens.

Systems Organization Makes *Elemental Geosystems* Flow

Each section of this book is organized around the flow of energy, materials, and information. *Elemental Geosystems* presents subjects in the same sequence in which they occur in nature. In this way you and your teacher logically progress through topics that unfold according to the flow of individual systems, or in accord with time and the flow of events. See Figure 1.6 for an illustration of this systems organization.

For flexibility, *Elemental Geosystems* is divided into four parts, each containing chapters that link content in logical groupings. The diagram below, from Figure 1.7 illustrates our part structure. A quick check of the Table of Contents and this illustration shows you the order of chapters within these four parts.



The text culminates with Chapter 17, "Earth and the Human Denominator," a unique capstone chapter that summarizes physical geography as an important discipline to help us understand Earth's present status and possible future. Think of the world's population and the totality of

our impact as the *human denominator*. Just as the denominator in a fraction tells how many parts a whole is divided into, so the growing human population and the increasing demand for resources and rising planetary impact suggest how much the whole Earth system must adjust. This chapter is sure to stimulate further thought and discussion, dealing as it does with the most profound issue of our time, Earth's stewardship.

Elemental Geosystems Is a Text That Teaches

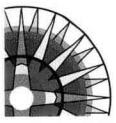
Elemental Geosystems is written to help you in the learning process. **Boldface** words are defined where they first appear in the text. These terms are collected in the Glossary alphabetically, with a chapter-number reference. *Italics* are used in the text to emphasize other words and phrases of importance. Also, in the introduction to each chapter, a new feature called "In this chapter" gives you an overview.

An important continuing feature is a list of Key Learning Concepts that opens each chapter, stating what you should be able to do upon completing the chapter. These objectives are keyed to the main headings in the chapter. At the end of each chapter is a unique Summary and Review section that corresponds to the Key Learning Concepts. Grouped under each learning concept are a narrative review that defines the boldfaced terms, a key term list with page numbers, and specific review questions for that concept. You can conveniently review each concept, test your understanding with review questions, check key terms in the glossary, and then return to the chapter and the next learning concept.

A Critical Thinking section ends each chapter, challenging you to take the next step with information from the chapter. *Key learning concepts* help you determine what you want to learn, the *text* helps you develop information and more questions, *summary and review* helps you assess what you have learned and what more you might want to know about the subject, and *critical thinking* provokes action and application.

"Career Link" essays feature geographers and other scientists in a variety of professional fields practicing their spatial analysis craft. You will read about an astronaut with over 1200 hours in orbit, a weather forecaster at the Forecast Systems Lab, a park ranger who works at the active lava flows in Hawai'i, an environmental scientist, a hydrologist with the National Weather Service, a snow avalanche specialist, and an expert on global scale ecosystems, among others.

Continued coverage of Canadian physical geography includes text, figures, and maps of periglacial landscapes and Canadian soils (see Appendix B and color soils map). Canadian data on a variety of subjects are portrayed on dozens of different maps in combination with the data for the United States—physical geography does not stop at the United States-Canadian border!



"Focus Study" essays, completely revised and several new to this edition, provide additional explanation of diverse key topics: the stratospheric ozone predicament, solar energy collection and wind power, forecasting near-record hurricane seasons, the El Niño phenomenon, the status of the High Plains Aquifer, the record low flows of the Colorado River, floodplain strategies, an environmental approach to shoreline planning, the Mount St. Helens eruption, the present status of the Colorado River, and the loss of biodiversity.

"News Reports" relate topics of special interest. These are some examples: GPS, careers in GIS, a 34-kilometer sky dive to study the atmosphere, jet streams and airline flight times, how one culture harvests fog, the UV Index, coordination of global climate change research with many URLs presented, the new height measurements of Mount Everest, artificial scouring of the Grand Canyon in an attempt to restore beaches and habitats, the record glacial meltdown in Alaska, and the Gaia hypothesis.

We now live on a planet served by the Internet and its World Wide Web. The fact that we have Internet access into almost all the compartments aboard Spaceship Earth is clearly evident in *Elemental Geosystems*. You will find more than 180 URLs (Internet addresses) in the body of the text (printed in blue color and boldface). Given the fluid nature of the Internet, URLs were rechecked at press time for accuracy. If some URLs changed since publication, you can most likely find the new location using elements of the old address. Our Internet link begins with a new Table 1.1 presenting the URLs for major geography organizations.

The Geosystems Learning/ Teaching Package

The fourth edition provides a complete physical geography program for you and your teacher.

For You the Student:

- ***Elemental Geosystems Student Animations CD***, a CD-ROM by Robert Christopherson is packaged with each copy of the text. This exciting CD contains 30 new animations illustrating key concepts in the text, along with support material from the text for every animation. The CD also contains numerous satellite loops of various phenomena. Instantly graded self-tests follow the animations, with pop-up details to reinforce correct answers and your learning. See the text's Walkthrough preview for more details.
- ***Student Study Guide***, Fourth Edition (0-13-101554-0), by Robert Christopherson and Charlie Thomsen. The study guide includes additional

learning objectives, a complete chapter outline, critical thinking exercises, problems and short essay work using actual figures from the text, and a self-test with answer key in the back.

- ***Geosystems WWW Site***: This site gives you the opportunity to further explore topics presented in the book using the Internet. The site contains numerous review exercises (from which you get immediate feedback), exercises to expand your understanding of physical geography, and resources for further exploration. This Web site provides an excellent opportunity from which to start using the Internet for the study of geography. Please visit the site at **www.prenhall.com/christopherson**.
- ***Science on the Internet: A Student's Guide*** (0-13-028253-7) by Andrew T. Stull and Harry Nickla is a guide to the Internet and World Wide Web specific to geography.
- ***Prentice Hall–New York Times Themes of the Times*** supplements, especially Physical Geography (0-13-142636-2), and also Environmental Science (0-13-142638-9), reprint significant recent articles on related topics. These are available at no charge from your local Prentice Hall representative; ask your teacher about a copy.

For You the Teacher:

Elemental Geosystems is designed to give you flexibility in presenting your course. The text is true to each scientific discipline from which it draws subject matter. This diversity is a strength of physical geography, yet makes it difficult to cover the entire book in a school term. You should feel free to customize use of the text based on your specialty or emphasis. The four-part structure of chapters, systems organization within each chapter, and focus study and news report features will all assist you in sampling some chapters while covering others to greater depth. The following materials are available to assist you—have a great class!

- ***Instructor's Resource Manual***, Fourth Edition (0-13-101566-4), by Robert Christopherson and Charlie Thomsen: The Instructor's Resource Manual, intended as a resource for both new and experienced teachers, includes lecture outlines and key terms, additional source materials, teaching tips, complete annotation of chapter review questions, and a list of overhead transparencies. This is also available on the IRCD.
- ***Instructor's Resource CD-ROM***, Fourth Edition (0-13-101558-3): This edition contains all of the figures and some of the photographs from the text. Images are high-resolution, low compression in high quality digital form. The software makes customizing your multimedia presentations easy. You can organize figures in any order you want, add labels, lines, and your own artwork to them using an overlay tool, integrate materials from other sources, and edit and annotate lecture notes. New to this edition are the Geoscience Animations and customizable ***PowerPoint*** lecture presentations, ready for classroom.
- ***Test Item File*** (0-13-101559-1): The Test Item File contains many test questions drawn from the book, available in printed format. This is also available on the IRCD.
- ***Test Manager Geosystems Test Bank*** (0-13-101557-5), by Robert Christopherson and Charlie Thomsen: This collaboration has produced the most extensive and fully revised test item file available in physical geography. This test bank employs **TestGen-EQ** software. **TestGen-EQ** is a computerized test generator that lets you view and edit test bank questions, transfer questions to tests, and print customized formats. Included is the **QuizMaster-EQ** program that lets you administer tests on a computer network, record student scores, and print diagnostic reports. Mac and IBM/DOS computer formats are served.
- ***Overhead Transparencies*** (0-13-101556-7) includes more than 300 illustrations from the text on 300 transparencies, all enlarged for excellent classroom visibility.
- ***Applied Physical Geography—Geosystems in the Laboratory***, Fifth Edition (0-13-034823-6), by Robert Christopherson and Gail Hobbs of Pierce College; Reviewer comments and the feedback from users were very positive for the third edition. The new fifth edition is the result of a careful revision. Twenty lab exercises, divided into logical sections, allow flexibility in presentation. Each exercise comes with a list of learning concepts. Our manual is the only one that comes with its own complete glossary and stereolenses for viewing photo stereopairs and stereomaps in the manual. A complete ***Solutions and Answers Manual*** is available to teachers (0-13-034815-5).

Acknowledgments

As in all past editions, I recognize my family, for they continue to grant us support in reaching our *Geosystems* goals—both our moms, my sister Lynne, brothers Randy and Marty, and our children Keri, Matt, Reneé, and Steve. And the next generation: Chavon, Bryce, Payton, Brock, Trevor, Blake, and our newest Chase. When I look into our grandchildren's faces, it tells me why we need to work toward a sustainable future, one that works for the children.

I give special gratitude to all the students and colleagues during my 29 years at American River College for defining the importance of Earth's future, for their questions, and their enthusiasm. To all students and teachers this text remains dedicated. The tragic loss of Galen and Barbara Rowell further signals the importance of life.

They contributed so much to our world view and to our appreciation and awe at the foot of Earth's wonders—I add them to our dedication. One of Galen's photos is on our cover.

My thanks go to the many authors and scientists who published research, articles, and books that enriched my work. And, although unnamed here, to all the correspondence received from students and teachers from across the globe who shared with me over the Internet, e-mail, FAX, and phone—a continuing appreciated dialogue. Thanks also to all the colleagues who served as reviewers on one or more editions, who participated in our focus groups, or who offered helpful suggestions at our national and regional geography meetings. I am grateful to all of them for their generosity of ideas and sacrifice of time. Here is a master list of all our reviewers.

Ted J. Alsop, *Utah State University*
Ward Barrett, *University of Minnesota*
David Berner, *Normandale Community College*
Franco Biondi, *University of Nevada, Reno*
Peter D. Blanken, *University of Colorado–Boulder*
David R. Butler, *Southwest Texas State University*
Mary-Louise Byrne, *Wilfrid Laurier University*
Ian A. Campbell, *University of Alberta–Edmonton*
Randall S. Cerveny, *Arizona State University*
Fred Chambers, *University of Colorado–Boulder*
Muncel Chang, *Butte College and California State University–Chico*
Andrew Comrie, *University of Arizona*
C. Mark Cowell, *Indiana State University*
Richard A. Crooker, *Kutztown University*
Armando M. da Silva, *Towson State University*
Dirk H. de Boer, *University of Saskatchewan*
Mario P. Delisio, *Boise State University*
Joseph R. Desloges, *University of Toronto*
Lee R. Dexter, *Northern Arizona University*
Don W. Duckson, Jr., *Frostburg State University*
Christopher H. Exline, *University of Nevada–Reno*
Michael M. Folsom, *Eastern Washington University*
Mark Francek, *Central Michigan University*
Glen Fredlund, *University of Wisconsin–Milwaukee*
David E. Greenland, *University of North Carolina–Chapel Hill*
Duane Griffin, *Bucknell University*
Barry N. Haack, *George Mason University*
Roy Haggerty, *Oregon State University*
John W. Hall, *Louisiana State University–Shreveport*
Vern Harnapp, *University of Akron*
Jason "Jake" Haugland, *University of Colorado–Boulder*
Gail Hobbs, *Pierce College*
David A. Howarth, *University of Louisville*
Patricia G. Humbertson, *Youngstown State University*
David W. Icenogle, *Auburn University*
Philip L. Jackson, *Oregon State University*
J. Peter Johnson, Jr., *Carleton University*
Guy King, *California State University–Chico*
Ronald G. Knapp, *SUNY–The College at New Paltz*
Peter W. Knightes, *Central Texas College*
Thomas Krabacher, *California State University–Sacramento*
Richard Kurzhals, *Grand Rapids Junior College*
Steve Ladochy, *California State University, Los Angeles*
Robert D. Larson, *Southwest Texas State University*
Paul R. Larson, *Southern Utah University*
Elena Lioubimtseva, *Grand Valley State University*
Joyce Lundberg, *Carleton University*
W. Andrew Marcus, *Montana State University*
Elliot G. McIntire, *California State University, Northridge*
Norman Meek, *California State University, San Bernardino*
Sherry Morea-Oaks, *Boulder, CO*
Patrick Moss, *University of Wisconsin–Madison*
Lawrence C. Nkemdirim, *University of Calgary*
Andrew Oliphant, *San Francisco State University*
John E. Oliver, *Indiana State University*
Bradley M. Opdyke, *Michigan State University*
Richard L. Orndorff, *University of Nevada, Las Vegas*
Patrick Pease, *East Carolina University*
James Penn, *Southeastern Louisiana University*
Greg Pope, *Montclair State University*
Robin J. Rapai, *University of North Dakota*
Philip D. Renner, *American River College*
William C. Rense, *Shippensburg University*
Dar Roberts, *University of California–Santa Barbara*
Wolf Roder, *University of Cincinnati*
Robert Rohli, *Louisiana State University*
Bill Russell, *L.A. Pierce College*
Dorothy Sack, *Ohio University*
Glenn R. Sebastian, *University of South Alabama*
Daniel A. Selwa, *U.S.C. Coastal Carolina College*
Thomas W. Small, *Frostburg State University*
Daniel J. Smith, *University of Victoria*
Stephen J. Stadler, *Oklahoma State University*
Michael Talbot, *Pima Community College*
Susanna T.Y. Tong, *University of Cincinnati*
Suzanne Traub-Metlay, *Front Range Community College*
David Weide, *University of Nevada–Las Vegas*
Thomas B. Williams, *Western Illinois University*
Brenton M. Yarnal, *Pennsylvania State University*
Stephen R. Yool, *University of Arizona*

I extend my continuing gratitude to the editorial, production, and sales staff of Prentice Hall. Thanks to ESM President Paul Corey for his leadership and friendship from the beginnings of the *Geosystems* books. Thanks to Dan Kaveney, Geosciences Executive Editor, who is dedicated, innovative, and energetic as a geographer and friend. I feel these two executives are like my brothers in this effort, for they are positive forces in these texts and in geographic education. My compliments to a talented and wise Amanda Griffith who managed this project and all

my ancillaries, and was always there with answers. My appreciation to Chris Rapp for expertise on all the CD projects and his help and guidance on the dramatic new animations CD. And thanks to Ginger Birkeland for work on the *Geosystems* Web site. Thanks to Margaret Ziegler's organizational skills in the Geosciences office. And to all the staff for allowing me to participate in the entire publishing process.

My thanks to Kim Dellas, project Production Editor, for such expertise and care in converting all my materials into this textbook and to copy editor Marcia Youngman for such detail. Thanks to the art and design team at Prentice Hall for this powerful cover and beautiful text design and for letting me in on many decisions. The many sales representatives that spend months in the field communicating the *Elemental Geosystems* approach are a tremendous asset to the book, thanks and safe travels to them, always.

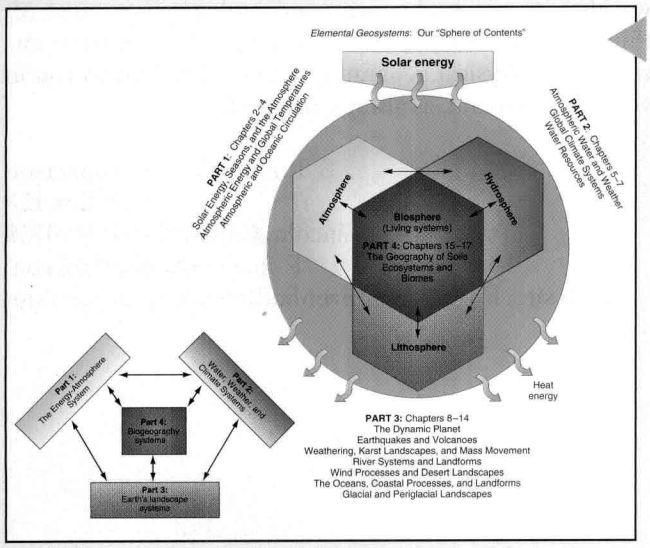
As on every book I mention my partnership with a special collaborator, photographer, and production assistant, Bobbé Christopherson. She works tirelessly on all the textbook projects. She catalogues photographs, prepares our extensive figure and photo logs, processes and prints satellite imagery and photos, copy edits, obtains permissions, and assists me in proofing art and editing final pages. Bobbé is an activist in Earth matters. Her eclectic interests embrace birds, invertebrate marine biology, plants and wildflowers, the Hawaiian volcanoes, and her nature photography. And she is my best friend, wife, and colleague.

Physical geography teaches us a holistic view of the intricate supporting web that is Earth's environment and our place in it. Dramatic changes that demand our understanding are occurring in many human-Earth relations, as we alter physical, chemical, and biological systems. All things considered, this is a critical time for you to be enrolled in a physical geography course! The best to you in your studies—and, as always, ***carpe diem!***

Robert W. Christopherson
P. O. Box 128
Lincoln, California 95648-0128
E-mail: bobobbe@aol.com
Web site: **http://www.prenhall.com/christopherson**

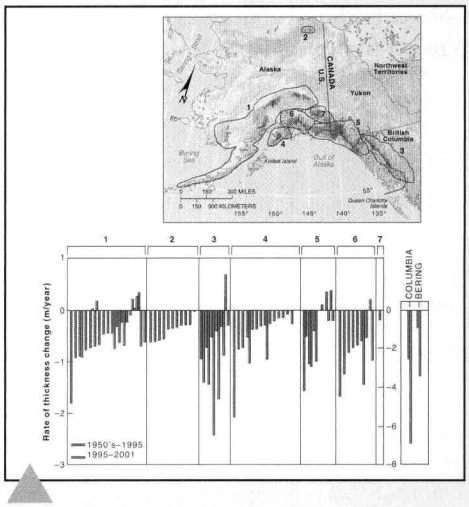
HALLMARK FEATURES

Elemental Geosystems, 4e features a strong emphasis on the *science* of physical geography, coupled with a focus on the student's learning process. To facilitate this approach, the book focuses on four main areas: organization, currency, writing, and art.



UNIQUE ORGANIZATION AND FLOW OF TOPICS

Elemental Geosystems four-part organization and chapter sequence treats subjects as process systems, essentially nonmathematical, with text material organized in the same direction as the flow of energy and matter in the environment. This edition, as in its previous editions, has served to update the field and bring physical geography into play as an important Earth systems science.

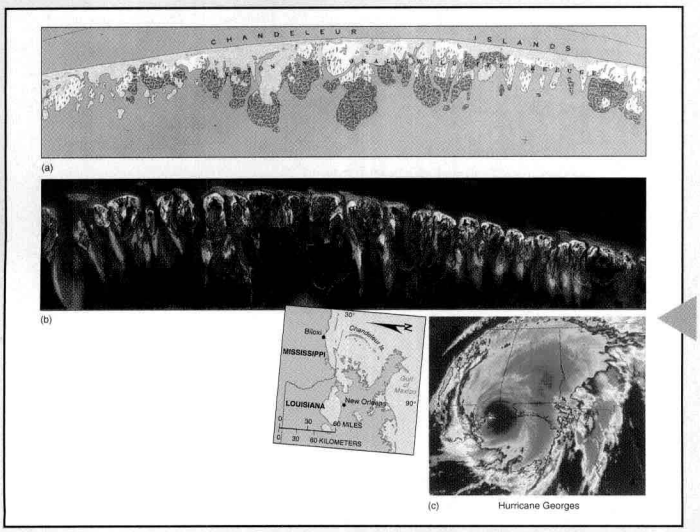


CURRENCY

This text is the most up-to-date physical geography text available. Currency has always been a hallmark of ***Elemental Geosystems*** and this edition is no exception. A few examples of the author's use of currency include: a new study about the negative net mass balance in Alaskan glaciers, the latest weather technology (including ASOS and AWIPS), cirrus cloud studies following the airline 3-day shutdown after 9/11/01 events, and agenda of the 2002 Earth Summit as it relates to physical geography.

WRITING AND PEDAGOGY

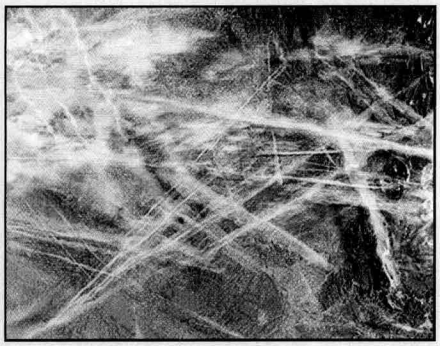
The book features a strong writing and pedagogical program. The writing program is characterized by numerous interesting examples for students, by a strong focus on physical geography's applicability to understanding current events, and vignettes that highlight some interesting careers in physical geography. The pedagogical program includes extensive study materials at the beginning and end of every chapter, a study guide written by Robert W. Christopherson, and a free online study guide available to all students.



ART AND CARTOGRAPHY

Elemental Geosystems highlights the field of physical geography through the extensive use of maps, photographs, satellite images, and line drawings. The book's signature technique is to combine maps with other forms of visual media to give a clearer and more complete picture of the concept illustrated.

NEW TO THIS EDITION



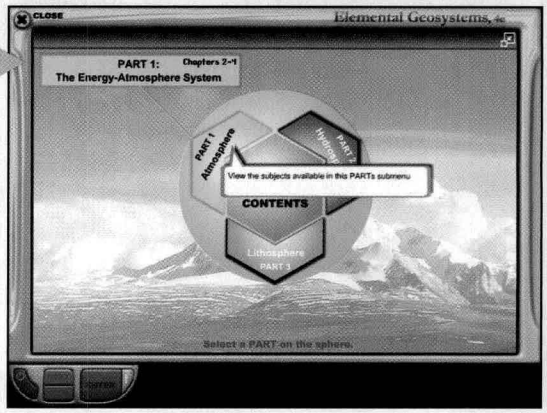
Satellite image of jet contrails triggering cloud development

THOROUGHLY REVISED AND UPDATED THROUGHOUT

Currency has always been a hallmark of ***Elemental Geosystems,*** and this edition has been thoroughly updated. Much of the updated material draws from events and studies from as recent as 2002. A few examples include a new study about the negative net mass balance in Alaskan glaciers, the latest weather technology (including ASOS and AWIPS), cirrus cloud studies following the airline 3-day shutdown after 9/11/01 events, and especially low Colorado River flows, 2000 - 2002 as it relates to physical geography.

NEW STUDENT ANIMATION CD-ROM

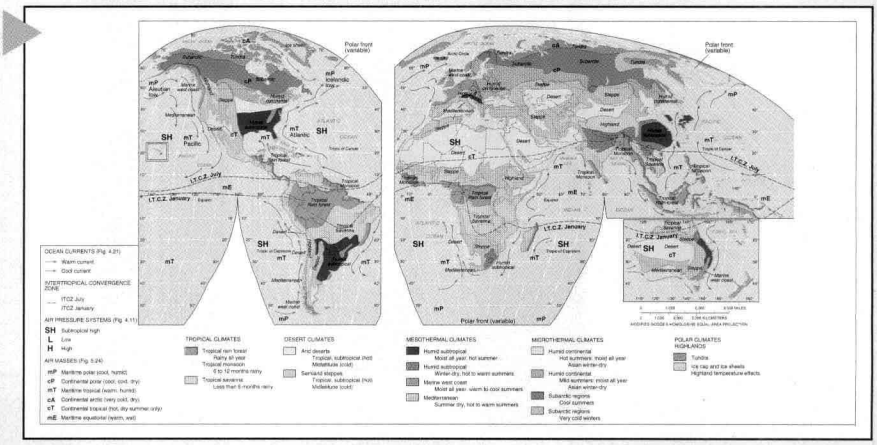
The new student CD-ROM is packaged automatically with each copy of the text and features 30 animations of key concepts in physical geography. These animations are interactive and will greatly augment classroom presentation and student studies. The author has taken the Prentice Hall Geoscience animations and added pedagogy to help students understand and learn more efficiently about physical processes. This CD-ROM is a unique product to the market, and referenced throughout the text by CD, Satellite Loop, and Notebook icons.



REVISED COVERAGE OF GLOBAL CLIMATE SYSTEMS

Chapter 6 Global Climate

The causes of climate are labeled on each climograph and the maps are altered to reflect cause. In this way students can see the causative factors that produce the conditions on which the station's classification is based. The previous use of the Köppen classification systems is diminished, yet retained in an Appendix for those still using the systems explicit classification criteria.



ons of Geography

Association of American Ge-
2001, offered this assessment:

ll, the signs of severe envi-
around us. Unsustainable
ly into the fabric of mod-
n threatens food security.
atens biodiversity. Water
c health, and fierce com-
ay well become a source
the future . . . .the over-
ientific experts have con-

In this chapter: Our study of *Elemental Geosystems*—Earth systems—begins in this chapter with a look at the science of physical geography and the geographic tools we use. Physical geography is key to studying entire Earth systems because of its integrative approach.

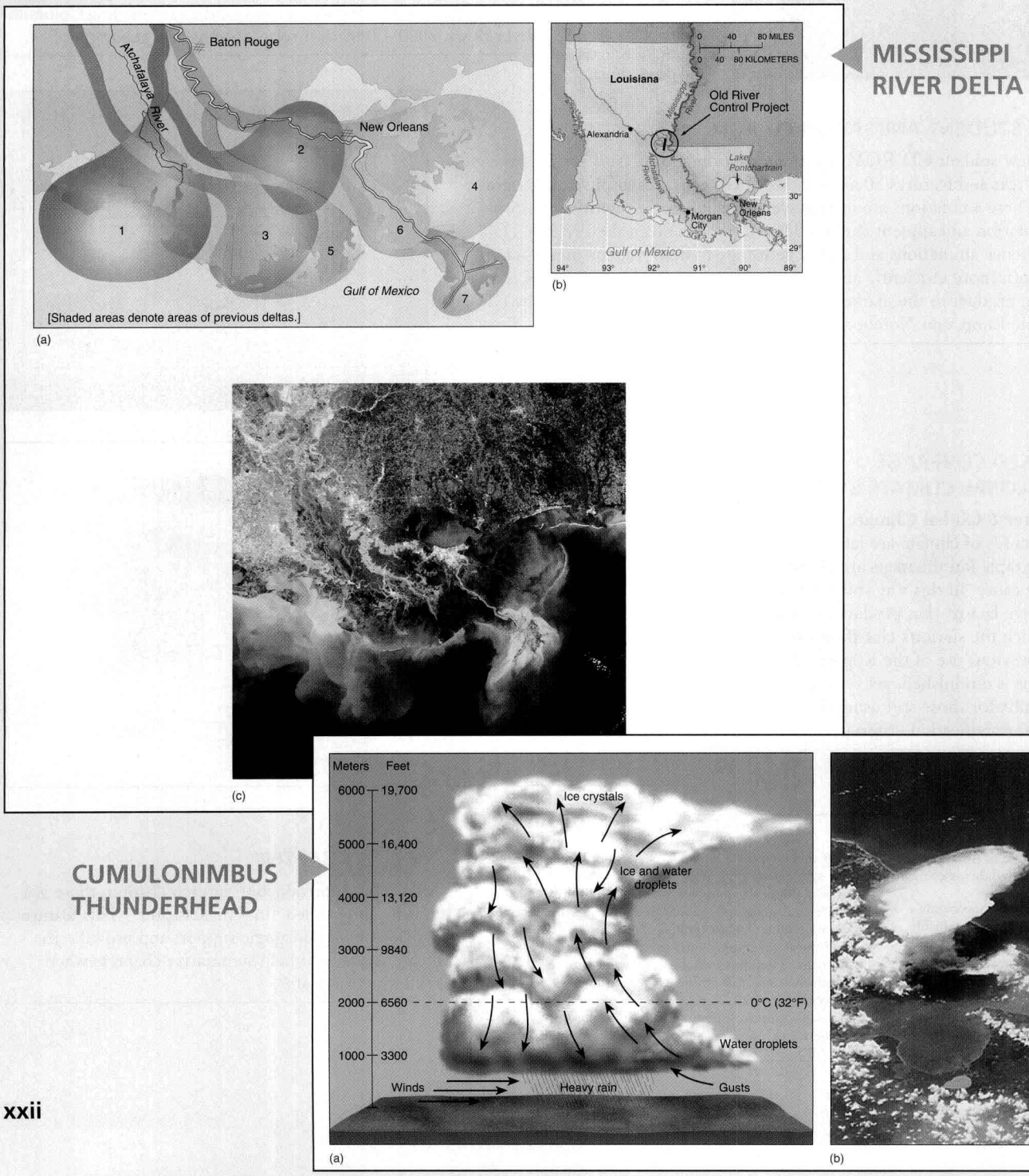
Physical geographers utilize systems to study the environment. Therefore, we discuss systems and the feedback mechanisms that influence system operations. We then consider location, a key theme of geographic inquiry—the latitude, longitude, and time coordinates that inscribe Earth's surface, and the global positioning systems (GPS) technologies to measure them. The study of

"IN THIS CHAPTER"

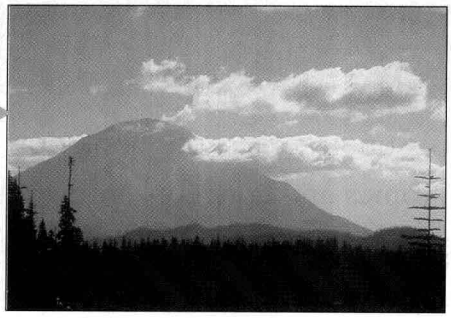
After a brief introduction in each chapter, there is a new heading called "In This Chapter." This feature provides solid pedagogic support and provides the students a way to help summarize chapters when reviewing for exams.

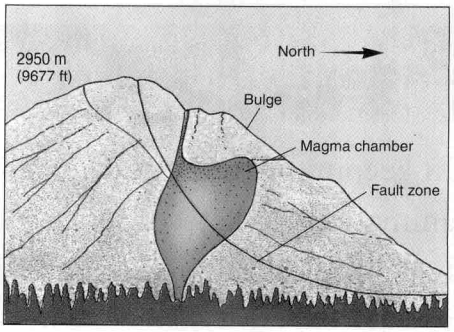
SUPERIOR GRAPHICS PROGRAM

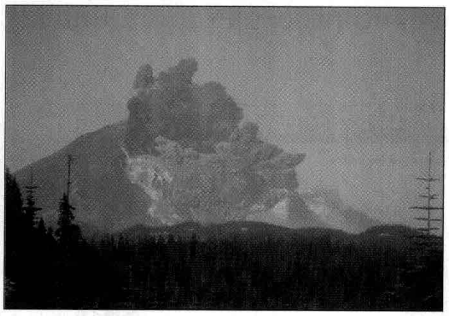
Elemental Geosystems employs a sophisticated, yet extremely accessible, system of maps, photographs, line drawings, and satellite images. The fourth edition features a refinement of this basic philosophy as well as a dramatic expansion of the remotely-sensed images employed.

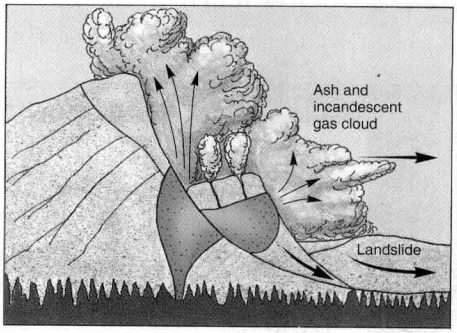


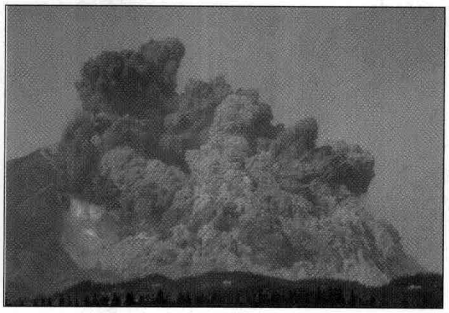
THE MOUNT ST. HELENS ERUPTION SEQUENCE AND CORRESPONDING SCHEMATICS

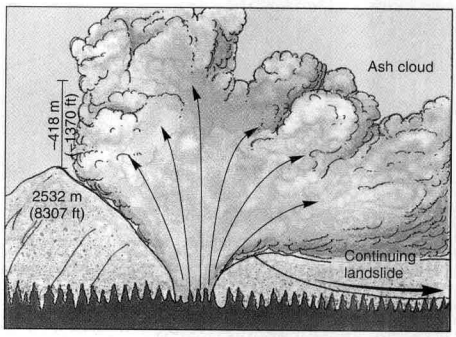


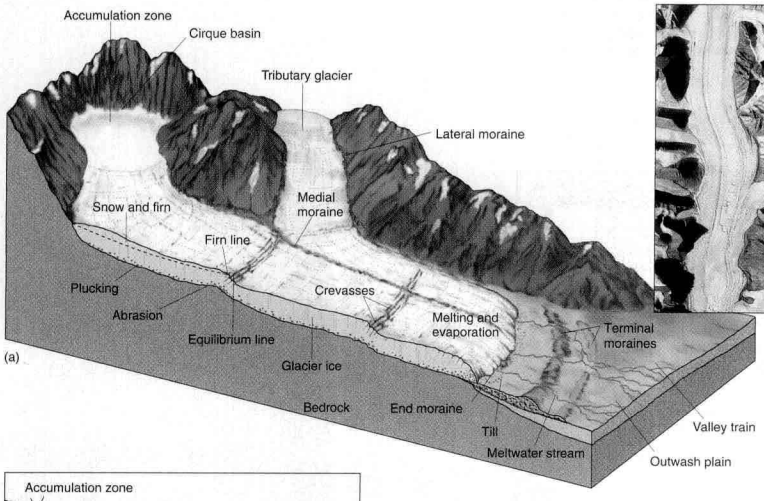


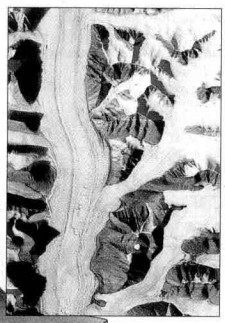




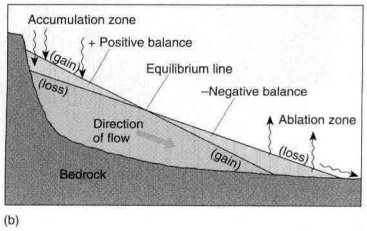


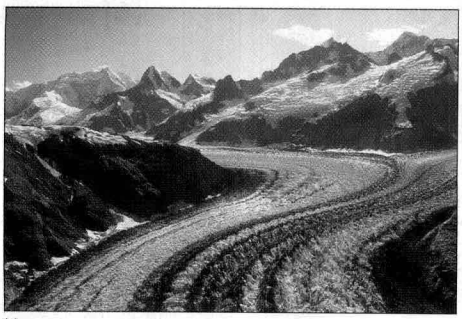






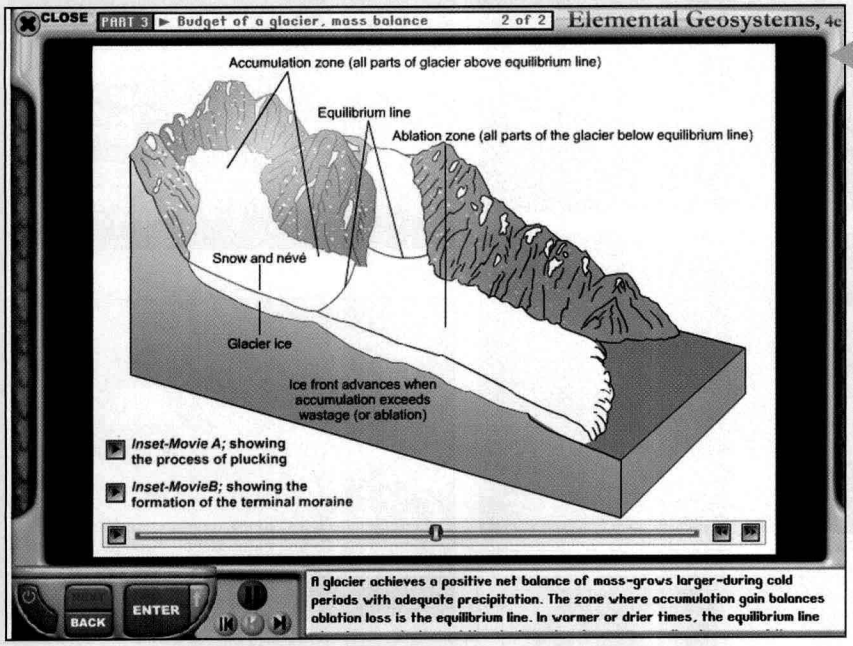
MASS BALANCE AND RETREATING ALPINE GLACIER



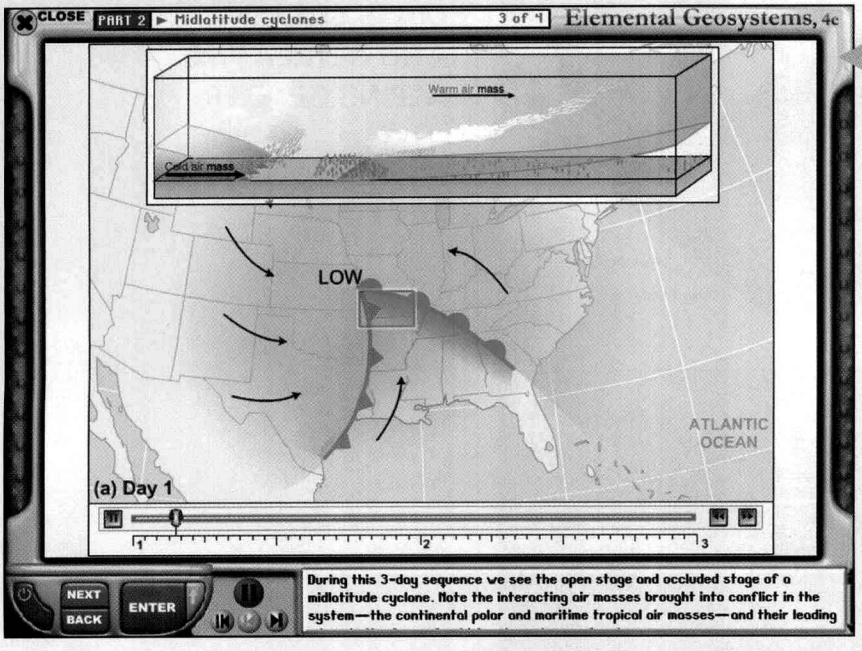


STUDENT ANIMATION CD-ROM

In keeping with the text's emphasis on graphics, the book now features animations of key concepts. The topics and concepts animated were chosen by a panel of physical geographers as the most difficult concepts and processes for students to visualize. These animations have been specifically crafted to help students learn these concepts and processes more quickly and effectively.

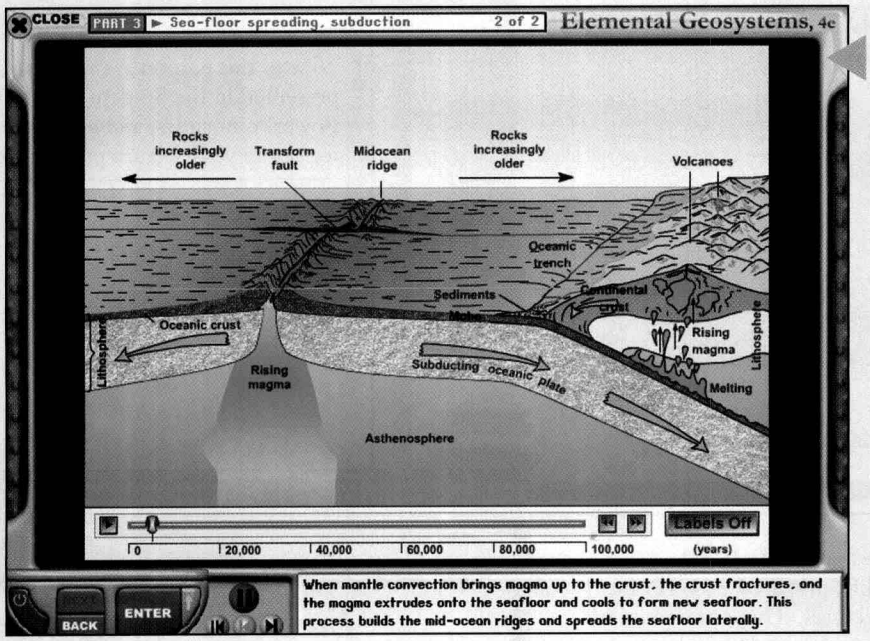


GLACIAL PROCESSES AND BUDGET

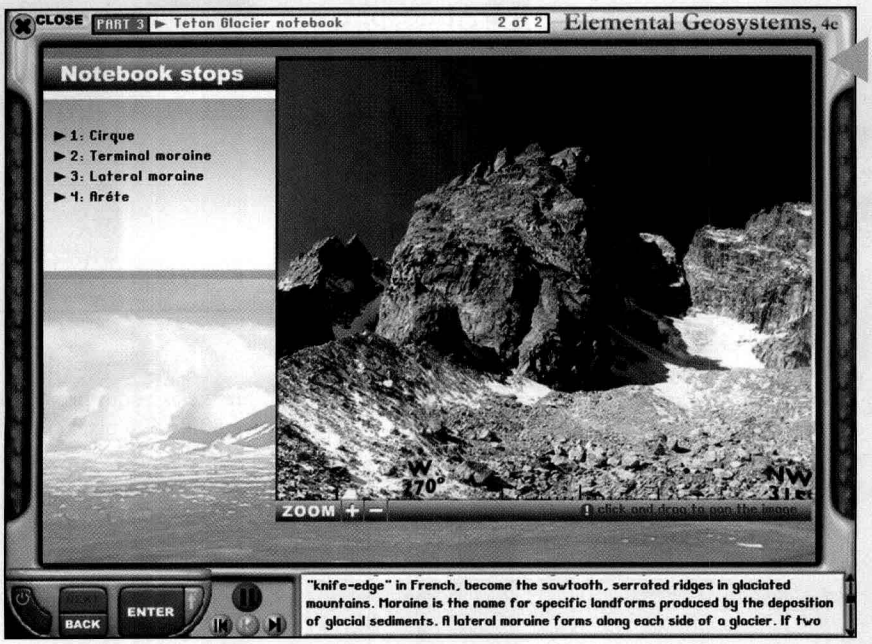


MIDLATITUDE CYCLONES

Each animation allows the student to control the action. The user can replay the animation, control the pace of the animation, and stop and start the animation anywhere in its sequence. In order to facilitate effective independent study, Robert W. Christopherson has written accompanying narrations to each animation.



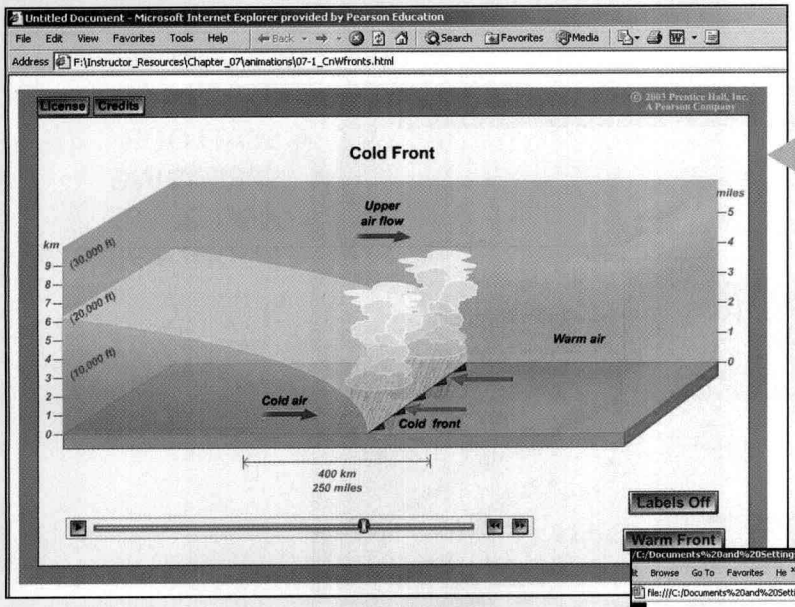
SEAFLOOR SPREADING AND PLATE BOUNDARIES



TETON GLACIER NOTEBOOK

LECTURE PRESENTATION TOOLS

The Instructor's Resource CD-ROM (0-13-101558-3) provides high-quality electronic versions of photos and illustrations from the book, as well as additional photographs and customizable PowerPoint lecture presentations.



New to this edition are the animations presented in the Student CD-ROM as PowerPoint slides, and as original Flash files, for use in your lecture presentations.

The Instructor's Resource CD-ROM features customizable, prepared PowerPoint presentations for lectures. These presentations follow the outline recommended in the Instructor's Manual, and have the appropriate graphics already inserted.

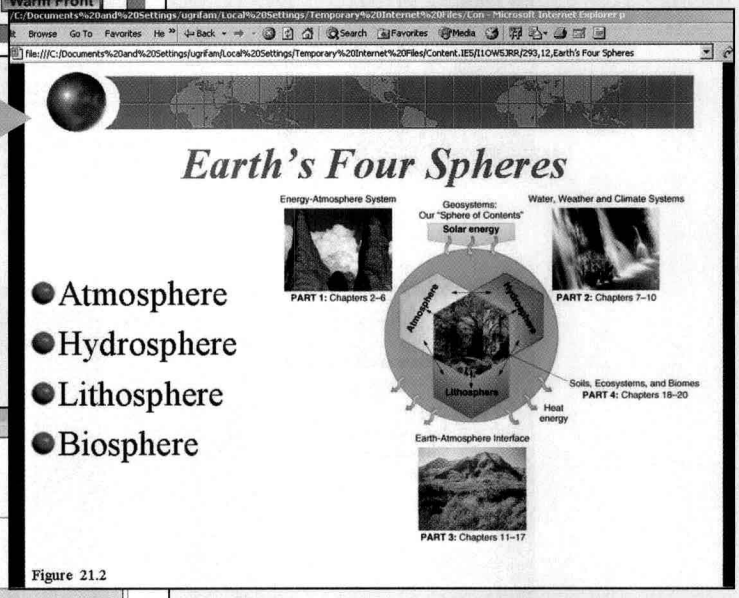
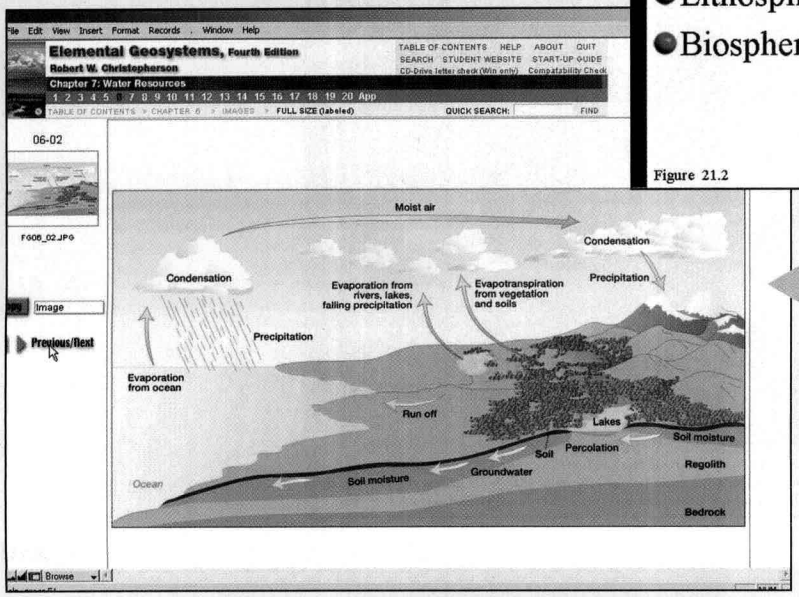


Figure 21.2



To guarantee classroom projection quality, all images are 800 x 600 pixel, 16-bit JPEG files, and are designed for easy import into lecture presentation software.

INSTRUCTOR'S TEACHING PACKAGE

INSTRUCTOR'S MANUAL (0-13-101566-4)

Intended as a resource for both new and experienced instructors, the Instructor's Manual includes a variety of lecture outlines, additional source materials, teaching tips, advice about how to integrate visual supplements (including Web-based resources), and various other ideas for the classroom.

TEST GEN EQ (0-13-101557-5)

Computerized test generator that lets you view and edit test bank questions, transfer questions to tests, and print the test in a variety of customized formats. Included in each package is the QuizMaster EQ program that lets you administer tests on a computer network, record student scores, and print diagnostic reports.

TEST ITEM FILE (0-13-101559-1)

The test item file is a printed bank of test item questions, a valuable complement to an instructor's own test/quiz files.

TRANSPARENCIES (0-13-101556-7)

Dramatically expanded transparency set includes over 300 pieces of art from the text, all enlarged for excellent classroom visibility.

STUDENT LEARNING PACKAGE

NEW STUDENT CD-ROM

The new Student CD-ROM is packaged automatically with each copy of the text. Robert has taken the Prentice Hall Geoscience animations and added pedagogy to help students understand and learn more efficiently about physical processes.

STUDENT STUDY GUIDE (0-13-101554-0)

The study guide includes additional learning objectives, a complete chapter outline, critical thinking exercises, problems and short essay work using actual figures from the text, and a self-test with answer key in the back.

APPLIED PHYSICAL GEOGRAPHY – GEOSYSTEMS IN THE LABORATORY, 5E (0-13-034823-6)

The new edition is a result of careful revision and contains 20 lab exercises, divided into logical sections, allowing for flexibility in their presentation. Each exercise comes with a list of learning concepts. This is the only manual that comes with its own complete glossary and stereo lenses and stereo maps for viewing photo stereo pairs presented in the manual. A complete **Solutions Manual** is available for the instructor (0-13-034815-5).

FREE ONLINE STUDY GUIDE

www.prenhall.com/christopherson

This innovative online resource center is keyed by chapter to the text. It provides Key Terms, Chapter Exercises, Additional Internet Resources, and Additional Readings to support and enhance students' study of physical geography. The CW also offers instructors access to Syllabus Manager, Prentice Hall's online syllabus creation and management tool.

OPTIONAL RESOURCES

RAND MCNALLY ATLAS OF WORLD GEOGRAPHY

The *Rand McNally Atlas of World Geography* includes more than 65 physical and political maps of the world, continents, regions, countries and vicinities. Free when packaged with the text.

To order this package use ISBN: 0-13-183751-6

THE GEOGRAPHY COLORING BOOK, 3/E BY WYNN KAPIT

The *Geography Coloring Book* is a unique educational tool that introduces students to the countries of the world and the states of the United States. Each section begins with a plate containing a political map, a physical map, and/or a regional map. Through active participation and coloring the maps, students gain a broader understanding of material and retain more information. Free when packaged with the text.

To order this package use ISBN: 0-13-183752-4

BUILDING GEOGRAPHIC LITERACY: AN INTERACTIVE APPROACH, 4/E BY CHARLES A. STANSFIELD

Innovative in its approach, this interactive workbook enables students to learn place geography and, as they learn it, to reinforce and apply their knowledge by constructing thematic maps that convey physical, economic, cultural, or political characteristics of places. Free when packaged with the text.

To order this package use ISBN: 0-13-183749-4