

# FUNDAMENTALS OF PHYSICAL GEOGRAPHY

SECOND EDITION

JAMES F. PETERSEN  
DOROTHY SACK  
ROBERT E. GABLER







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***Fundamentals of Physical Geography,***  
**Second Edition**

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Copy Editor: Graphic World Inc.

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Cover Designer: William Stanton

Cover Image: Ethan Meleg/All Canada Photos/  
Corbis

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WCN: 02-200-203

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Library of Congress Control Number: 2013945907

ISBN-13: 978-1-133-60653-6

ISBN-10: 1-133-60653-9

**Cengage Learning**

200 First Stamford Place, 4th Floor

Stamford, CT 06902

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# Preface

**F***undamentals of Physical Geography*, now in its second edition, was written to provide students from any academic major with a basic knowledge of Earth's natural features and the processes that affect them. The book also considers human impacts on the environment and how environmental processes affect people. The essential content of introductory physical geography is presented in a clear, condensed style and is an excellent format for courses that follow either the semester or quarter system.

Earth is a complex system driven by interactions among many factors that include climate, weather and the atmosphere, organisms and their communities, water, landforms, and soils. Physical geography concerns understanding Earth as an integrated system, how it functions, and how it varies over space and time. This knowledge is crucial for making informed decisions about the use and preservation of Earth's natural environments and resources. Our interactions with the environment can benefit or endanger our own living conditions as well those of future generations. The more we know about the Earth system and how it operates, the more effective we can be in working toward preservation, stewardship, and sustainability. At the college level, physical geography is an ideal science course for students who would like to make informed decisions that consider environmental limits and possibilities as well as people's wants and needs.

Recognition of geography's importance to society as a major field of inquiry has grown along with environmental awareness. Geographic knowledge, skills, and techniques are increasingly valued in the workplace. Physical geographers use the latest technological advances to observe, study, map, and measure features and processes and their interactions as parts of the Earth system. They work on modeling environmental responses and interactions. Physical geographers analyze digital images from satellites and aircraft and employ mapmaking techniques (cartography), geographic information science (GIS), global positioning systems (GPS), and other tools for environmental analysis and problem solving.

*Fundamentals of Physical Geography's* focus on relevance is supported by explanations of geographic tools and methods. Practical applications that use geographic data, maps, and satellite images, and numerous landscape photographs that illustrate important themes and examples are provided in the textbook. Related activities along with the text material encourage spatial thinking and give students opportunities to really apply the geographic knowledge they are acquiring.

## Features

### Comprehensive View of the Earth System

*Fundamentals of Physical Geography*, Second Edition, introduces all major aspects of the Earth system, identifying physical phenomena and natural processes and stressing their characteristics, relationships, interactions, and distributions. The text covers a wide range of topics, including weather, climate, the atmosphere, water, the solid Earth, landforms, and our planet's living environments. With only 17 chapters, this textbook provides beginning geography students with a thorough introduction to the essential content of physical geography.

### Engaging Graphics

Because studying geography is enhanced with visual aids, the text includes a wide array of illustrations and photographs that help the concepts come alive. Locator maps accompany selected photographs to provide a spatial context and help students identify the feature's location on Earth. Clear and simple diagrams illuminate important concepts, and environmental system illustrations provide a broad view of the features, inputs, and outputs of certain environmental systems, such as storms, glaciers, rivers, the flow of underground water, or the moving of continents by plate tectonics.

### Clear Explanations

The text uses a clear narrative style to explain the processes, physical features, and events that occur within, on, or above Earth's surface. The writing style, examples, and illustrations facilitate rapid comprehension, making the study of physical geography meaningful and enjoyable.

### Introduction to the Geographer's Tools

Digital technologies have revolutionized our abilities to study Earth's natural processes and environments. A full chapter is devoted to maps, digital imagery, and other data used by geographers. Illustrations throughout include maps and images with descriptions and assessments of the environmental attributes shown in the scenes. There are also introductory discussions of many techniques that geographers use for displaying

and analyzing environmental features and processes, including remote sensing, geographic information systems, cartography, and global positioning systems.

## Focus on Student Interaction

The text encourages students to think, conceptualize, hypothesize, and interact with the subject matter of physical geography. Activities at the end of each chapter can be completed either individually or as a group and were designed to engage students and promote active learning. Review questions reinforce concepts and prepare students for exams; practical application assignments require active solutions, such as sketching a diagram, performing calculations, or exploring geographic features using Google Earth. Questions following many figure captions prompt students to either think beyond or use the map, graph, diagram, or image and give further consideration to the aspect presented. Detailed learning objectives at the beginning of the chapters provide a means for assessing comprehension of the material.

## Three Unique Perspectives

Feature boxes appear in the chapters to illustrate three major scientific perspectives of physical geography. Through a **spatial perspective**, physical geography focuses on understanding and explaining the locations and distributions of natural phenomena. Our discipline also uses a **physical science perspective**, which applies the knowledge and methods of the natural and physical sciences using the scientific method and systems analysis. Through an **environmental perspective**, physical geographers consider impacts, influences, and interactions between human and natural components of the environment, that is, how the environment influences human life and how humans affect the environment.

## Map Interpretation Series

Developing map interpretation skills is a priority in physical geography, and this text includes activities based on full-color maps, generally printed at their original scale. These activities help students develop valuable map-reading skills and reinforce the topical material presented. The map interpretation features can be incorporated into lab activities and they can help link lectures to the textbook and to practical applications. These include end of chapter topographic map and image examples and the weather map interpretation.

## New in This Edition

Revising *Fundamentals of Physical Geography* for a second edition involved thoughtful consideration of the input from many reviewers and adopters. Not only is our planet ever-changing, but so are the many ways that we observe, measure, and analyze Earth's characteristics and environments and the processes that affect them. New scientific findings and new

ways of communicating those findings are continually being developed, and we work to incorporate those that are appropriate for an introductory text.

## New and Revised Text

As authors, we seek to include coverage of physical geographic topics that will spark student interest. This involves relating recent environmental concerns, findings, and natural disasters, examining the conditions that led to those events, and explaining their relation to physical geography. Some examples of recent natural disasters include deadly outbreaks of tornadoes; terrible wildfires in Colorado, California, and Texas; and serious drought or flooding in many areas. The devastating earthquake-generated tsunamis in Japan and South Asia, as well as hurricane and storm damage in the United States, continue to be discussed in terms of human impacts and how to avoid, or at least minimize, such tragic events in the future. Throughout the text, we cover the hazards as well as the beauty of Earth's natural processes.

We continue to take an Earth systems approach, which is reinforced throughout the text with examples and illustrations at a variety of spatial and temporal scales. The concept of scale in atmospheric processes has been given a stronger emphasis than in the first edition. More attention is given to unusual weather conditions, and sections on the greenhouse effect and global climate change have been expanded. We have enhanced discussions of the potential and predicted impacts of global warming on multiple aspects of the Earth system, including glaciers and sea level.

Many other sections contain new or expanded material. These include examples of human interactions with the environment (Chapter 1); a new topographic map interpretation exercise and an example of mapping with lasers, called lidar (Chapter 2); using solar energy (Chapter 3); the urban heat island (Chapter 4); upper air circulation (Chapter 5); tornado chasers (Chapter 6); introduced exotic species, such as Burmese pythons (Chapter 9); measurement of seismic waves (Chapter 10); a new topographic map interpretation exercise on volcanic landforms (Chapter 11); sensitive soils and the interplay of people and slope processes (Chapter 12); the nature of springs (Chapter 13); flood hazards (Chapter 14); differences between humid- and arid-region streams (Chapter 15); recent dramatic changes in glaciers (Chapter 16); and tsunamis and changes in global sea level (Chapter 17).

## Enhanced Illustration Program

Topics that were revised or expanded required including many new figures and updating others, including photographs, satellite images, and maps, often with detailed invitations for interpretation by students. This edition has many new or improved graphs, maps, and diagrams, and about 150 new photographs. Three new activities in the **Map Interpretation** series deal with reading topographic maps (Chapter 2), a comparative analysis of weather maps and corresponding satellite images (Chapter 4), and volcanic terrain (Chapter 11).

## New Features

### Understanding Map Content

Thematic maps have the ability to present a great deal of geographic data in graphic form. The goal of the **Understanding Map Content** is to help students understand the information, geographic/spatial representations, and data presented in thematic maps. Students are encouraged to answer questions based on map content. This opportunity for practice will increase students' appreciation for the amount of useful information contained in a thematic map and enhance their ability to analyze and comprehend the geographic data and spatial relationships presented within thematic maps. These activities encourage true map understanding and illustrate the usefulness of map interpretation skills not only for studying geography but also throughout our daily lives.

### Thinking Geographically

Most chapters dealing with Earth surface processes and landforms include map activities in the **Map Interpretation** series. These continue in this edition with full-size topographic map excerpts presented at the end of the chapters on volcanoes, solutional topography (karst), rivers, desert landforms, glaciers, and coasts. These chapters also include new landscape image interpretation activities in the **Thinking Geographically** series. Students are asked to interpret a landscape image, which features a scene related to the chapter content. These offer practice in looking closely at and visually evaluating a landscape to recognize the geographic features present, interpret their significance, assess how they may be related, and think about how the landforms and landscapes developed.

## Fundamentals of Physical Geography—Four Major Objectives

### To Meet the Academic Needs of the Student

In content and style, *Fundamentals of Physical Geography*, Second Edition, was written specifically to meet the needs of students, the end users of this textbook. Students can use the knowledge and understanding obtained through the text and its activities to help them make informed decisions involving the environment at the local, regional, and global scale. The book also considers the needs of beginning students or those with little or no background in the study of physical geography or other Earth sciences. Examples from throughout the world illustrate important concepts and help students bridge the gap between theory and practical application.

### To Integrate the Illustrations with the Written Text

The photographs, maps, aerial and satellite images, scientific visualizations, block diagrams, graphs, and line drawings clearly illustrate important concepts in physical geography. Text discussions are strongly linked to the illustrations, encouraging students to examine them in graphic form and visualize physical processes and phenomena. Some examples of topics that are clearly explained by integrating visuals and text include map and image interpretation (Chapter 2), the seasons and Earth's energy budget (Chapter 3), wind systems (Chapter 4), storms (Chapter 6), soils (Chapter 9), plate tectonics (Chapter 10), river systems (Chapter 14), glaciers (Chapter 16), and coastal processes (Chapter 17).

### To Communicate the Nature of Geography

The nature of physical geography and its three major scientific perspectives (spatial, physical, and environmental) are discussed in Chapter 1. In subsequent chapters, all three perspectives are stressed. For example, location is a dominant topic in Chapter 2 and remains an important theme throughout the text. Spatial distributions are emphasized as the elements of weather and climate are discussed in Chapters 4 through 6. The changing Earth system is a central focus in the text and featured in Chapters 1, 8, 16, and 17. Characteristics of climate regions and their associated environments are presented in Chapters 7 and 8. Spatial interactions are demonstrated in discussions of weather systems (Chapter 6), soils (Chapter 9), and volcanic and tectonic activity (Chapter 11). Karst (Chapter 13), arid (Chapter 15), glacial (Chapter 16), and coastal (Chapter 17) landforms covary with specific environmental variables, such as soluble rock (karst), past or present climates (karst, arid, glacial), or the interface of land, sea, and air (coastal). Feature boxes in every chapter present interesting and important examples of each perspective.

### To Fulfill the Major Requirements of Introductory Physical Science Courses

*Fundamentals of Physical Geography*, Second Edition, offers a full chapter on the scientific tools and methodologies of physical geography. Earth as a system and the natural processes affecting physical phenomena beneath, at, and above Earth's surface are examined in detail. Use of the scientific method and scientific explanations are stressed. End-of-chapter questions include interpreting graphs of environmental data (or graphing data for study), quantitative analysis, classification, calculating environmental variables, and hands-on map interpretation. Models and systems are frequently cited in discussions of important concepts, and scientific classification is presented in several

chapters. Some of these topics include air masses, tornadoes, and hurricanes (Chapter 6); climates (Chapters 7 and 8); biogeography and soils (Chapter 9); water resources (Chapter 13); rivers (Chapter 14); and coasts (Chapter 17).

Physical geography plays a central role in understanding environmental aspects and issues, human–environment interactions, and approaches to environmental problem solving. The students in this course include the professional geographers of tomorrow. Spreading the message about the importance, relevance, and career potential of geography in today’s world is essential to the strength of geography at educational levels from pre-collegiate through university. *Fundamentals of Physical Geography*, Second Edition, seeks to reinforce that message.

## Ancillaries

Instructors and students alike will greatly benefit from the comprehensive ancillary package that accompanies this text.

### Instructor Resources

**Global Geoscience Watch** Updated several times a day, the Global Geoscience Watch is an ideal one-stop site for classroom discussion and research projects for all things geoscience. Broken into the four key course areas (Geography, Geology, Meteorology, and Oceanography), instructors can easily get to the most relevant content available for their courses. Instructors and their students will have access to the latest information from trusted academic sources, news outlets, and magazines. You will also receive access to statistics, primary sources, case studies, podcasts, and much more.

**Geology CourseMate** Cengage Learning’s Geology CourseMate brings course concepts to life with interactive learning, study, and exam preparation tools that support the printed textbook. Watch student comprehension grow as your class uses the text-specific flashcards, videos, animations, quizzes, and other interactive tools to enhance their learning. CourseMate goes beyond the book to deliver what your students need. Learn more at [cengage.com/coursemate](http://cengage.com/coursemate).

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- Cross-compatible capability. Import and export content into other systems.

**Instructor Companion Website** Everything you need for your course in one place! This collection of book-specific lecture and class tools is available online via [www.cengage.com/login](http://www.cengage.com/login). Access and download PowerPoint presentations, images, instructor’s manual, videos, and more.

### Student Resources

**Global Geoscience Watch** Use Global Geoscience Watch to stay current in your course. Updated several times a day, this resource gives you access to the latest information from trusted academic sources, news outlets, and magazines. You will also receive access to statistics, primary sources, case studies, podcasts, and much more. The Global Geoscience Watch is an ideal one-stop site for all your research needs.

**Geology CourseMate** Make the most of your study time by accessing everything you need to succeed in one place. Read your textbook; take notes; review flashcards; watch videos, animations, and active figures; and take practice quizzes—online with CourseMate. Log in or purchase access at [www.cengagebrain.com](http://www.cengagebrain.com).

**Online Lab Manual** The lessons contained in the Lab Manual are designed to build and heighten understanding of the text chapters. Use these lessons to see how the textbook content can be applied to the everyday problems in the world around you. Lab Manual lessons help build valuable skills such as map reading, map and graph interpretation, three-dimensional thinking, problem solving, and predictive modeling.

## Acknowledgments

*Fundamentals of Physical Geography*, Second Edition, would not have been possible without the encouragement and assistance of editors, friends, and colleagues from throughout the country. Great appreciation is extended to Martha, Emily, and Hannah Petersen; Greg Nadon; and Sarah Gabler for their patience, support, and understanding.

Special thanks go to the splendid freelancers and staff members of Cengage Learning. These include Yolanda Cossio, Product Director; Aileen Berg, Product Manager; Liana

Sarkisian, Content Developer; Stefanie Beeck, Media Developer; and Victor Luu, Product Assistant.

**Photos courtesy of:** Rainer Duttmann, University of Kiel; Richard Earl, Texas State University; Dan Satterfield, WOBC, Salisbury, MD; Erin Himmel/National Park Service; Delphine Farmer, Colorado State University; Lynn Betts/NRCS; Melissa Gabrielson, Chuck Young, and Fred Broerman, U.S. Fish and Wildlife Service; Bob DeGross, Everglades National Park; J. Good, National Park Service; Michael McCollum/McCollum Associates; Jason Neely, Polar Field Services; Christoph W. Borst and Gary L. Kinsland, University of Louisiana at Lafayette; **VORTEX II**/Sean Waugh, NOAA/NSSL; Michael Studinger, NASA; John Shea, FEMA; USGS Alaska Volcano Observatory, D. Josefczyk; National Scenic Byways/Digital Library; Sasan Saatchi NASA/JPL-Caltech; Wind Cave National Park; Emily Petersen; Parv Sethi; Martha Moran, White River National Forest; Mark Muir, Fishlake National Forest; National Park Service, Cape Cod National Seashore; Mark Reid, USGS; Dawn Endico; Gary P. Fleming, Virginia Natural Heritage Program; Tessy Shirakawa, Mesa Verde National Park; Bill Case, Chris Wilkerson, and Michael Vanden Berg, Utah Geological Survey; Center for Cave and Karst Studies, Western Kentucky University; Hari Eswaran, USDA Natural Resources Conservation Service; Richard Hackney, Western Kentucky University; David Hansen, University of Minnesota; Susan Jones, Nashville, Tennessee; Bob Jorstad, Eastern Illinois University; National Agricultural Imagery Program/Texas Natural Resources Information System; Parris Lyew-Ayee, Oxford University, UK; L. Elliot Jones, U.S. Geological Survey; Anthony G. Taranto Jr., Palisades

Interstate Park—New Jersey Section; Justin Wilkinson, Earth Sciences, NASA Johnson Space Center; Hajo Eicken, Alfred Wegener Institute for Polar and Marine Research; U.S. Fish and Wildlife Service; Loxahatchee National Wildlife Refuge; Philippe Rekacewicz, UNEP/GRID-Arendal *World Atlas of Desertification*. Greg Nadon, Ohio University, L. Michael Trapasso, Western Kentucky University.

Colleagues who reviewed this text and related *Physical Geography* editions include Peter Blanken, University of Colorado; J. Michael Daniels, University of Wyoming; James Doerner, University of Northern Colorado; Richard Earl, Texas State University; Ryan Fogt, Ohio University; Greg Gaston, University of North Alabama; Chris Houser, University of West Florida; Paul Hudson, University of Texas; Debra Morimoto, Merced College; Alan Paul Price, University of Wisconsin; Peter Siska, Austin Peay State University; and Richard W. Smith, Harford Community College.

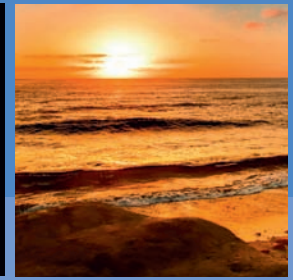
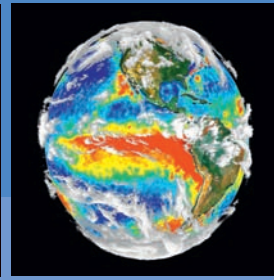
The comments and suggestions of all of the previously mentioned individuals have been instrumental in developing this text. Countless others, both known and unknown, deserve heartfelt thanks for their interest and support over the years. Despite the painstaking efforts of the reviewers, there will always be questions of content, approach, and opinion associated with the text. The authors wish to make it clear that they accept full responsibility for all that is included in *Fundamentals of Physical Geography*, Second Edition.

*James F. Petersen  
Dorothy Sack  
Robert E. Gabler*

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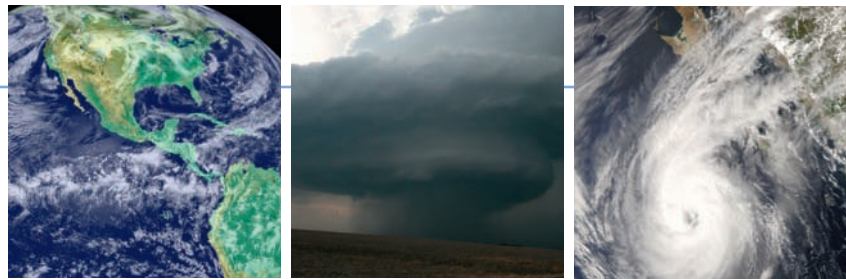
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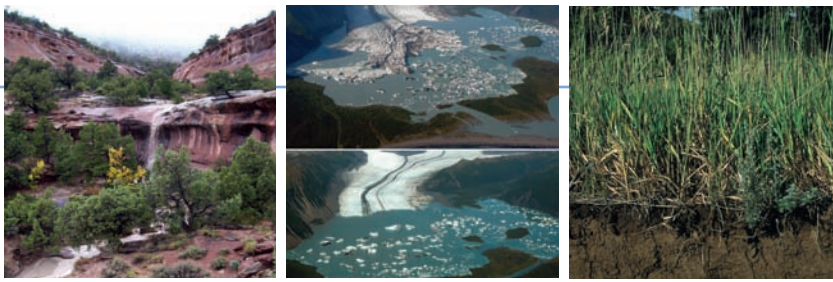
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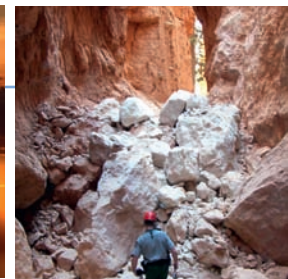
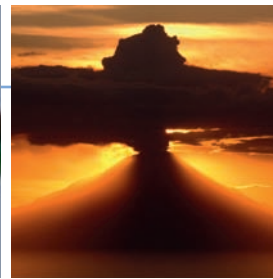
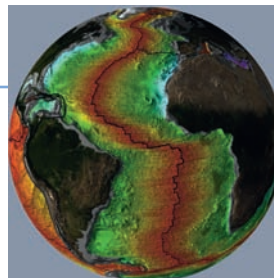
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# Author Biographies



**James F. Petersen** James F. Petersen is professor of geography at Texas State University–San Marcos, Texas. He is a broadly trained physical geographer with strong interests in geomorphology and earth science education. He enjoys writing about topics relating to physical geography for the public, particularly environmental interpretation, and has written a landform guidebook for Enchanted Rock State Natural Area in central Texas and a number of field guides. He is a strong supporter of geographic education, having served as president of the National Council for Geographic Education (NCGE) in 2000 after more than 15 years of service to that organization. He has also written and served as a senior consultant for nationally published educational materials at levels from middle school through university and has led many workshops for geography teachers. In 2011, he was awarded the George J. Miller Distinguished Service Award for distinguished service to geographic education, the highest honor given by the NCGE.



**Dorothy Sack** Dorothy Sack, professor of geography at Ohio University in Athens, Ohio, is a physical geographer who specializes in geomorphology. Her research emphasizes arid region landforms, including geomorphic evidence of paleolakes, which contributes to paleoclimate reconstruction. She has published research results in a variety of professional journals, academic volumes, and Utah Geological Survey maps and reports. She also has research interests and publications on the history of geomorphology and the impact of off-road vehicles. Her work has been funded by the National Geographic Society, NSF, Association of American Geographers (AAG), American Chemical Society, and other sources. She is active in professional organizations, having served as chair of the AAG Geomorphology Specialty Group, chair of the AAG History of Geography Specialty Groups, and in several other offices for the AAG, Geological Society of America, and History of Earth Sciences Society. She enjoys teaching and research, and has received the Outstanding Teacher Award from Ohio University's College of Arts and Sciences.



**Robert E. Gabler** During his nearly five decades of professional experience, Professor Gabler has taught geography at Hunter College, City of New York; Columbia University; and Western Illinois University, in addition to 5 years in public elementary and secondary schools. At times in his career at Western Illinois he served as chair of the Geography and Geology Department, chair of the Geography Department, and director of International Programs for the university. He received three University Presidential Citations for teaching excellence and university service, served two terms as chair of the Faculty Senate, edited the *Bulletin of the Illinois Geographical Society*, and authored numerous articles in state and national periodicals. He is a past president of the Illinois Geographical Society, former director of coordinators and past president of the National Council for Geographic Education, and the recipient of the NCGE George J. Miller Distinguished Service Award.



# Physical Geography: Earth Environments and Systems

1

## Outline

The Study of Geography

Major Perspectives in  
Physical Geography

Models and Systems

The Earth in Space

Physical Geography  
and You



**"The Blue Marble,"** lunar  
astronauts' view of Earth:  
an oasis of life in the  
vastness of space.

NASA



## Objectives

When you complete this chapter you should be able to:

- Explain physical geography as a discipline and profession that considers both the natural world and the human interface with the natural world.
- Understand how geographic information and techniques are directly applicable in many career fields.
- Describe the three major perspectives of physical geography: the spatial perspective, the physical science perspective, and the environmental perspective.
- Conceptualize Earth as a system of interacting parts that respond to both natural and human-induced processes.
- Discuss several interactions between humans and their environments, including examples that are advantageous and others that are detrimental or risky.
- Recognize how knowledge of physical geography invites better understanding of our environment.

In 1972, as the last astronaut mission to the moon was on its way, the three crew members looked back to photograph a spectacular view of Earth. Seeing our planet surrounded by the emptiness of space illustrated the fact that life on Earth depends on self-contained environmental and natural resources that are not limitless. Today, it is said that more people have seen this photograph than any other in history. This iconic Earth image continues to be an internationally known symbol for environmental awareness, and it has increased our concern for conserving our planet's resources and environments.

Viewed from far enough away to see an entire hemisphere, Earth is beautiful and intriguing. From this perspective we can begin to appreciate the big picture, a global view of our planet's physical geography. If we look carefully, we can recognize geographic patterns shaped by the processes that make our world dynamic and ever changing. Characteristics of the oceans, atmosphere, landmasses, and evidence of life, revealed by vegetated regions, are apparent.

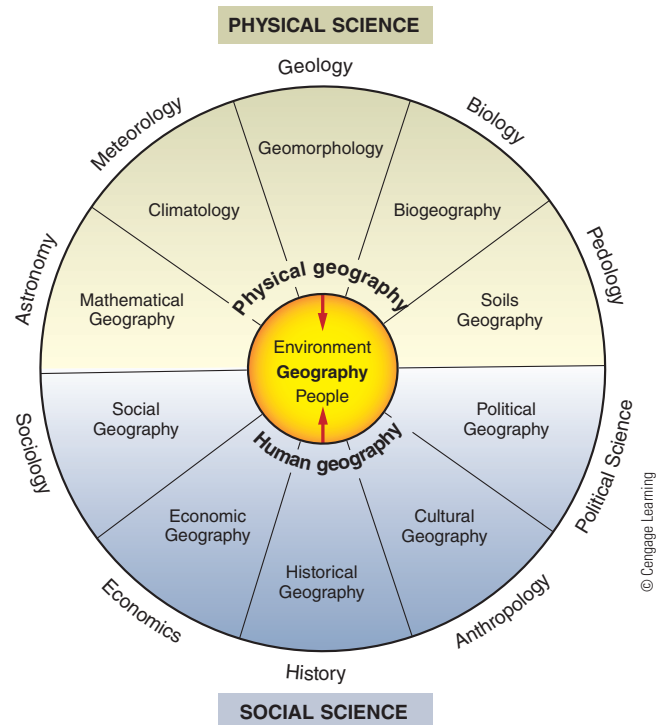
From a human perspective, Earth might seem immense and almost limitless. In contrast, viewing the big picture reveals Earth's fragile nature: a spherical island of life surrounded by the vast dark emptiness of space. Except for the external addition of energy from the sun, our planet is a self-contained system that has all the requirements to sustain life. The nature of Earth and its environments provide the life-support systems for all living things. It is important to gain an understanding of the planet that sustains us, and learn about the components and processes that operate to change or regulate the Earth system. Learning the relevant questions to ask is an important step toward finding answers and explanations. Understanding how Earth's features and processes interact to develop the environmental diversity on our planet is the goal of a course in physical geography.

## The Study of Geography

**Geography** refers to the examination, description, and explanation of Earth—its variability from place to place, how places and features change over time, and the processes responsible for these variations and changes. Geography is often called the

**spatial science** (the science of locational space) because it includes analyzing and explaining the locations, distributions, patterns, variations, and similarities or differences among phenomena on Earth's surface.

Geographers study the processes that influenced Earth's landscapes in the past, how they continue to affect them today, how landscapes and environments might change in the future, and the significance or impact of these changes. Geography is distinctive among the sciences by virtue of its definition and central purpose, and it can involve studying any topic related to the scientific analysis of natural or human processes on Earth (■ Fig. 1.1).



■ **FIGURE 1.1** Geography has many subdivisions that are related to other disciplines and share some of their interests. Geographers apply their own unique perspectives and approaches to these areas of study.

**What advantage might a geographer have when working with other physical scientists seeking a solution to a problem?**



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■ **FIGURE 1.2** Physical geographers study the elements and processes that affect natural environments. These include rock structures, landforms, soils, vegetation, climate, weather, and human impacts. This is in the White River National Forest, Colorado.

**What physical geography characteristics can you observe in this scene?**

Geographers are also interested in how to divide areas into meaningful **regions**, which are areas identified by distinctive characteristics that distinguish them from surrounding areas. Physical, human, or a combination of factors can define a region. *Regional geography* concentrates on the characteristics of a region or of multiple regions.

## Physical Geography

**Physical geography** encompasses the processes and features that make up Earth, including human activities where they interface with the environment. Geographers generally take a **holistic approach**, meaning that they often consider both the natural and human phenomena that are relevant to understanding aspects of our planet. Physical geographers are concerned with nearly all aspects of Earth and are trained to view a natural environment in its entirety, as well as how it functions as a unit (■ Fig. 1.2). Most physical geographers focus their expertise on one or two specialties. For example, many *meteorologists* and *climatologists* have studied geography. Meteorologists are interested in the processes that affect daily weather, and they forecast weather conditions. Climatologists are interested in regional climates, the averages and extremes of long-term weather data, understanding climate change, climate hazards, and the human and environmental impacts of climate.

*Geomorphology* is the study of the nature and development of landforms and is a major subfield of physical geography. Geomorphologists are interested in understanding variations in landforms and the processes that produce

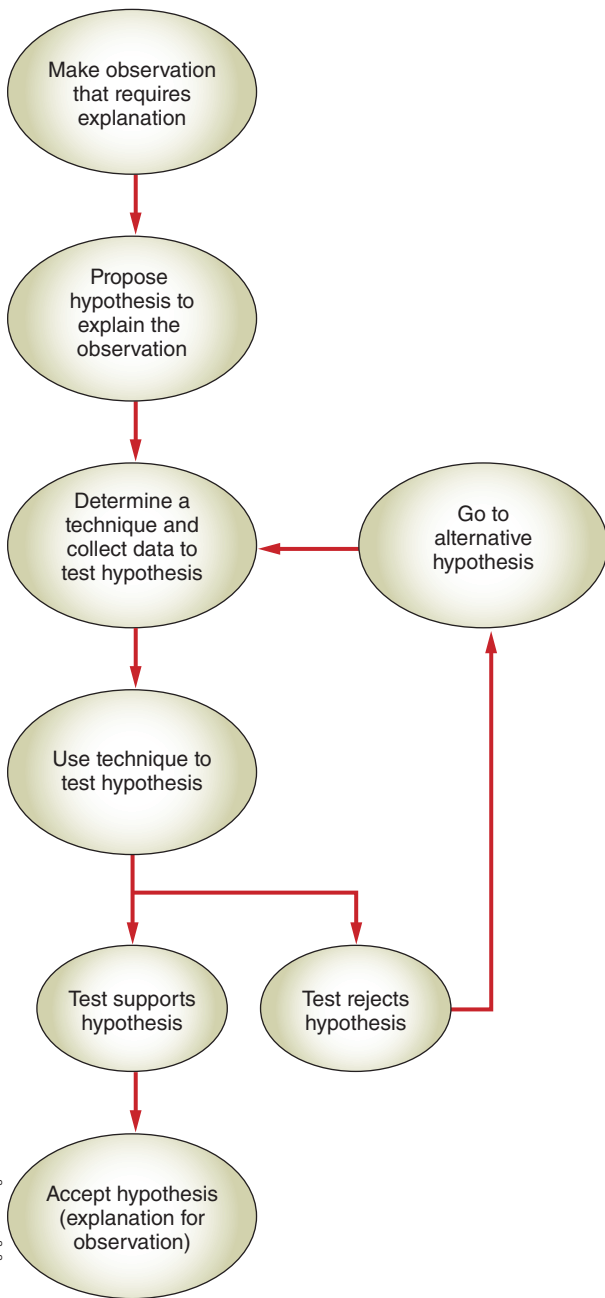
Earth's surface landscapes. *Biogeographers* study plants, animals, and environments, examining the processes that influence, limit, or facilitate their characteristics, distributions, and changes over time. Many *soil scientists* are geographers who map and analyze soil types, determine the suitability of soils for certain uses, and work to conserve soil resources.

Geographers are also widely involved in the study of water bodies and water resources, including their processes, movements, impacts, quality, and other characteristics. They can serve as *hydrologists*, *oceanographers*, or *glaciologists*. Many geographers also function as *water resource managers*, working to ensure that lakes, watersheds, springs, and groundwater sources are adequate in quantity and quality to meet human and environmental needs.

Like other scientists, physical geographers typically apply the **scientific method** as they seek to learn about aspects of Earth. The scientific method involves seeking the answers to questions and determining the validity of new ideas by objectively testing all pertinent evidence and facts that affect the issue being studied (■ Fig. 1.3). Using the scientific method, new ideas or proposed answers to questions are only accepted as valid if they are clearly supported by the evidence.

## Technology, Tools, and Methods

The technologies that are used for learning about the physical geography of our planet are rapidly changing. The abilities of computer systems to capture, process, model, and display



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■ **FIGURE 1.3** The scientific method, widely applicable in physical geography, involves the steps shown here.

- 1. Making an observation that requires an explanation.** On a trip to the mountains, you notice that it gets colder as you go up in elevation. Is that just a result of local conditions on the day you were there, or is it a universal relationship?
- 2. Restating the observation as a hypothesis.** Here is an example: As we go higher in elevation, the temperature gets cooler. (The answer may seem obvious, but although it is generally true, there are exceptions depending on environmental conditions, which are discussed in later chapters.)
- 3. Determining a technique for testing the hypothesis and collecting necessary data.** The next step is finding a technique for evaluating data and facts that relate to the hypothesis. In this case, you would gather temperature and elevation data (taken at about the same time for all data points) in the study area.
- 4. Applying the technique or strategy to test the validity of the hypothesis.** Here we discover if the hypothesis is supported by adequate evidence. The technique will recommend either accepting or rejecting the hypothesis. If the hypothesis is rejected, we can test an alternative hypothesis, or we might just discover that our hypothesized relationship is not valid.

spatial data—functions that can now be performed on a personal computer—were only a dream in the 1980s. Today, the Internet provides access to information and images on virtually any topic. Continuous satellite imaging of Earth has been ongoing for more than 30 years, which has given us a better perspective on environmental changes. Using various energy sources to produce images from space, we are able to see, measure, monitor, and map processes and the effects of certain processes, including many that are invisible to the naked eye. Graphic displays of environmental data and information are becoming more vivid and striking as a result of sophisticated methods of data processing and visual representation. Increased computer power allows the development and display of high-resolution images, three-dimensional scenes, and animated images of Earth's features, changes, and processes (■ Fig. 1.4).

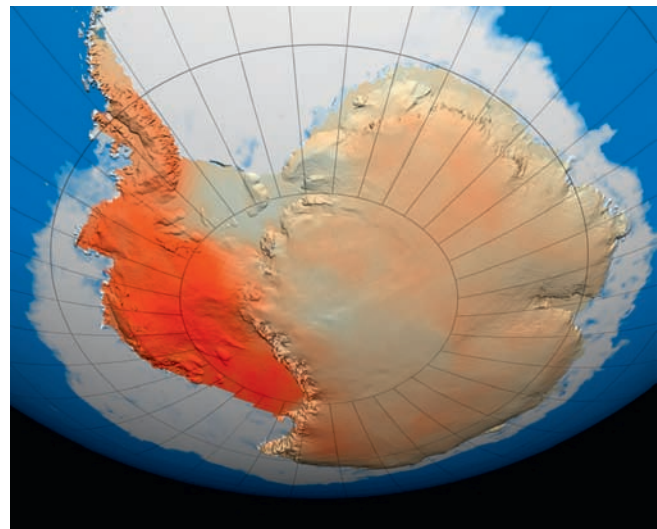


Image by R.B. Husar, Washington University; land layer from the SeaWiFS Project; fire maps from the European Space Agency; sea surface temperature from the Naval Oceanographic Office's Visualization Laboratory; and cloud layer from SSEC, University of Wisconsin

■ **FIGURE 1.4** This computer-generated, three-dimensional model of Antarctica was made by combining a 50-year history of temperature records from locations on the continent with modern satellite images of the ice surface. The red area shows the region that has experienced the largest temperature increase in response to global warming.

**What global warming impacts have caused concern in recent years?**



© Ashley Cooper/Corbis

■ **FIGURE 1.5** A geographer uses computer technology to analyze maps and imagery.

**In what ways are computer-generated maps and landscape images helpful in studying physical geography?**

Satellite technology (*GPS, the Global Positioning System*) is used to determine the precise location of a receiver on Earth's surface, a capability that has many useful applications for geography and mapping. Today, most mapmaking (*cartography*) and many aspects of map analysis are computer-assisted operations, although the ability to visually interpret a map, a landscape, or an environmental image remains an important geographic skill.

Physical geographers should be able to make observations and gather data in the field, but they must also keep up with new technologies that support and facilitate traditional fieldwork. Technology can provide maps, images, and data, but a person who is knowledgeable about the geographical aspects of the subject being studied is essential to the processes of analysis and problem solving. Many geographers are gainfully employed in positions that apply technology to the problems of understanding our planet and its environments, and their numbers are certain to increase in the future (■ Fig. 1.5).

## Major Perspectives in Physical Geography

Your textbook demonstrates three major perspectives that physical geography emphasizes: spatial science, physical science, and environmental science. Although the focus on each of these perspectives varies from chapter to chapter, take note of how each perspective relates to the unique nature of geography as a discipline.

## The Spatial Perspective

A central theme in geography is illustrated by its definition as the *spatial science*. Physical geographers have many divergent interests, but they share the common goals of understanding and explaining spatial variations on Earth's surface. The following examples illustrate spatial factors that geographers typically consider and the problems they address.

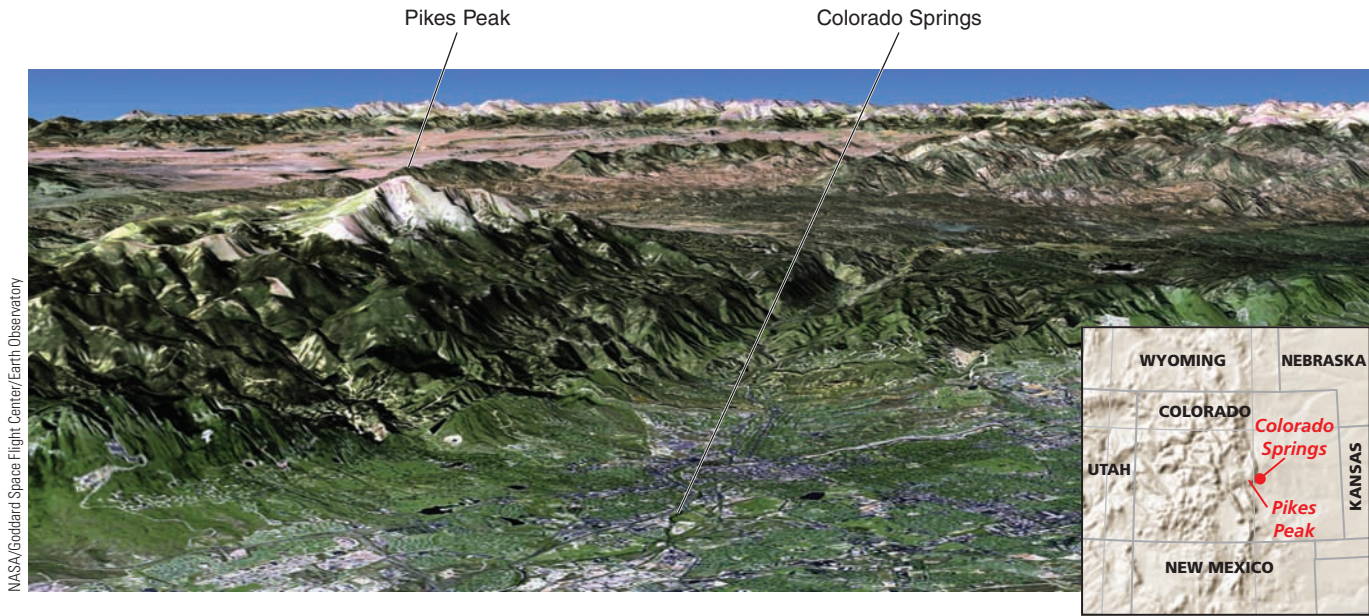
**Location** Geographic studies often begin with locational information. Features are located using one of two methods: **absolute location**, which is expressed by a coordinate system (or address), or **relative location**, which identifies where a feature exists in relation to something else, usually a fairly well known location. For example, Pikes Peak, in the Rocky Mountains of Colorado, with an elevation of 4302 meters (14,115 ft), has a location of latitude 38°51' north and longitude 105°03' west. This is an example of an *absolute location*. However, it could also be stated that Pikes Peak is 36 kilometers (22 mi) west of Colorado Springs (■ Fig. 1.6). This is an example of a *relative location*.

**Characteristics of Places** Physical geographers are interested in the environmental features and processes that make a place unique, as well as in the shared or similar characteristics between places. For example, what physical geographic features make the Rocky Mountains appear as they do? Further, how are the Appalachian Mountains different from the Rockies, and what characteristics are common to these two mountain ranges? Another aspect of the characteristics of places is the analysis of the environmental advantages and challenges that exist in a place.

**Spatial Distribution and Pattern** **Spatial distribution** is a locational characteristic that refers to the extent of an area or areas where a feature exists. For example, where on Earth do we find tropical rainforests? What is the distribution of rainfall in the United States on a particular day? Where do major earthquakes occur? **Spatial pattern** refers to how features are arranged in space: Are they regular or random, clustered together or widely spaced? Population distributions can be dense or sparse (■ Fig. 1.7). The spatial pattern of earthquakes may be aligned on a map because earthquake faults display similar linear patterns.

**Spatial Interaction** Few processes on Earth operate in isolation, because areas on our planet are interconnected. A condition, an occurrence, or a process in one place generally has an impact on other places. Unfortunately, the exact nature of a **spatial interaction**—whether one event actually causes another—is often difficult to establish with certainty.

Examples of observed spatial interactions include the occurrence of abnormally warm ocean waters off South America's west coast, a condition called *El Niño*, and its link to unusual weather in other parts of the world. Clearing the tropical rainforest might also have an impact on world climates.



■ **FIGURE 1.6** A three-dimensional digital model shows the relative location of Pikes Peak to Colorado Springs, Colorado. Because this is a perspective view, the 36 km (22 mi) distance appears to be shorter than its actual ground distance.

**What physical geographic characteristics of this place can you extract from the image?**



■ **FIGURE 1.7** A nighttime satellite image provides good illustrations of distribution and pattern. Spatial distribution means where features are located (or, perhaps, absent). Spatial pattern refers to their arrangement. Geographers seek to explain these spatial relationships.

**Can you locate and propose possible explanations for two patterns and two distributions in this scene?**

Geographers work to understand spatial relationships, interactions, and impacts at local, regional, and global scales.

**The Changing Earth** Earth's features and landscapes are continuously changing in a spatial context. Weather maps show where and how weather elements change from day to day, over the seasons, and from year to year. Storms, earthquakes, landslides, and stream processes modify the landscape. Coastlines can change position because of storm waves, tsu-

namis, or changes in sea level. Areas that were once forested have been clear-cut, changing the nature of the environment there. Desert-like conditions seem to be expanding in many arid regions of the world. Volcanic islands have been created in historic times.

World climates have changed throughout Earth's history, with attendant shifts in the distributions of plant and animal life. Recent global warming is affecting virtually all areas of the world, but the impact varies by geographic region and loca-

## GEOGRAPHY'S SPATIAL PERSPECTIVE

## NATURAL REGIONS

The term *region* has a precise meaning and special significance to geographers. Simply stated, a region is an area that is defined by a certain shared characteristic (or a set of characteristics) existing within its boundaries. The concept of a region is a tool for thinking about and analyzing logical divisions of areas based on their geographic characteristics. Geographers not only study and explain regions, including their locations and characteristics, but also strive to delimit them: to outline their boundaries on a map. An unlimited number of regions can be derived for each of the four major Earth subsystems.

Regions help us understand the arrangement and nature of areas on our planet. Regions can also be divided into subregions. For example, North America is a region, but it can be subdivided into many subregions. Examples of subregions based on natural characteristics include the Atlantic Coastal Plain (similarity of landforms, geology, and locality), the Prairies (ecological type), the Sonoran Desert (climate type, ecological type, and locality), the Pacific Northwest (general locality), and Tornado Alley (region of high potential for these storms).

There are three important points to remember about natural regions. Each of these points has endless applications and adds considerably to the questions that the process of defining regions based on spatial characteristics seeks to answer.

- **Natural regions can change in size and shape over time in response to environmental changes.** An example is desertification, the expansion of desert regions that has occurred in recent years. Using images from space, we can see and monitor changes in the

areas covered by deserts and other natural regions.

- **Boundaries separating different natural or environmental regions tend to be indistinct or transitional, rather than sharp.** For example, on a climate map, lines separating desert from nondesert regions do not imply that extremely arid conditions instantly appear when the line is crossed. When we travel to a desert, the region is likely to get progressively more arid as we approach our destination.
- **Regions are spatial models devised by humans for geographic analysis, study, and understand-**

**ing.** Natural regions are conceptual models that help us comprehend and organize spatial relationships and geographic distributions. Learning geography is an invitation to think spatially, and regions provide an essential and extremely useful conceptual framework in that process.

Understanding regions, through an awareness of how areas can be divided into geographically logical units and why it is useful to do so, is essential in geography. Regions help us to understand, reason about, and make sense of the spatial aspects of our world.



The Great Basin of the Western United States is a landform region that is clearly defined based on an important physical geographic characteristic. No rivers flow to the ocean from this arid and semiarid region of mountains and topographic basins. The rivers and streams that exist flow into enclosed basins where the water evaporates away from temporary lakes, or they flow into lakes like the Great Salt Lake, which has no outlet to the sea. Topographic features called drainage divides (mountain ridges) form the outer edges of the Great Basin, defining and enclosing this natural region.



■ **FIGURE 1.8** Photographs taken 92 years apart in Montana's Glacier National Park show that Shepard Glacier, like other glaciers in the park, has dramatically receded during that time. This retreat is in response to climate warming and droughts.

**What other kinds of environmental change might require long-term observation and recording of evidence?**

tion. Today, changes in Earth's climates and environments are complicated by the impact of human activities. Most of Earth's glaciers are shrinking in response to global warming (■ Fig. 1.8). Earth and its environments are always changing, although at different time scales, so the impacts and direction of certain changes can be difficult to determine.

## The Physical Science Perspective

Physical geographers observe phenomena, compile data, and seek answers to questions that are also of interest to researchers in other physical sciences. However, physical geographers bring distinctive points of view to scientific studies: a holistic perspective and a spatial perspective. By examining the factors, features, and processes that influence an environment and how these elements work together, we can better understand our planet's dynamic physical geography. We can also appreciate the importance of viewing Earth as a constantly functioning system.

**The Earth System** A **system** is any entity that consists of a set of interrelated and interacting parts or components. Our planetary environment, the **Earth system**, operates on interactions among a vast combination of factors. The individual components of a system, termed **variables**, change through interactions with one another as parts of a functioning unit. For example, in a mountainous environment, elevation changes influence the rainfall distribution and the temperature regime, which in turn affect the density, type, and variety of vegetation. Plants, moisture, and the underlying rock affect the soil that forms in an area. Vegetation and soils influence the impact of erosion on the land surface. A change in one environmental factor nearly always has an impact on other parts of an environmental system.

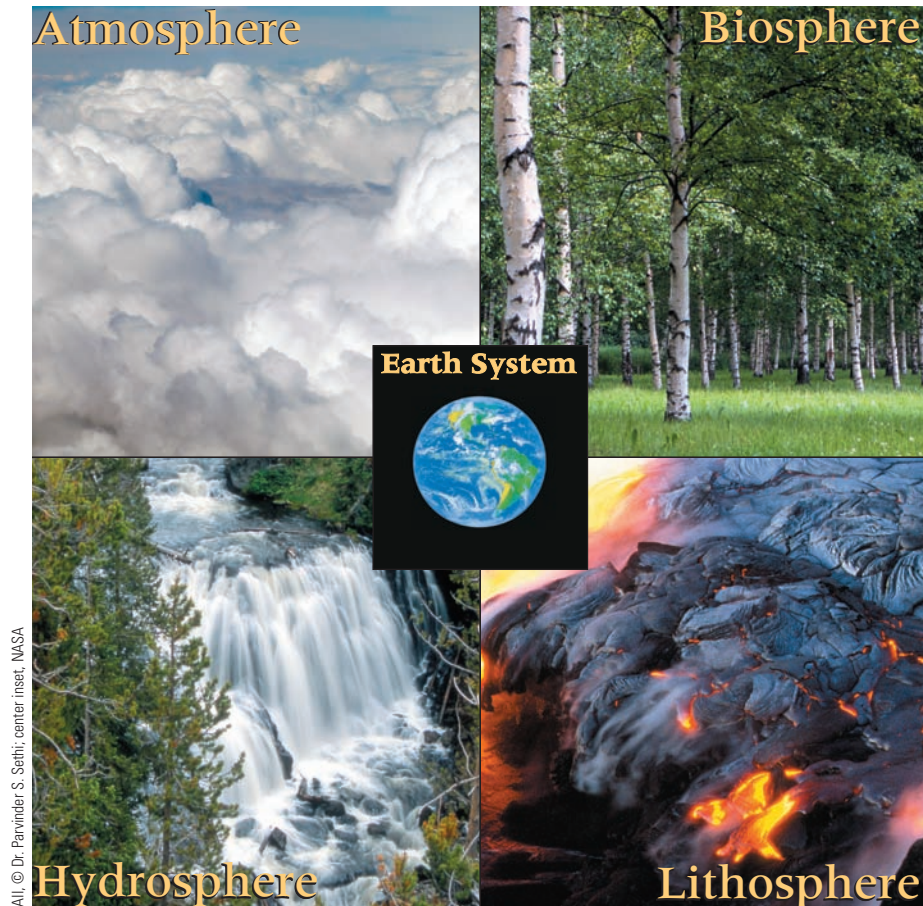
Systems can be divided into **subsystems**, which are functioning units of a system that demonstrate strong internal connections. For example, the human body is a system that is composed of many subsystems (such as the respiratory system,

circulatory system, and digestive system). Examining the Earth system as a set of interdependent subsystems facilitates the study of physical geography.

**Earth's Four Major Subsystems** The Earth system has four major subsystems (■ Fig. 1.9). The **atmosphere** is the gaseous blanket of air that envelops, shields, and insulates Earth. The **lithosphere** makes up the solid Earth—landforms, rocks, soils, and minerals. The **hydrosphere** includes the waters of Earth—oceans, lakes, rivers, and glaciers. The **biosphere** is composed of all living things: people, other animals, and plants.

The characteristics of these subsystems interact to create and nurture the conditions necessary for life on Earth, but the impact and intensity of those interactions are not equal everywhere. This inequality leads to our planet's environmental diversity and produces the wide variety of geographic patterns on Earth.

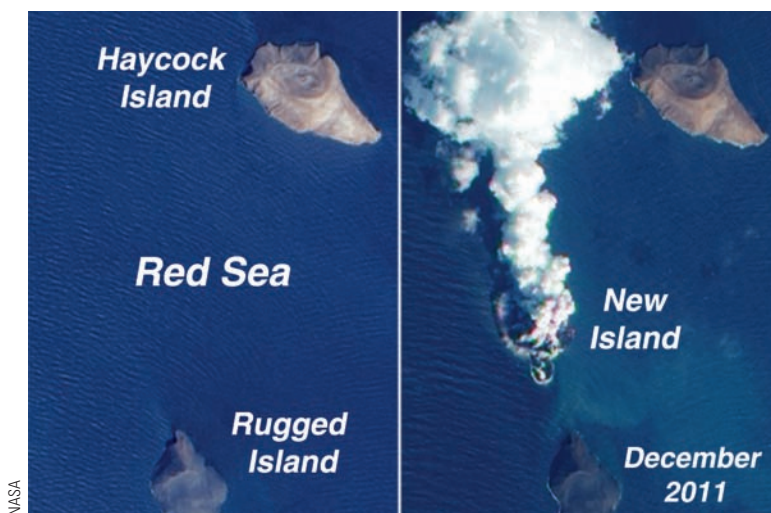
**Earth Impacts** The Earth system is *dynamic*, responding to continuous changes, and we can directly observe some of these changes: the seasons, the ocean tides, earthquakes, floods, volcanic eruptions. Certain interactions that change our planet function in cycles and processes that operate at widely varying rates. Many aspects of our planet can take years, or even more than a lifetime, to accumulate enough change so that humans can recognize their impact. Long-term changes in our planet are often difficult to understand or forecast with certainty. The evidence must be carefully and scientifically studied to determine what is occurring and what the potential consequences might be. Changes of this type include climate change, drought cycles, the spread of deserts, erosion of coastlines, and major changes in river systems. Volcanic islands have been created in historic times (■ Fig. 1.10), and a new Hawaiian island is now forming beneath the waters of the Pacific Ocean. Change may be naturally caused or human induced, or it can result from a combination of these factors. Today, much of the concern about environmental changes,



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■ **FIGURE 1.9** Earth's four major subsystems. Studying Earth as a system is central to understanding changes in our planet's environments and adjusting to or dealing with these changes. Earth consists of many interconnected subsystems.

**How do these systems overlap? For example, how does the atmosphere overlap with the hydrosphere, or with the biosphere?**



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■ **FIGURE 1.10** This new volcanic island formed in the Red Sea beginning on December 23, 2011 when volcanic eruptions from the seafloor began to reach the surface. The island at this time was about 500 meters long, but growing.

**Once this volcanic island cools, what other environmental changes could slowly begin to take place?**

such as global warming, centers on the increasing impact that human activities are exerting on Earth's natural systems.

## The Environmental Perspective

In the broadest sense, our **environment** can be defined as our surroundings, consisting of all physical, social, and cultural aspects of our world that affect our growth, our health, and our way of living. Physical environments are systems composed of a wide variety of features, characteristics, and processes that involve interconnections among weather, climate, soils, rocks, terrain, plants, animals, water, and humans. Physical geography's holistic approach is well suited to understanding environments, because important environmental factors and processes are considered both individually and as parts of a functioning system.