Preface

Teaching earth science can be viewed as content instruction, covering the principles of science and earth systems. But can it also be considered as an opportunity to *engage* students in the nature of scientific inquiry?

> *A traditional science instructor concentrates on teaching factual knowledge, with the implicit assumption that expert-like ways of thinking about the subject come along for free or are already present. But that is not what cognitive science tells us. It tells us instead that students need to develop these different ways of thinking by means of extended, focused, mental effort.*
>
> *Carl Wieman*
> *Nobel Prize winner*

For many, the wonder of Earth and its features is enough to drive learning. For these happy few, a readable book with lots of attractive photographs is almost all that is required. *But for many—in fact most—learning takes more than pretty words and pictures.* Providing high-quality teaching is the most cost-effective, tangible, and timely effort that geoscience instructors can make to improve student engagement, increase attendance, and add majors.

But how do we do that? There is extensive literature describing what effective teaching looks like, but most science instructors have not had access to these articles and books. Further, few of us were ever explicitly taught the components of good teaching. Instead, we were left to figure it out for ourselves on the basis of our classroom experiences as students.

The Good Earth was published to support both the traditional earth science class ***and*** to serve as an accessible resource for instructors seeking to apply effective teaching strategies to enhance learning.

The Good Earth *Difference*

We wrote *The Good Earth* to support an active learning approach to teaching and to provide the necessary resources for instructors moving through the transition from passive to active learning. Like you, we want our students to walk away from this course with an appreciation for science and the ability to make life decisions based on scientific reasoning.

Our goal was to write a book that was engaging for students but that also included resources that illustrated for instructors how to use teaching practices that have been shown to support student learning. The materials and methods discussed in the text and the accompanying *Instructor's Manual* have been tried and tested in our own classes. Our research shows that the integration of the materials and pedagogy provided in this book not only improved students' understanding of earth science as measured by standardized national tests, but it can also improve students' logical thinking skills by twice as much as a typical "traditional" lecture class. Such methods are overwhelmingly preferred by students and increase student attendance and satisfaction with the course. Finally, a significant point for us is that these methods make teaching class more fun for the instructor.

I love the voice the authors use. Reading the text is like listening to a very intelligent but down-to-earth friend explain a difficult topic. The authors are excellent at organizing and presenting the material. . . . The illustrations are superior to other texts in all ways.

Patricia Hartshorn
University of Michigan–Dearborn

Student-Centered Research

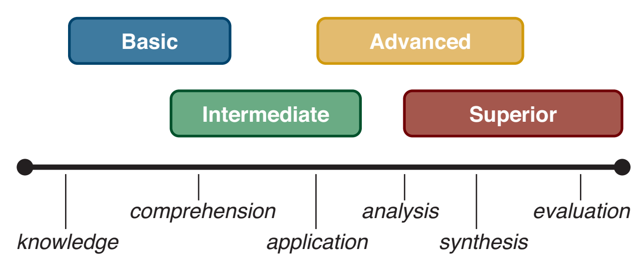
The Good Earth can be used as a text for a traditional, teacher-centered lecture-based course. In fact, we have taken great care to write a book that students would find more engaging than a typical text. But the greatest benefit will come when the book is used as part of an active-learning, student-centered course. For some instructors, it may simply be a matter of adding some of our exercises to an existing active-learning class environment. For others, the book and accompanying materials will give them an opportunity to add components as they gradually change their pedagogy. If you want a more interactive class, try one or all of the following three recommendations based on research findings:

1. Students learn key concepts better when they have opportunities to actively monitor their understanding during class. Rather than just standing up and talking, the instructor can break lectures into segments separated by brief exercises to make sure that students understand concepts before moving on. Students' understanding must be frequently challenged to provide an opportunity to identify misconceptions and replace them with improved, more realistic models.

   The Good Earth includes hundreds of Checkpoint exercises that can also be used as handout-ready PDF files (located on the text website along with answer keys). Practice makes perfect: the more opportunities students have to assess their learning and to practice the application of new skills, the better their performance. If you are concerned about reduced time for lecture, we have found that an emphasis on fostering deeper understanding and less content coverage in lecture, combined with greater student responsibility for reading, produced no decrease in content knowledge attainment and improved student comprehension of key concepts. Some exercises can be assigned as homework, and the answer key in the back of the book can help students to assess their self-directed-learning.

2. Students become better learners when we challenge them to answer questions that require the use of higher-order thinking skills (for example, analysis, synthesis, evaluation). Brain research shows that people become smarter when they experience cognitive challenges. However, it is important not to throw students into the deep end without any help. Instead, instructors need to step through a series of problems of increasing difficulty (scaffolding) so that they can train students to correctly apply their newly acquired thinking skills.

   Therefore, we have carefully created a series of color-coded **Checkpoint** exercises for each section of every chapter. The exercises are pitched at four skill levels: basic, intermediate, advanced, and superior, to give students and instructors an opportunity to scaffold student understanding of key concepts. The questions represent four levels of Bloom's taxonomy. Blue and green questions typically are comprehension and application-level questions. Yellow and red checkpoints typically require analysis, synthesis, or evaluation skills. It is not necessary to complete all the exercises; instructors can select the exercises that are most appropriate for their learning goals.



This was kind of a neat idea, and the questions [Checkpoints] do get quite challenging at higher orders. I feel these are good things for students to do while studying, with the idea that if they understand the higher order questions they will understand concepts better for exams. I thought these checkpoints have some very well-formulated questions in the chapters I reviewed.

Swarndeep Gill
California University of Pennsylvania

I like the fact that the authors are mindful and well versed in science education research and pedagogy. This aspect of the author's background is evident in the design of the Checkpoint questions.

The use of Concept Maps and Venn Diagrams is fairly cutting edge for introductory Earth Science textbooks that I am familiar with. This is probably the most innovative aspect of this book and distinguishes it from similar texts, even though the content is presented very similarly to other texts.

Jeffrey Templeton
Western Oregon University

Sort ...

Checkpoint 11.1

basic intermediate advanced superior

Sort the following 12 terms into six pairs of terms that most closely relate to one another. Explain your choices.

groundwater	plants	transpiration
stream	ice	infiltration
rainfall	precipitation	water vapor
gas	meltwater	runoff

Match the lettered responses ...

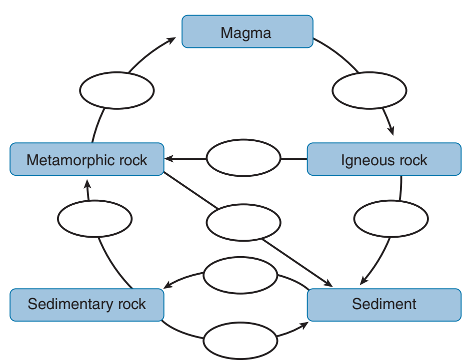
Checkpoint 7.22

basic intermediate advanced superior

Rock Cycle Diagram

The following diagram illustrates some of the interactions of the rock cycle. Match the lettered responses to the blank ovals on the diagram. (*Note:* Some letters are used more than once.) Example: If you believe that metamorphic rock is converted to magma by cementation and compaction, enter "a" in the top left oval.

a) Cementation and compaction (lithification)
b) Heat and pressure
c) Weathering, transportation, deposition
d) Cooling and solidification
e) Melting



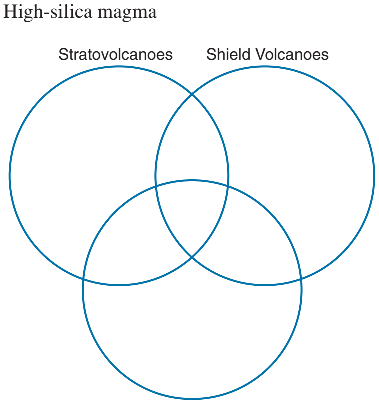
Checkpoint 6.19

basic intermediate advanced superior

Venn Diagram: Shield Volcanoes, Stratovolcanoes, and Cinder Cones

Use the Venn diagram provided here to compare and contrast the three principal types of volcanoes. Place the number corresponding to features unique to each type in the larger areas of the circles; note features they share in the overlap area in the center of the image. Five items are provided; identify at least 12 more.

1. Associated with subduction zones
2. Have a triangular shape in profile
3. Example: Mount Hood, Oregon
4. Mild eruptions
5. High-silica magma



Compare and contrast ...

Evaluate the five most important factors ...

Checkpoint 12.12

basic intermediate advanced superior

Groundwater Evaluation Rubric

You are asked to help locate a new aquifer that will supply your town with water. In examining the potential sites, you recognize that several different factors will influence groundwater availability and at no single site are all of the factors optimal. You decide to create a scoring scheme to evaluate the five most important factors that will influence the availability of groundwater. The location that scores the highest according to the rubric will be selected for the well field. One factor is included as an example in the table below; identify five more.

Factors	Poor (1 point)	Moderate (2 points)	Good (3 points)
Depth to water table	Deep	Intermediate	Shallow

I have to compliment you on putting together Checkpoint 3.3. This was probably the best evaluation tool I have seen for determining whether a student really understands the meaning of the words we use to describe the scientific methods (hypothesis, prediction, etc.).

Neil Lundberg
Florida State University

3. Knowledge is socially constructed and people learn best in supportive social settings. Students do not enter our classrooms as empty vessels to be filled with knowledge. Instead, they actively construct mental models that assimilate new information with previous experiences. This construction of knowledge happens most readily when students work in small collaborative groups (three to four students), where they can talk and listen to peers as they build their understanding of new concepts. Students must be provided with opportunities to be self-reflective about their learning and to help them learn how to learn. Our research confirmed that students in classes where small groups worked to solve challenging problems outperformed students in classes where they worked on the same problems independently.

It is set up very user friendly and will make it easy for instructors to create an interactive learning environment. Also, the way the chapters and questions are laid out, students will know exactly what they should be getting from the chapter and how to test their knowledge and skills.

Jessica Kapp
University of Arizona

Whether you choose to use informal groups ("turn and talk to your neighbors") or formal groups determined by experiences (for example, number of science classes, scores on pretests, academic rank), collaborative learning is a powerful mechanism for maintaining attendance, increasing student-instructor dialogue, and enhancing learning. The Checkpoint exercises (especially advanced and superior level) and conceptests (conceptual multiple choice questions) provided with the book will give you many assignments that you can use as the basis for group work.

For detailed information regarding concept maps, Venn diagrams, Bloom's taxonomy, assessment, and so forth, please consult the *Instructor's Manual* on the text website: http://www.mhhe.com/thegoodearth3e

Tools for Teaching and Learning Science Literacy

Science can be thought of in three ways: as a body of knowledge, as the processes that people employ to explain the universe, and as a set of attitudes and values possessed by those who "do science." This latter aspect is often overlooked in college science textbooks. For each chapter of *The Good Earth*, the *Instructor's Manual* gives suggestions for incorporating into class discussion science attitudes and values such as open-mindedness, skepticism, persistence, and curiosity.

Additionally, the discussion of the **scientific method** is woven throughout the text. We emphasize three scientific themes throughout the text: 1) scientific literacy, 2) earth science and human experience, and 3) the science of global change. Numerous examples of human interaction with Earth serve as introductions to each chapter. Each chapter includes examples of the connection between science and technology, and builds on a context or event familiar to the student. We believe that links to students' past knowledge and experience are essential foundations upon which to build deeper understanding.

In addition to the theme of global change permeating the text, we devote a full chapter to the topic and do not duck the tough issues related to it. We use data and evidence to help students build their own understanding and assist them to realize that *"Much of what lies ahead for the good Earth is up to us. Know, care, act."*

I am pleased to see the final chapter on global change; most students assume that climate change is a political debate, so it is nice to see a textbook that discusses the science behind the news.

Bryan C. Wilbur
Pasadena City College

Ways to Direct Learning

Rather than put key vocabulary terms in bold, we put **key concepts** in bold font. Our rationale is that conceptual understanding is the goal; vocabulary terms alone may not lead to the understanding that we desire. Research suggests that listing key terms encourages the memorization of those terms, rather than the understanding of the associated concepts—rather like learning words in a foreign language but being unable to put together a sentence. To make students fluent in science, we chose to focus on a vocabulary that builds students' conceptual understanding of major ideas in earth science. These ideas were recommended by standards-setting groups, such as the American Association for the Advancement of Science (AAAS).

Students can use the Checkpoint surveys to self-evaluate their comprehension of the major concepts in the section. Self-evaluation is a life skill that persists far longer than the evaluation imposed by an outside party (that is, the instructor). We believe in ongoing assessment tied to each key concept while ideas are still fresh. In contrast, other texts may provide tools for assessment only at the end of the chapter, after all of the content has been covered.

National Committee on Science Education Standards and Assessment

National Research Council

LEARNING SCIENCE IS AN ACTIVE PROCESS. Learning science is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others. Science teaching must involve students in inquiry-oriented investigations in which they interact with their teachers and peers.

FOCUS AND SUPPORT INQUIRIES. Student inquiry in the science classroom encompasses a range of activities. Some activities provide a basis for observation, data collection, reflection, and analysis of firsthand events and phenomena. Other activities encourage the critical analysis of secondary sources—including media, books, and journals in a library.

ENCOURAGE AND MODEL THE SKILLS OF SCIENTIFIC INQUIRY, AS WELL AS THE CURIOSITY, OPENNESS TO NEW IDEAS, AND SKEPTICISM THAT CHARACTERIZE SCIENCE.

USE MULTIPLE METHODS AND SYSTEMATICALLY GATHER DATA ON STUDENT UNDERSTANDING AND ABILITY. Because assessment information is a powerful tool for monitoring the development of student understanding, modifying activities, and promoting student self-reflection, the effective teacher of science carefully selects and uses assessment tasks that are also good learning experiences.

Often students have some fundamental knowledge of earth science and, when reminded, are able to apply this information to the introduction of new concepts. Each chapter includes a **Self-Reflection Survey** to promote awareness of personal experiences.

Self-Reflection Survey: Section 1.1

Respond to the following questions as a means of uncovering what you already know about Earth and earth science.

1. Which of the following earth science phenom experienced? Which would you most like to ex Can you think of three more things to add to t
   - A volcanic eruption
   - A glacier
   - A river in flood
   - A cave system
   - An underground mine
   - A canyon
   - An earthquake
   - An erosional coastline (rocky cliffs)
   - A depositional coastline (beaches)
   - A hot desert
   - A continental divide
   - Rock layers with fossils
   - A big, assembled dinosaur skeleton
   - A meteor shower or comet
   - The aurora borealis (the northern lights)
   - A meteorite crater
   - A mountain range over 3,000 meters (over in elevation
   - The top of a cloud
2. What three questions about Earth would you able to answer by the end of this course?

Self-Reflection Survey: Section 17.1

Answer the following questions as a means of uncovering what you already know about global change.

1. Respond to the following questions taken from recent CNN and Gallup polls, and compare your answers to those of other respondents. (See footnote to compare responses.*)

   i) Which of the following statements comes closest to your view of global warming?

   a. Global warming is a proven fact and is mostly caused by emissions from cars and industrial facilities such as power plants and factories.

   b. Global warming is a proven fact and is mostly caused by natural changes that have nothing to do with emissions from cars and industrial facilities.

   c. Global warming is a theory that has not yet been proved.

   d. Unsure.

   ii) In thinking about the issue of global warming, sometimes called the *greenhouse effect*, how well do you feel you understand this issue?

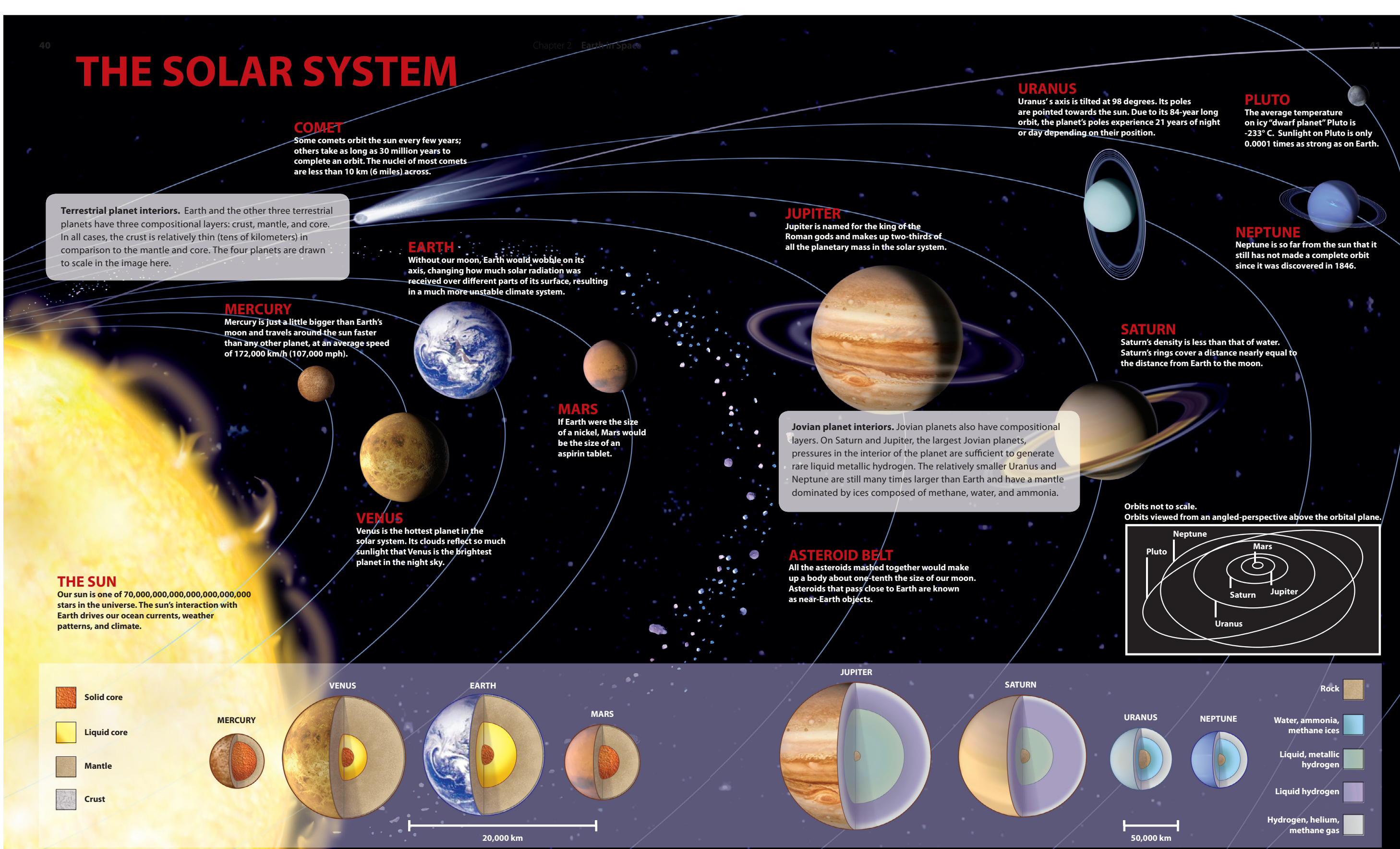
   a. Very well.

   b. Fairly well.

   c. Not very well.

   d. Not at all.

Visuals are of great importance for understanding earth science concepts. *The Good Earth* features two-page **Snapshots** to emphasize an important concept in every chapter.



We frequently hear complaints that students don't get the **Big Picture** and become lost in the vocabulary or in trying to memorize facts. We responded to this concern by connecting a chapter-opening "Big Picture" question and photo to the end-of-chapter summary, titled **The Big Picture,** to help students link the key concepts before moving to a new chapter.

the big picture

When Mount St. Helens began rumbling in 1980, teams of scientists rushed to the mountain with truckloads of instruments to monitor the activity. Still, the May 18 eruption came as a surprise. Despite the experience of the scientists and the sophistication of the devices they deployed, little detailed information on the eruptive history of the volcano had been gathered beforehand and few monitoring instruments had been collecting data. That is no longer the case. In the past quarter-century, scientists have made a concerted effort to place a variety of instruments around the volcano, and even in space, to monitor every rumble and movement. Even with what they know today, it is unlikely that volcanologists would have predicted the precise time of the May 18 eruption. But they would have known enough to have more vigorously encouraged the authorities to move people farther from the volcano itself, dramatically reducing the loss of life.

Educating the public is an important factor in reducing the effects of hazards such as volcanoes. Education should provide a scientifically literate population with the necessary skills to critically respond to scientists' assertions. Deciding what evidence to dismiss and what to pay attention to might mean the difference between life and death for those who live in the shadow of an active volcano. The people living near Mount St. Helens in 1980 weighed the evidence and the accompanying call to action. Some heeded the call to evacuate, while others ignored the evidence provided by the volcanologists, chose to hold their ground, and paid for their decision with their lives.

Mount St. Helens is one of only a few US volcanoes with such a high degree of monitoring. However, the US Geological Survey plans to create a National Volcano Early Warning System that would identify the most threatening volcanic hazards, including the number of people and the extent of property endangered. A preliminary assessment of volcanic threat identified 55 volcanoes as high-threat or very-high-threat sites and recommended that each volcano have an extensive network of monitoring equipment to identify the first signs of unrest. Few such networks are currently deployed, and some of these volcanoes have no monitoring systems at all.

One of the volcanoes in the very-high-threat group is Mount Rainier, pictured looming over Tacoma, Washington, at the beginning of this chapter. At 4,392 meters (14,410 feet), Mount Rainier is the tallest and most imposing volcano in Washington. It is located about 70 kilometers (43 miles) southeast of Tacoma. What questions would you ask if you lived in Tacoma?

Historical records indicate that Mount Rainier does not erupt with the frequency of Mount St. Helens. The distance of the peak and the prevailing westerly winds make it unlikely that tephra would ever reach Tacoma. In addition, lava flows and pyroclastic debris would not extend beyond the foot of the mountain, staying tens of kilometers short of Tacoma. Still, large lahars have the potential to reach the northern suburbs of the city and enter neighboring Puget Sound. Even if Tacoma is safe, many smaller towns lie in stream valleys just a 10-minute trip from the volcano by lahar. It is the residents of towns such as Ashford, Packwood, and Orting (Figure 6.33) who need an early warning system for volcanoes.

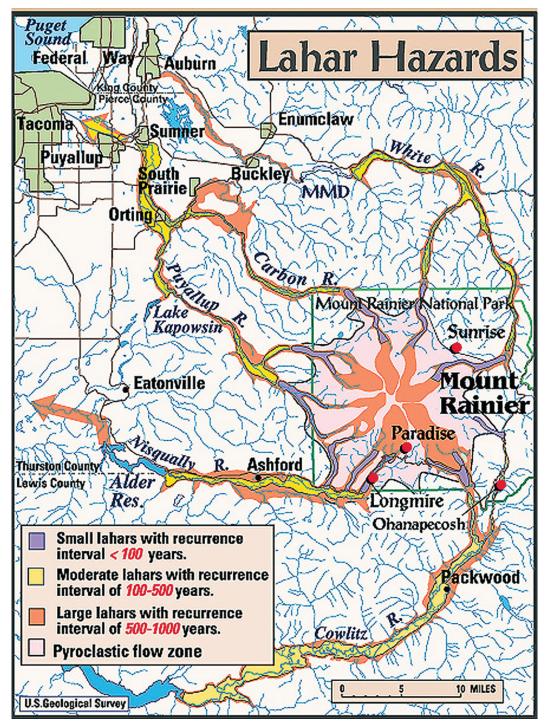


Figure 6.33 Lahar hazards associated with Mount Rainier, Washington.

ple was a magnitude-7.6 quake on October 8, 2005, in northern Pakistan, at the western end of the Himalayas. The earthquake demolished whole towns, killed 90,000 people, and left another 4 million homeless. The unrest continues; Earth at this very moment is shifting, rumbling, building, and decaying. We must carefully observe and prepare.

Volcanoes and Mountains: Concept Map

Complete the following concept map to evaluate your understanding of the interactions between the earth system and volcanoes and mountains. Match the following interactions with the lettered labels on the figure, using the information from this chapter.

Eruption melted ice on Nevado del Ruiz to cause fatal lahars.

Sulfur dioxide blocks incoming sunlight.

Added water causes partial melting of mantle.

Volcanoes add CO_2 and sulfur dioxide to atmosphere.

Commercial airlines are at risk from tephra clouds.

Solar radiation heats Tibetan plateau.

Rain strips CO_2 from atmosphere.

ive tsunami.

ities.

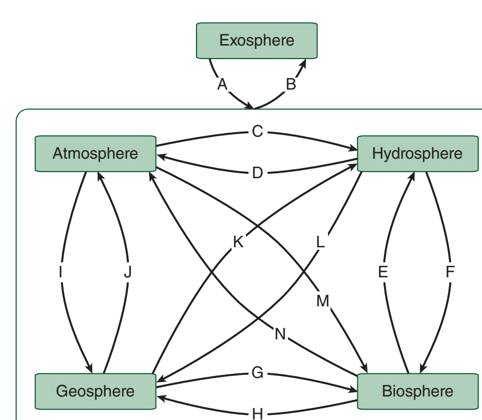
k zones for volcanoes; trees

rivers and lakes from

ng over Himalayas.

Weathering processes break down rocks in mountains.

Instrumentation of volcanoes.

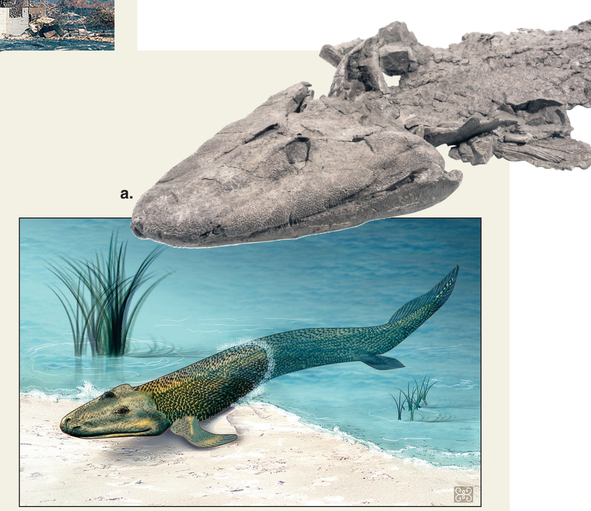


Numerous diagrams, photos, and tables support visual processes and concepts.

a.

b.

Figure 6.15 Hawaiian lava. **a.** A lava tube transports hot, fluid, low-viscosity basalt lava toward the front of a lava flow on Kilauea volcano, Hawaii. **b.** Walter's Kalapana Store and Drive-in was burned and buried within a few weeks in 1990 as lava from the Kilauea volcano invaded communities along the southern coast of Hawaii. Note the height of the original sign. How deep is the lava at this location?



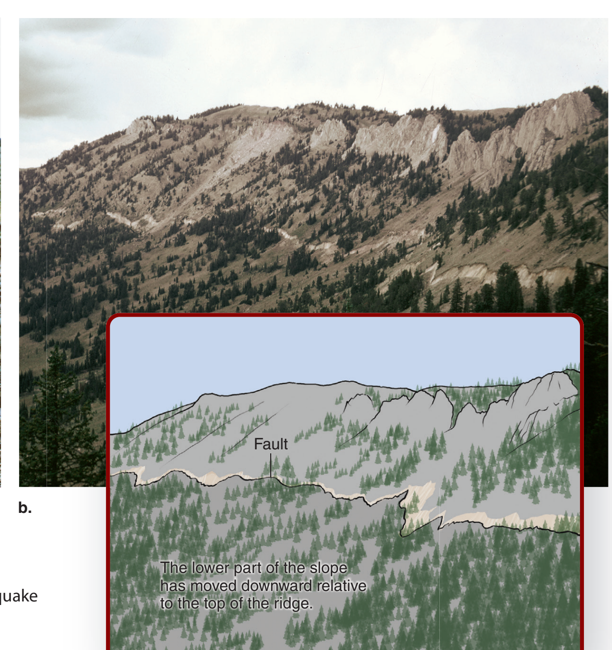
a.

b.

Figure 8.15 Recently discovered Tiktaalik fossil. **a.** This is a transitional fossil between fish and amphibians. The fossil was discovered on Ellesmere Island, Canada, in 375 million-year-old rocks. Several individuals were found, some up to nearly 3 meters (9 feet) long. **b.** A re-creation of what Tiktaalik may have looked like in life.

To further aid in the understanding of earth processes, many figures include a simple drawing to portray a **Geologist's View.**

a.



b.

Geologist's View

Figure 5.5 Signs of movement on a fault. Movement on a 44-kilometer-long (27-mile-long) fault caused the Hebgen earthquake in Montana in 1959. **a.** The fault broke the surface near a ranch (background). **b.** The fault can be followed for several kilometers along the south flank of Kirkwood Ridge in the center of the image.

How Is This Text Organized?

The Good Earth covers the primary topics included in other earth science texts. However, there are a few notable differences in its content compared to other textbooks.

The Good Earth begins with an introduction (Chapter 1), then takes up the topic of astronomy (Chapters 2, 3), and moves on to solid earth (Chapters 4, 5, 6, 7, 8) and the surficial processes (Chapters 9, 10, 11, 12), which overlap with the hydrosphere (Chapters 11, 12, 13), before dealing with the atmosphere (Chapters 14, 15, 16) and finishing with a wrap-up chapter on global change (Chapter 17) that incorporates elements of all the previous chapters.

Astronomy is dealt with early in the text (Chapters 2 and 3) from the context of Earth's position in space. By beginning with Earth's place in the universe, we give students a "big picture," set the context for looking at the uniqueness of this planet in contrast to our neighbors in space, and hopefully, inspire a bit of wonder in the reader. In both chapters, we grab the reader's attention by emphasizing space from a human perspective. We believe this provides a more appealing beginning to an earth science class than the traditional several weeks spent discussing minerals, rocks, and weathering. Chapter 2, in particular, guides students to see methods that scientists employ as they build our knowledge of the planet and its place in the universe.

Plate tectonics appears early (Chapter 4). We introduce this important unifying concept at the beginning of the text and then use it as a foundation to introduce other solid earth topics (for example, earthquakes, volcanoes). Because an understanding of plate tectonics is pivotal to all the content that follows in subsequent chapters, we revisit this concept several times in subsequent chapters, thereby showing students the interrelationships among the other solid earth topics, such as rock formation, earthquakes, and volcanoes.

Driven by recent research findings, we have chosen to emphasize some topics that are discussed briefly or not at all in other earth science texts. We have included chapters on the threat of a collision with near-Earth objects (Chapter 3), Earth's climate system (Chapter 16), and global change (Chapter 17). In addition, the continuing debate about the teaching of creationism in the public schools has lead us to address this topic head-on in our treatment of geologic time (Chapter 8).

New in This Edition

One major change evident throughout the text is the addition of Chapter Learning Outcomes at the beginning of each chapter and the identification of key Learning Objectives at the start of each section in the chapter.

Additional updates to this edition include:

- Figures have been updated and/or replaced throughout the text to better illustrate key concepts and to provide updated data.
- References and discussions to recent significant events have been added:
  - the massive 2010 oil spill in the Gulf of Mexico after the blowout of the Deepwater Horizon drilling platform
  - the major earthquake and tsunami in Japan in 2011
  - east coast damage from superstorm (hurricane) Sandy in 2012
  - the destructive tornado that struck Moore, Oklahoma, in 2013
- Recent data on the human toll and economic costs of recent earthquakes
- Information about the recent sightings of Near Earth Objects
- New discussion on tools used by Earth Scientists
- Rewritten content on extra-solar planets and how planets formed
- A new more detailed account of the rejection of Wegener's drift hypothesis
- Addition of Harry Hess's contribution to the Seafloor Spreading Theory
- Expanded discussion on early earth evolution
- New statistics on weather hazards
- Updated information on recent changes in Arctic Ocean ice coverage
- Updated climate and emissions data
- Increased coverage on the factors affecting density of seawater
- An analogy of a water balloon is used to further explain the concept of Tidal Bulge

Digital Resources

McGraw-Hill offers various tools and technology products to support *The Good Earth,* 3rd Edition.

McGraw-Hill's Connect Plus (www.mcgrawhillconnect.com/Earth Science) is a web-based assignment and assessment platform that gives students the means to better connect with their coursework, with their instructors, and with the important concepts that they will need to know for success now and in the future. The following resources are available in Connect:

- Auto-graded assessments
- LearnSmart, an adaptive diagnostic tool
- Powerful reporting against learning outcomes and level of difficulty
- McGraw-Hill Tegrity Campus, which digitally records and distributes your lectures with a click of a button
- The full textbook as an integrated, dynamic eBook that you can also assign.
- Instructor Resources such as an Instructor's Manual, PowerPoints, and Test Banks.
- Image Bank that includes all images available for presentation tools.

With ConnectPlus, instructors can deliver assignments, quizzes, and tests online. Instructors can edit existing questions and author entirely new problems; track individual student performance—by question, assignment; or in relation to the class overall—with detailed grade reports; integrate grade reports easily with Learning Management Systems (LMS), such as WebCT and Blackboard; and much more.

By choosing Connect, instructors are providing their students with a powerful tool for improving academic performance and truly mastering course material. Connect allows students to practice important skills at their own pace and on their own schedule. Importantly, students' assessment results and instructors' feedback are all saved online, so students can continually review their progress and plot their course to success.

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Educators know that the more students can see, hear, and experience class resources, the better they learn. With Tegrity Campus, students quickly recall key moments by using Tegrity Campus's unique search feature. This search helps students efficiently find what they need, when they need it, across an entire semester of class recordings. Help turn your students' study time into learning moments immediately supported by your lecture. To learn more about Tegrity, watch a 2-minute Flash demo at http://tegritycampus.mhhe.com.

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