

# **Instructor's Guide for Exploring Physical Geography**

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Exploring Physical Geography  
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This document is part of the instructor's guide for *Exploring Physical Geography*, a textbook authored by Reynolds, Rohli, Johnson, Waylen, and Francek, and published by McGraw-Hill Education. The instructor's guide has three components:

- this document,
- a *What-to-Know List* in Word format, and
- a series of PDFs that contain the *Notes* pages from the In-Class PowerPoint files.

This document contains the following: (1) an overview of the educational design and philosophy of the textbook, highlighting how to use the book; (2) a summary of how to use concept sketches (if an instructor decides to); and (3) a single-page overview for each chapter, highlighting some opportunities, challenges, and teaching tips. We recommend that an instructor briefly review the single-page overviews before designing the schedule for the semester, to decide what types of activities will take place during class time.

The *Instructor Notes* PDFs are provided in a separate file for each chapter and are designed for reviewing a subject shortly before teaching. The *Notes* PDFs are derived from the notes field in the In-Class PowerPoint files provided with this textbook. The notes field contains (1) name of any media file associated with that slide, (2) suggestions for student-observation exercises and for instructions to students, and (3) notes about content and teaching tips. The notes field can be viewed on the instructor's computer in PowerPoint, while the students see only the slide show, or the *Notes* PDFs can be printed out and used as paper notes during class. Such printouts, even in black and white, constitute a handy backup in case of last-minute computer or projector malfunctions. The PowerPoint files are designed to guide the instructor so that the instructor does not need to consult any notes during class. The PowerPoint files and associated media files are available on the McGraw-Hill Instructor's website and on [exploringphysicalgeography.com](http://exploringphysicalgeography.com).

## Overview of Exploring Physical Geography

### ***Design and Usage of the Textbook***

Compared to other textbooks, this textbook takes a totally different approach, one that is based on cognitive and education research. Nearly all information in the book is built around figures, rather than being in long blocks of text that are not well articulated with the figures. Each page has one or more annotated illustrations that help students visualize geographic processes, concepts, and features. This approach is suited to the way most instructors already teach, the way we learn, and the way we share ideas with our colleagues. It provides students with a coherent view of geography as a series of systems, with a clear relationship among processes, features, and other aspects.

The book has over 2,600 figures, including illustrations, maps, and photographs. The book includes hundreds of new maps and 3D perspectives of real places that were constructed using real data. Most of the artwork has a 3D perspective so students can use the 3D cues to tell what is a map, what is a perspective view, and what is a cross section.

Topics are presented in two-page spreads so that students can focus on one important geographic process or concept at a time. A visual approach and two-page spreads are suited to today's student, who are busy, have short blocks of time, and were raised in a visually rich world

with access to the Internet. Students are more likely to read this book because it is more inviting, and the format allows them to read small, intact, segments. A student has a higher likelihood of learning from the book during short breaks between classes or other activities.

The book emphasizes geographic concepts, geographic processes, and the way geographers approach problems. The book de-emphasizes terms that are unimportant and unlikely to be used by most students. To steer students away from a strictly terminology-based approach, there are no boldface terms in the text. Instead, key terms are presented in italics so they better blend in with the text and so that the student encounters them in context.

The end of each chapter is an *Investigation* that has students do an authentic problem similar to those done by geographers. These Investigations are built around virtual places and challenge students with nontrivial problems that require observations, interpretations, and critical thinking. Investigations have a clear relevance to society, such as determining where it is safe to live. Some Investigations employ calculations and reading graphs, and students are prepared for these by example calculations earlier in the chapter. These Investigations can be done as in-class activities, homework, or as an end-of-chapter assessment, or they can be incorporated into an instructor's existing laboratory sequence. The online materials have worksheets and assessment items.

### ***What to Cover and Informing Students about What Is Important***

The book covers all the important content for an introductory geography course, but the content is not diluted by extraneous information, stories, and examples. The authors feel that the instructor is in the best position to provide these in class, using examples that are especially relevant to their particular students. To get an idea of the deep level of content, examine the *What-to-Know List* for any chapter. Our experience with the book is that we can only assign 60 to 75% of the items on the list, but those percentages and specific items vary between instructors.

The approach of the book is that everything in the book is potentially important (depending on an instructor's content preferences). The design and implementation of the book allow instructors to rely on the book to cover topics because students do not have to sift through nonessential material to determine what is important. This frees up the instructor to do inquiry, to model approaches to scientific problems, to explore local examples, and to cover other topics of interest to the instructor. We have been using a similar book in geosciences classes for more than a year and have found we can indeed rely on the book — students learned many concepts totally from the book, without us ever even mentioning them in class. One of the authors teaches an online class using a similar book, without a single online lecture, and students successfully learn from the book on their own.

The design of the book makes it easy for the instructor to indicate what is being covered in class and what is not. Instructors can assign or leave out two-page spreads, individual numbered sections within two-page spreads, or individual items in the *Before You Leave This Page* list (via an edited *What-to-Know List*). Instructors can interleave their own content easily because the two-page spread approach allows instructors to temporally sequence their own content between two-page spreads; we recommend this wherever possible to introduce local case studies and examples.

The *Before You Leave This Page* list on each two page spread functions as a built in *What-to-Know* list for students. With this list incorporated into the textbook, students can determine – at

the time they study the material – what they need to know, what they need to know how to do, and whether they have mastered these concepts and skills. Instructors are provided with a master *What-to-Know List* that is a compilation of the items from the *Before You Leave This Page* list. We strongly recommend that an instructor edit this list and post it, or hand it out to students in order to guide student reading and studying to those aspects that the instructor thinks are important. If this edited list is provided to students at the start of the semester (or before each chapter), students know what is and is not important before they begin reading and studying. This potentially limits the “Is this on the test?” question – if it is on the *What-to-Know List*, it may be on the test. The test bank is tightly articulated with the *What-to-Know List*, so the test questions are consistent with what the students expect. A *What-to-Know List* also frees the instructor from having to cover all the content in class simply to let students know what is important and what will be on the test. The list can also be handed out as a study guide before examinations.

### ***Implications of Cognitive and Science-Education Research***

This textbook was developed using first principles from research on cognition and science education. The book is designed to prevent cognitive overload by integrating figures and text so that students can use their visual and phonetic mental processing systems at the same time. Cognitive research demonstrates that such an integrated text-figure approach helps students learn and retain more and be better able to apply or transfer this information to new situations. The book is also specifically designed to reduce cognitive overload by treating topics in digestible two-page spreads and in sections within two-page spreads. The breaks between sections and two-page spreads allow students to consolidate and evaluate their knowledge and understanding before continuing on.

Inquiry is built into the textbook at all levels. The title of each two-page spread and of each section is a question. Each chapter-opening two-page spread features a real place and asks questions intended to interest students in the subject; each question can be answered by information contained in the chapter. The book is designed in a *learning-cycle* approach, where students are asked to observe prior to the introduction of terms and concepts, and then the new knowledge is applied to a problem. Terms are presented in context, after students have observed the feature, concept, or process being presented. Each chapter is a learning cycle, with the Opening spread being an exploration and invitation to learn, the Topical spreads representing the term-and-concept-introduction phase of a learning cycle, and the Connections and Investigation spreads being the application phase of the learning cycle.

### ***The Role of Media and Ancillaries***

By design, there is extremely close articulation between the textbook and ancillaries. In addition to writing, designing, and doing the near-final layout of the textbook, the authors developed the interactive media, constructed the PowerPoint files, annotated the notes field in the PowerPoint files with content and teaching tips, developed all the test questions, and wrote this instructor’s guide. The media includes interactive 3D animations of the same figures that are in the textbook and can be launched from links included in the PowerPoint files or launched independently. We recommend using media when time allows and when it suits the goals of the instructor, but the PowerPoint files are purposely designed so that media files do not start automatically and can be skipped without an obvious interruption. The media files are mostly

self-contained HTML5 files (mp4), suitable to be used on nearly any modern Windows or Macintosh computer system or tablet. These files can be put on the instructor's website to allow students independent access. They are also accessible through McGraw-Hill's Connect online learning environment and from the Smartbook.

The main PowerPoint files are referred to as the *In-Class* PowerPoints, because these are the files instructors will likely modify and use in the classroom. They have figures surrounded by concise text, along with media links and teaching notes. We deliberately kept the number of photographs to a minimum in these files, in part because we assume that most instructors have their own slides for many features. Local examples are generally but not always more interesting to students than ones from far-off places. Instructors have access to properly sized versions of nearly every photograph in the textbook (in the *All-Figures* PowerPoints) and can easily insert these as desired.

The *In-Class* PowerPoint files, and associated media files, are in a separate folder for each chapter. The media links in the PowerPoint files are set up so that the program looks for the media files in the same folder as the PowerPoint file. We recommend "running" the PowerPoint files from the hard drive on your teaching computer. One approach is to therefore drag the entire folder for that chapter to the teaching computer, so that PowerPoint can find the media files. Note, however, that many of the media files are large and copying them over could take many minutes. If time is short, drag only the PowerPoint file first and then drag whatever media files are actually going to be used.

The *In-Class* PowerPoint files have some unique aspects made possible by the authors being responsible for constructing these files. The authors converted all of the original figure source files (e.g., Photoshop files) into TIF versions that have white lettering and transparent backgrounds. When these transparent TIF files are placed onto the PowerPoint pages, they allow the PowerPoint background to wrap tightly around the figure, rather than have a glaring, white border around the artwork. The transparency also allows text to be nestled around the figure, in the same manner as in the textbook. The PowerPoint files work well with any dark background, but the dark blue background we chose creates the intentional illusion that the figures are in positive 3D relief, coming off the page. A version of all figures, in this transparent format, are available in the "normal" *All-Figures* PowerPoint. A separate set of *All-Figures* PowerPoints, with the word "white" in their file name, contains JPEG files suitable for using with a light background. Normal, white-background JPEG versions of every figure, with black text, are also on the McGraw-Hill website. All these figures have a maximum size of 1200 pixels wide or 900 pixels high.

In addition to the *In-Class* PowerPoints, there are *All-Figures* PowerPoint files with nearly every figure and photograph in the textbook. These *All-Figures* PowerPoint files represent a huge addition to the teaching collection of any instructor. Most photographs are by the authors and so do not duplicate ones already in an instructor's collection. The only textbook photographs not included are those where McGraw-Hill does not hold an electronic copyright. The "normal" *All-Figures* PowerPoint files, like the *In-Class* files, are larger than is typical because transparent TIF files greatly increase file size over JPEG files (which do not retain transparency). A McGraw-Hill copyright notice is part of each image file in the *In-Class*, *All-Figures*, and white-JPEG collections. In the *In-Class* PowerPoint files, we have cropped the figure container so that the copyright does not show, but it is still present on either the bottom or right side of the image,

if an instructor prefers to have it show. We hid the copyright so that it did not overlap with text arranged around the figure or otherwise constrain the layout of the slide. A copyright is still displayed on each figure in the *All-Figures PowerPoint*, but were purposely made subdued by retaining some transparency (the same is true for the hidden copyrights in the *In-Class* files); they can be easily hidden by cropping the bottom or right side of the image. Copyrights are also on the white JPEG versions.

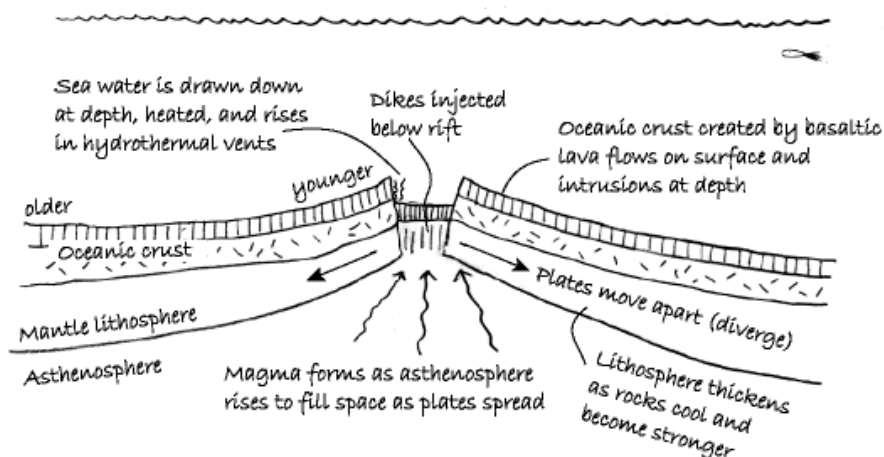
For each chapter, the authors generally wrote 50 to 100 multiple-choice test questions. The questions emphasize geographic concepts, geographic processes, and the process of science. There are no questions that only ask for definitions of geographic terms, but instead students need to understand the terms to answer more complex questions. The questions are built from the *Before You Leave This Page* lists. Multiple-choice questions are built around figures wherever possible. The test questions are available on McGraw-Hill's website and are also available in Word format. The Word files are set up with styles so that test questions and distracters automatically (but sensibly) renumber themselves when rearranged or copied and pasted into a new test file. To keep a test question and any associated figure joined together, each question is a small separate table that can be easily selected, copied, and pasted into a new file. In addition to multiple-choice questions, the master *What-to-Know List* contains ready-made constructed response questions to use as essay or concept-sketch questions.

## An Introduction to Concept Sketches

### Concept Sketches and How They Are Used

For a number of years, we have become convinced that concept sketches are one of the best ways to teach geography, to learn geography, and to quickly assess the depth of student understanding. Here, we summarize what a concept sketch is and how to use one. This summary is largely an edited-down version of an article in the *Journal of Geoscience Education* (Johnson and Reynolds, 2005) and in several GSA abstracts.

In our view, a *concept sketch* is a simplified sketch illustrating the main aspects of a concept or system, annotated with concise but complete labels that (1) identify the features, (2) depict the processes that are occurring, and (3) characterize the relationships between features and processes. It is not simply a sketch labeled with only the names of features. A concept sketch of a mid-ocean ridge is shown below.



This sketch illustrates some of the processes occurring (rising magma, submarine eruptions), the main features produced (rift, oceanic crust, lithosphere), and how the processes and features are related.

A concept sketch can (and often does) have several parts, such as figures labeled to explain the difference between El Niño and La Niña phases of ENSO. Although most concept sketches are simplified cross sections, they can also be map views or 3D perspectives. An example is a map-view concept sketch of a meandering river highlighting the sites of deposition and erosion.

Concept sketches can be constructed by the instructor or by students, and each approach has some advantages. An instructor can generate a concept sketch to guide students toward the key aspects of a subject and show how the aspects are related. Such sketches could be constructed in advance, but we have found much more success drawing, labeling, and describing them in real time during a lecture. The pace of drawing and describing the sketch on-the-fly seems about right for students to be able to think about the topic as they sketch. If the instructor generates the sketch and the students copy it, we strongly recommend letting students describe the sketch to a neighboring student – otherwise they may have copied it without processing the key points. The main advantages of instructor-generated sketches are (1) the instructor can model thinking for the students and teach students how to create such a sketch; (2) the resulting sketch is more likely to show the most important features and correct relationships between them, omitting less important details and incorrect interpretations; and (3) more material can probably be covered, but this may come at the expense of student understanding. We tend to use instructor-generated concept sketches early in the semester or for concepts, such as atmospheric circulation patterns, that are especially difficult for students to depict on their own.

The general procedure for student-generated concept sketches is to have students first interact with some prompting material about a topic and then construct a concept sketch that portrays the essential aspects. The prompting material could be photographs, textbook-style illustrations, computer animations, video clips, in-class demonstrations, or maps. We use each kind of prompt many times during a semester. To complete a successful concept sketch, students should do the following steps:

- interact with and observe the prompting materials;
- list what they think are the key features and processes, versus nonessential items;
- decide how the various aspects are related;
- brainstorm how to depict (sketch) the system; and
- draw and annotate the sketch.

Unless the sketch is being used as an assessment, we generally have adjacent students compare their lists and share their ideas. Then, we have students use their sketches to describe to each other how the sketched system operates, to negotiate any differences, and to identify remaining questions and gaps in their understanding. We commonly help the students use the proper terms, perhaps by starting a whole-class discussion or doing a short lecture burst (a 5 to 10 minute lecture). For complex topics, the instructor might provide guidance during any step to help students over a known hurdle.

One main advantage of student-generated concept sketches is that students are actively engaged – that is, they have to interact with the material in a meaningful way in order to create a sketch. It clearly takes a deeper level of mental processing to decide what is important and what is not, to think about relationships between features, to arrange items in a hierarchy, and portray

these relationships on paper, than it does to simply copy an instructor's sketch. By creating and discussing a sketch, students get the chance to use geographic words to talk about geography, which promotes transfer of information from short-term to long-term memory.

Once the students have created a concept sketch, we recommend having them use the sketch to think more deeply about the system or use the sketch to solve a problem. An excellent way to do this is to have students apply their knowledge by answering a *transfer question*, a question that requires them to transfer their knowledge to a new situation or new problem. You can ask students to use their sketch to make predictions, to envision how the system might change if some variable (like wind direction) was different, or to ask questions about the underlying processes and the causes and consequences.

## **A Learning-Cycle Approach**

An excellent way to use concept sketches in the classroom, or to teach in general, is to employ a *learning-cycle approach*. A variety of learning cycles exist, but each variation shares three common elements: engaging the students through an *exploration phase*; introducing students to formal nomenclature and definitions in the *term- and concept-introduction phase*; and finally, having students apply concepts and skills in new situations in the *concept-application phase*.

During the *exploration phase*, the instructor creates interest and generates curiosity in the subject matter by giving students an opportunity to explore and observe some concept or phenomena without much instructor intervention. During this exploration stage, students can make observations, generate hypotheses and predictions, devise ways to test their predictions, discuss alternatives with their classmates, and record their observations and interpretations.

The *term-and-concept-introduction phase* affords the instructor an opportunity to introduce or elaborate on useful terms and concepts. The instructor provides definitions and explanations of aspects of the subject the students themselves observed and experienced during the exploration phase. We view the term-and-concept-introduction phase as a chance for the instructor to help the students construct a coherent mental framework.

In the third phase, the *concept-application phase*, students apply concepts and skills in new, but similar, situations. Students should be using the new terms and concepts to ask questions, propose solutions, make decisions, experiment, and record observations. Transfer questions are well suited for such applications. In *Exploring Physical Geography*, the Connections and Investigation two-page spreads at the end of each chapter are designed as the application phase of a learning cycle. This phase helps students consolidate their knowledge and identify what they do not understand.

The steps described previously for constructing a concept sketch is precisely a learning cycle. The students first observe (i.e. explore) and try to recognize the key aspects. Then, perhaps with instructor guidance, they use the proper terms, learn key concepts, and explain their sketches to one another. The concept-application phase takes place when students answer a transfer question or otherwise use their sketches or the new knowledge to solve a problem. Implementing concept sketching using a learning-cycle approach allows students to use their own observations to construct personal concepts and mental frameworks, and encourages them to take ownership of this knowledge.



## ***Using Concept Sketches for Teaching, Learning, and Assessment***

*Exploring Physical Geography* was designed around a concept-sketch approach, with text arranged around and articulated with illustrations. We encourage students to draw and annotate their own simplified versions of our figures and text. Many items on the *Before You Leave This Page List* are presented as a sketch, describe, and explain activity. If students follow this approach, we are convinced they will learn more than simply reading and highlighting the book. We also designed opportunities in the PowerPoints for student observation and generation of concept sketches.

Even with this emphasis, instructors can teach with the book in any manner, with or without concept sketches. The PowerPoints provide a powerful and visually stunning way to convey content to students, in a traditional lecture mode. The authors plan to use this approach in short bursts of 5 to 10 minutes. The PowerPoints are also well suited to encourage student observation, exploration, and generation of concept sketches, which we will use extensively every day. We think both approaches will be successful because students can use the textbook to reinforce and supplement either type of instruction. The PowerPoint slides are deliberately sparse on words because we want an instructor to be able to convey the main points, without students copying down long strings of text (and thereby recreating what is already in the textbook).

Plate tectonics provides an excellent example of how we have students construct concept sketches in class. We begin with an exploration phase by showing a short, silent animation depicting the evolution of one type of plate boundary. Students are asked to observe the processes and resulting features, and to write a list of any essential elements to include in their concept sketches. After students have made their observations, they are asked to think-pair-share, whereby they share and compare observations with their classmates. An instructor can call on different groups to contribute their observations and may list these observations on the front board. This can lead to a whole-class discussion to decide which aspects seem most important to show, or an instructor can choose to let student groups negotiate this among themselves.

After this brief term-introduction phase described above, students should incorporate their observations into a concept sketch, usually on a sheet of paper or on a portable white board shared by 2 to 4 students. Their sketch should include drawing and labeling pertinent features and writing short explanatory remarks that capture the dynamic elements of plate tectonics. Students then explain their sketches to neighboring classmates or to other groups, and some may present their sketches to the entire classroom by giving a mini-presentation. We repeat the entire process for each type of plate boundary, one at a time, but may skip the public listing of observations as students get better at deciding what is important. A short term-and-concept lecture burst should accompany each new type of plate boundary because specific features are original to each setting.

Authentic assessment is difficult in introductory geography courses, especially those with more than a hundred students. Concept sketches are an efficient and authentic means of assessment at various stages in the educational sequence. Concept sketches constructed by students *before instruction* are an invaluable and extremely revealing way to assess what students already know and to quickly identify student misconceptions. Concept sketches can be assigned as homework to help students learn from their textbook, especially for concepts you choose not to cover fully (or cover at all) in class. Sketches require students to interact with the text and illustrations in an active, sense-making manner. *Exploring Physical Geography* is

ideally suited to help students learn in this manner. For the instructor, such homework sketches are a time-efficient way to encourage students to read the book and allow the instructor to evaluate whether students read and *thought about* the assignment. Before exams, we provide students with a shortened list of *What-to-Know* items, one or more of which will be on the exam as a concept-sketch question. The wise student will prepare a sketch for each of these before the exam. An instructor can also have students hand in this test-preparation homework, and simply grade for level of effort (like a simple plus-minus system).

Concept sketches form an integral part of our quizzes and examinations. Concept sketches can serve as quizzes during class time, such as at the end of the class or after a topic has been covered. They also may constitute part of larger, more comprehensive exams. Test questions eliciting concept sketches are easy to write, and the *What-to-Know List* for *Exploring Physical Geography* provides ready-made questions for concept sketches or essays. During the actual exam, other items on the full *What-to-Know List* can be assessed with multiple-choice questions. Our experience is that including even one or two concept-sketch questions on an exam causes students to study differently than if the exam is all multiple choice. From years of experience with this type of book, we have found that an excellent approach is to deploy multiple-choice questions as online quizzes and have hour-long exams consisting of students answering two concept sketches. These two are chosen by the instructor at the time of the exam from a list of about ten possible concept-sketch questions provided to students well before the exam.

We have found that using concept sketches as an assessment tool is much faster than grading essays or other constructed-response questions, and is more authentic. A typical concept-sketch question for groundwater would ask the student to sketch how the water table relates to the land surface, including lakes, describing in complete sentences on the sketch how groundwater accumulates, in what direction groundwater flows, and how the water table relates to lakes. To answer such a question, a student cannot have memorized isolated facts. Instead, the student must have a coherent understanding of geographic concepts and systems, and must be able to represent the concept with all its interrelated processes, geographic features, and other aspects. This type of coherent understanding is authentic, in that it is consistent with our learning objectives and with how geographers represent, think about, and discuss geographic concepts. We have extensively implemented concept sketches in introductory geology courses with 230 students per class. Our experience from these classes is that grading a concept-sketch question typically requires 5 to 20 seconds (poorly answered ones take longer), permitting a hundred such questions to be graded in less than an hour. It is easy to tell from a glance at the sketch and labels whether students got the main points.

We grade such sketch questions with either a general or specific rubric, as shown in the table below. A general rubric assigns points based on a holistic assessment of the sketch, such as full points for a sketch that shows all essential concepts and contains no conceptual errors, or partial points for a sketch that does not include some key aspects or contains one or more conceptual errors. A specific rubric assigns a specific number of points for each feature or process that the instructor thinks should have been shown on the sketch, deducting appropriate points for anything that has been omitted or incorrectly portrayed. Specific rubrics take longer to grade, so the authors use general rubrics in large introductory geology courses.



appreciation of what is around them and for science in general. The philosophy, approach, and advantages of this book are also described in the syllabus. We also wanted to make the class lively, engaging, and even fun. So that's how we got here! We sincerely appreciate you joining us on this new and exciting path.

## Chapter Overviews

The following pages contain a single-page overview for each chapter. These do not retell the outline of the chapter, but explain the overall game plan. In some cases, we wanted to share our thoughts about why we arranged two-page spreads in the order we did, such as whether a series of spreads is set up as a learning cycle or as some other pedagogical sequence. The page also identifies specific two-page spreads where an instructor could spend time having students observe landscapes, maps, or other geographic aspects; solve miniature problems, or more deeply explore a topic, allowing the textbook to cover other spreads. Finally, we convey our experience with which Investigations work really well as in-class exercises and which ones are better done as homework or in the lab. We recommend you read or briefly skim these pages before setting up your class schedule. Other suggestions for observation exercises are embedded in the notes field of the PowerPoint files, but those are more appropriate to review shortly before (or during) teaching that subject.

## Chapter 1: The Nature of Physical Geography

Chapter 1 provides an overview of various geographic aspects, such as processes that affect Earth. Within the chapter are specifically designed opportunities for student observations, in part to convey the message that student participation will be frequent during the semester. We also think it is important to right away let students know that they will be responsible for some material that will not be covered in class (because the book is designed to let students learn these outside of class). To open time for student observations, instructors will probably choose not to cover in class some two-page spreads, such as 1.6 (Topographic Maps), 1.8 (Other Coordinate Systems), 1.10 (Use of Maps and Photographs), and 1.11 (GPS), and others. Some opportunities for observation and discussion are highlighted below, but others are identified in the *Notes* field of the *In-Class* PowerPoints. This chapter also provides an opportunity for the instructor to introduce some of the kinds of problems geographers encounter, along with some career options.

### Suggestions Referenced to Two-Page Spreads and Figures

1.0 The opening figure provides an excellent opportunity for student observation, asking students to think about how different aspects of the Earth systems affects people, such as land versus sea, topography, climate, and weather.

1.1 The Henry Mountains. This photograph works very well for having students make observations and then brainstorm how geography affects the life of the horses and cows on the green pasture. Another angle here is to focus on water and use this as an introduction into the hydrologic cycle.

1.2 We recommend following up the example of testing alternate explanations with one from the instructor's area of expertise, or a local example.

1.4 This section provides an introduction into aspects of the Earth system, such as the hydrologic cycle and rock cycle, providing a nice overview of the course.

Note: During the first week, we also recommend explaining to students some key educational aspects – after students experience them. These might include divergent versus convergent questions, think-pair-share, wait time, listing observations without judging them right away, not to believe everything other students say in class, etc.

## **Chapter 2: Energy and Matter in the Atmosphere**

Chapter 2 introduces the most important concepts of energy and matter, including heat and temperature, electromagnetic radiation, and insolation. It also covers topics that are important in many aspects in geography, such as geographic variation in insolation, why we have seasons, and energy balances. Some topics will not need to be covered in class, such as temperature scales. Others can be explored in more detail than covered in the book, such as introducing the equations for Stefan-Boltzmann's Law and Wien's Law. The chapter has the potential to explain many things students have observed, such as seasons, variations in length of day, and variations in temperature from place to place as a function of latitude or land versus water.

### **Suggestions Referenced to Two-Page Spreads and Figures**

2.0 Have students make observations about any expressions of energy and matter in the image, and think about any questions that come to mind. These photographs can open up discussion about various topics, such as Sun angle, variations in climate with latitude, sensible versus latent heat, clouds, sky color, etc.

2.4 We recommend using the graph of temperature versus energy such that you follow the graph as if heating up a pan of ice cubes, explaining what happens at each step.

2.6 Many students will be interested in how different frequencies, such as FM radio and microwaves, fit into the electromagnetic spectrum.

2.8 An option for an in-class demonstration is to bring a flashlight to class to illustrate zenith angle and the amount of insolation striking the atmosphere.

2.9 The same flashlight can be used with a tennis ball (pierced by a pencil or rod) to illustrate the tilt of Earth's axis and the seasons.

2.10 The same flashlight can be used to illustrate variations in the length of day during different seasons.

2.13 The 3D landscape provides an opportunity for students to think about how insolation interacts with the surface, including concepts such as reflection, scattering, and albedo.

2.16 The spinning-globe movies in the PowerPoint provides an opportunity for students to observe the patterns of insolation and outgoing longwave radiation, and explain the patterns and why they are not simply bands parallel to latitude.

2.17 The spinning-globe movies in the PowerPoint again provide a nice opportunity to observe how temperatures vary spatially, or from season to season, and allow introduction of concepts such as land temperatures versus ocean temperatures, and the impact of ocean currents.

2.18 Stepping through the graphs of insolation, daylight hours, and temperature provides students with an introduction into how and why these vary as a function of latitude from the North Pole to the South Pole.