

Preface

Our motivations for writing *Explorations: An Introduction to Astronomy* are many, both personal and pedagogic. Perhaps foremost among these is a desire to share with students our own sense of wonder about the Universe.

That sense of wonder grows deeper when we begin to understand why things happen. Many astronomy books today seem to simply say, “This is how it is.” We want instead to offer explanations that draw as much as possible on simple, everyday effects that students can see around them in the world. For example, why do some stars pulsate? A simple analogy of steam building up pressure under the lid of a pan offers a model of this phenomenon that is easy to understand and reasonably accurate. We have also tried to link complex physical processes to simple everyday experiences. An example of this is that you can see the effects of diffraction by looking at a bright light through a lock of your hair pulled over your eyes or through glasses that you have fogged with your breath. When we can thus link physical principles to everyday observations, many of the more abstract and remote ideas become more familiar. Throughout the book we have made heavy use of analogies, along with illustrations to make those analogies more concrete.

Knowing the facts about astronomical objects is important, but it is equally important to understand how astronomers deduce those facts. Thus, an additional aim throughout this text is to explain *how* astronomers have come to their understanding of our Universe. As the Science at Work boxes illustrate, observations can force astronomers to revise their ideas of how a given process occurs. As part of showing how scientists arrive at their ideas, we have set many of the modern discoveries in their historical context to illustrate that science is a dynamic process and subject to controversy—many ideas are not immediately accepted, even if they ultimately prove to be “correct.” We hope that by seeing the arguments for and against various ideas, students will have a better understanding of how science works.

If we had attempted to make this textbook completely comprehensive, it would have been very long and overwhelming in detail. It is challenging to keep *Explorations* to a reasonable size because reviewers tend to suggest things that we must include, but rarely suggest things to omit. To solve this problem, we cover some topics, such as timekeeping and astrobiology, in essays that the instructor might choose to skip. We also cover some background topics in later chapters, in the astronomical context where they are most often encountered. This makes it possible to jump directly to some of the later chapters without having to work through the details of all the earlier chapters.

Some astronomy textbooks maintain brevity by omitting most of the mathematics, but we feel that math is essential for understanding many of the methods used by astronomers. We have therefore included the essential mathematics in a number

of places. However, because math is so intimidating to so many students, we begin these discussions by introducing the essence of the calculation in everyday language so that the basic idea can be understood without understanding the mathematics. For example, Wien’s law relates the temperature of a hot object to its color by means of a mathematical law, but illustrations of the law can be seen in everyday life, as when we estimate how hot an electric stove burner is by the color of its glow. Where we do present the mathematics, we work through it step by step, explaining where terms must be cross-multiplied and so forth.

NEW TO THE SEVENTH EDITION

Content Updates and Additions

In this seventh edition of *Explorations*, we have carefully updated the art and text throughout the book. This not only adds to the book’s visual appeal but enhances student learning with clear, accurate representations that reflect the most current data in the field. We have also worked closely with the McGraw-Hill team to more tightly integrate the layout to make the book easier to read, making adjustments to figures and text to make sure they appear close to each other. This helps the reader connect words, logic, images, and geometry. Thanks are due to reviewers and users who have offered helpful suggestions for improving the organization, expanding the coverage of particular topics, and enhancing figures. Following are some of the highlights of these changes:

New Features

- At the start of each chapter, we now provide a set of Learning Objectives. These identify the most important skills that the reader should gain upon completing the chapter. This set of skills can be used as a checklist for successful completion of a chapter, as well as for identifying topics to reread or to seek further help.
- New “Astronomy by the Numbers” boxes have been added throughout the book. These work through the details of some mathematical derivations and provide worked examples of typical calculations outside of the the running text, making it easier for the instructor to select the depth of math required for the course.
- To help interpret planetary maps, we have created equal-area maps (Mollweide projection) for the Moon and terrestrial

planets. The topographic maps are color coded in a consistent way from digital elevation data, to help make comparisons clearer between planets.

- Scales and notes have been added within many figures to help make them more easily interpreted.

Revisions to End-of-Chapter Material

- We have revised and added dozens of end-of-chapter thought questions, worked problems, and test-yourself questions.
- The end-of-chapter questions and problems are keyed to the relevant section number to help students and instructors make connections between readings and problem solving.
- We have moved the “Further Explorations” listing of print articles online, making it possible to edit, update, and add to the list as needed and keep the information current.

Updated and Revised Topics

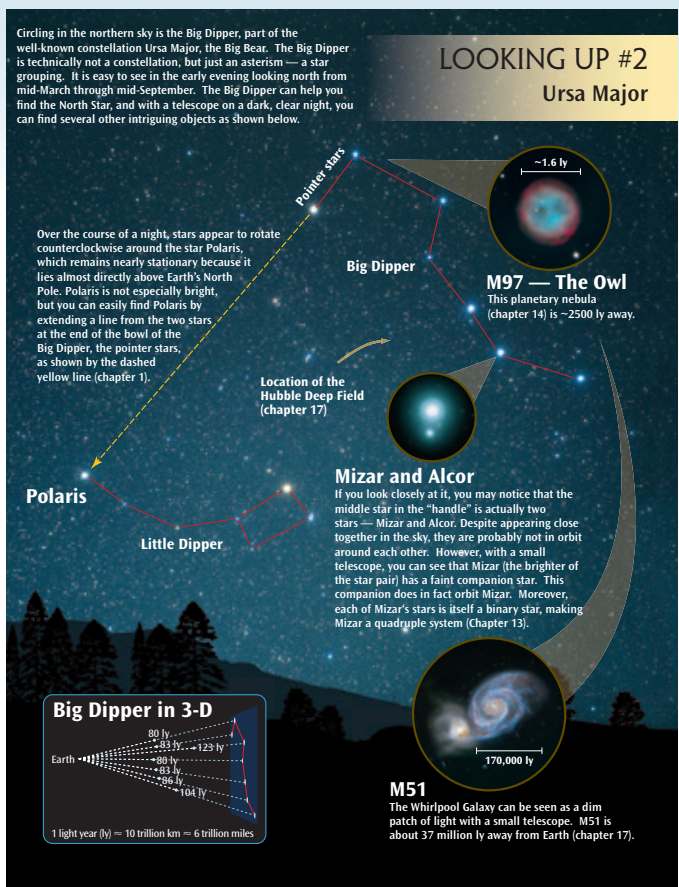
- Chapter 1: Additional diagrams to help understand motions of the Sun, stars, and eclipse shadows; added pictures of the Karnak Temple and Chichén Itzá showing solar alignments; new eclipse pictures and eclipse-path map.
- Chapter 2: New diagrams of lunar eclipse, angular size, motion of Earth in celestial sphere; new pictures of early illustrations of astronomical objects.
- Chapter 3: Revised section order, introducing Newton’s third law immediately after the second law. Added and revised illustrations help explain the laws of motion and gravity.
- Chapter 4: Merged the section on absorption in the Earth’s atmosphere with a section on spectrum formation. New picture of spectra in everyday life; added an energy-level diagram of helium to show source of visible spectral lines; expanded image of solar spectrum; added Doppler/delay images of asteroid.
- Chapter 5: New photos of refraction effects and major telescopes. Expanded discussion and diagram of CCD detector.
- Chapter 6: New equal-area maps of Earth showing topography, plates, and tectonic motions. New, more-detailed diagrams illustrating chemistry of ozone layer and global warming. Expanded discussion and new diagrams of Coriolis effect, and orbital changes that affect Earth’s climate.
- Chapter 7: New lunar images from the *Lunar Reconnaissance Orbiter*. New equal-area topographic map based on *Clementine* data. New and revised images illustrating lunar formation, orbit, and tides.
- Chapter 8: Expanded discussion of exoplanets including new results from *Kepler*. New figures illustrating direct imaging of exoplanets and detection of exoplanets by the transit method.
- Chapter 9: New *Messenger* images of Mercury. New *Venus Express* images and reprocessed *Magellan* images. New equal-area topographic maps of Venus and Mars, and Mars *Odyssey* map of water in surface. New pictures of Mars from *Odyssey*, *Phoenix*, *Opportunity*, *Mars Express*, *Global Surveyor*, and *Reconnaissance Orbiter*. Time-lapse picture of possible water seepage.
- Chapter 10: Discussion of Pluto and other large trans-Neptunian objects were moved to Chapter 11 so Chapter 10

now focuses on just the four outer planets, their rings and satellites. Added *Galileo* images of Jupiter and its satellites and Cassini images of Saturn and its satellites. Added a variety of images of ring systems to better explain their structure and composition. New radar images of Titan. Reprocessed images of Uranus, Neptune, and their moons and rings.

- Chapter 11: Now discusses the whole range of bodies orbiting the Sun other than the eight planets. Size comparison image of asteroids, including recent *Dawn* image of Vesta. New comparison diagram of plutoids and their orbits. New and revised images and figures of comets, including recent *Stardust* image of crater left by *Deep Impact* mission.
- Chapter 12: Revised diagrams of hydrostatic equilibrium, proton–proton chain, coronal heating, and solar magnetic field. Added *SOHO* image of coronal mass ejection.
- Chapter 13: Merged section 13.5 with 13.6. Merged section on variable stars into section in Chapter 14. Comparison of recent imaging of Betelgeuse. Star magnitude image; revised diagram of eclipsing binary.
- Chapter 14: Infrared/visible image comparison in Eagle nebula. New diagrams CNO cycle and triple alpha process. *Galex* image of atmosphere loss from Mira. New supernova images.
- Chapter 15: New diagrams of the curvature around black hole. Added supporting diagrams to help explain escape velocity and Hawking radiation.
- Chapter 16: Revised diagrams of effects of interstellar gas and dust on starlight. Revised graph and illustration of Milky Way’s rotation curve.
- Chapter 17: Reorganization of chapter with new section on galaxy interactions and evolution and a greatly expanded section on dark matter. Added discussion and a new figure explaining the limitations of Hubble’s law because of local motions. New diagrams and discussion of active galactic nuclei. New plots of galaxy rotation curves.
- Chapter 18: Reorganization of chapter, concluding with a section on dark energy and the fate of the universe. Revised and added several figures to illustrate the basic ideas of cosmology, including new illustrations to help understand inflation, expansion of the universe, and fluctuations in the CMB.
- Revised and updated the foldout star chart with Moon and planet finder.

Special Features

Looking Up Features The nine Looking Up figures at the start of the book—each one a full-page art piece—are designed to show students how some of the astronomical objects discussed in the text connect with the real sky that they can see overhead at night. The figures cover nine especially interesting regions ranging from the North Pole to the South Pole. In particular, they show where a variety of the frequently mentioned and important astronomical objects can be seen, many with a small telescope. Each Looking Up feature presents a photograph of one or more constellations in which



number of other figures and images. The answers to these questions are provided at the end of each chapter under the heading “Figure Question Answers.”

Foldout Star Chart The foldout star chart in the back of the book helps students study the sky and figure out where the Moon and planets are located in any month. The chart is useful for projects such as plotting the changing location of the Moon and planets, or the paths of meteors.

Electronic Media Integration To help students have a better grasp of key concepts, these icons have



been placed near figures and selections where students can gain additional understanding through the interactives and animations on the



Explorations website.

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Blackboard®, the Web-based course management system, has partnered with McGraw-Hill to better allow students and faculty to use online materials and activities to complement face-to-face teaching. Blackboard features exciting social learning and



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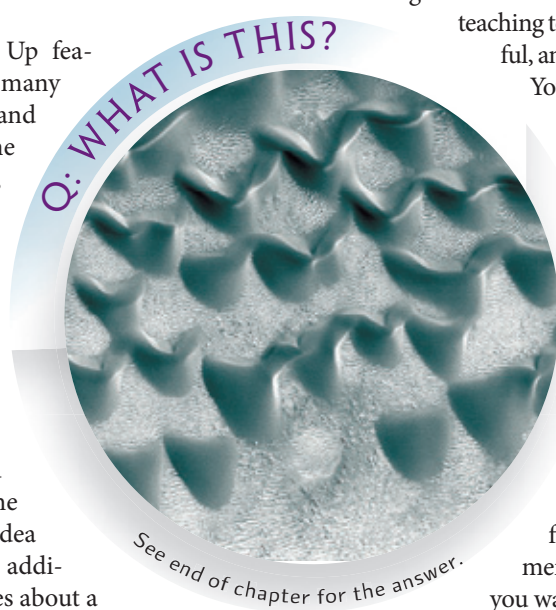
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nebulas, star clusters, and other interesting objects are identified and illustrated, with references to the relevant chapter. These latter illustrations include scale factors to help students visualize how even immense objects many light-years across can appear as mere dots in the sky. Along with the illustrated objects, most of the Looking Up features include a small insert to show how one of the constellation's stars are arranged in space.

In constructing the Looking Up features, we have had to draw upon many different sources for the distances and sizes of the objects presented. Some distances are poorly known. Thus, none of the numbers appearing in these Looking Up features should be assumed to be precise.


“What Is This?” Photographs and Figure Questions At the beginning of each chapter, students are presented with a photo of an astronomical object and asked to guess what it is. After reading the chapter, they should have some idea of what is shown in the photo. In addition, there are questions in red boxes about a



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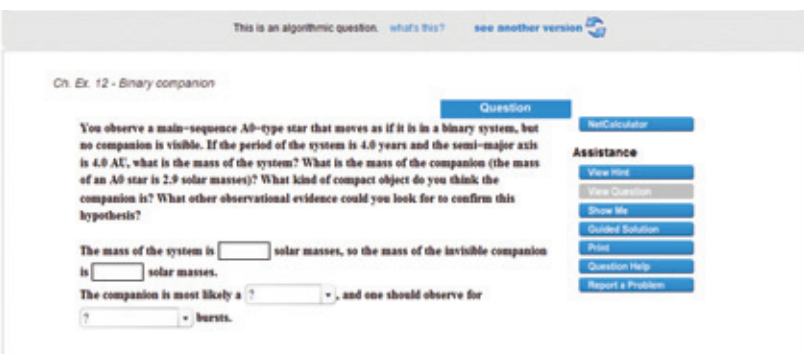
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Presentation Center Accessed from *Exploration's* Connect website, **Presentation Center** is an online digital library containing photos, artwork, animations, and other media types that can be used to create customized lectures, visually enhanced tests and quizzes, compelling course

websites, or attractive printed support materials. All assets are copyrighted by McGraw-Hill Higher Education, but can be used by instructors for classroom purposes. The visual resources in this collection include:

- **Art** Full-color digital files of all illustrations in the book can be readily incorporated into lecture presentations, exams, or custom made classroom materials. In addition, all files are pre-inserted into PowerPoint® slides for ease of lecture preparation.
- **Photos** The photo collection contains digital files of photographs from the text, which can be reproduced for multiple classroom uses.

Also accessed through your textbook's Connect website are:

- **PowerPoint® Lecture Outlines** Ready-made presentations that combine art and lecture notes are provided for each chapter of the text.
- **PowerPoint Slides** For instructors who prefer to create their lectures from scratch, all illustrations, photos, Sample Problems, and tables are pre-inserted by chapter into blank PowerPoint slides.
- **Animations** Numerous full-color animations illustrating important processes are also provided. Harness the visual impact of concepts in motion by importing these files into classroom presentations or online course materials.

Instructor's Manual

The Instructor's Manual containing answers to all questions and problems within the text is found on the Instructor's side of the *Explorations* website.

Classroom Performance System and Questions

The Classroom Performance System (CPS) brings interactivity into the classroom or lecture hall. CPS is a wireless response system that gives an instructor immediate feedback from every student in the class. Each CPS unit comes with up to 512 individual response pads and an appropriate number of corresponding receiver units. The wireless response pads are essentially remotes that are easy to use and engage students. The CPS system allows instructors to create their own questions or use the astronomy questions provided by McGraw-Hill.



Interactives

McGraw-Hill is proud to bring you an assortment of 23 outstanding Interactives like no other. Each Interactive is programmed in Flash for a stronger visual appeal. These Interactives offer a



fresh and dynamic method for teaching the astronomy basics. Each Interactive allows users to manipulate parameters and gain a better understanding of topics such as Blackbody Radiation, The Bohr Model, a Solar System Builder, Retrograde Motion, Cosmology, and the H-R Diagram by watching the effect of these manipulations. Each Interactive includes an analysis tool (interactive model), a tutorial describing its function, content describing its principal themes, related exercises, and solutions to the exercises. Users can jump between these exercises and analysis tools with just the click of a mouse.

How to Study with This Book

Learning anything requires a certain amount of work. You certainly don't expect to be able to pick up a guitar and play it without practice, nor do you expect to be able to jog 5 miles without working out regularly. Learning astronomy also requires some work. The steps below may help you learn the material better and more easily.

In reading any assignment, begin by looking at the *pictures*. Turn the pages of the chapter and familiarize yourself with what the objects you will be reading about look like. Then read the introduction. Next, jump to the summary. Finally, start again and read the assigned material through. As you read, make notes of things you don't understand and ask your instructor or teaching assistant for clarification. For example, if you are puzzled about why eclipses don't happen every month, make a note. Making a few short notes is much more effective than highlighting whole paragraphs.

Look carefully at the pictures and diagrams. If the figure has a question with it, try to answer it. Make your own sketch of diagrams to be sure you understand what they represent.

In a first reading of a chapter, if you are troubled by math, you might simply skip over it for the time being. Be sure, however, to read the material leading into the math so you at least understand the basic idea. When you encounter a mathematical expression of a physical law, express the law in words. For

example, the law of gravity relates the force of gravity to the mass of the objects and their distance from each other.

If you encounter words or terms as you read that you don't know, look them up in the glossary, the index, or a dictionary or encyclopedia. You are just wasting your time if you read a description of some object and you don't know what it is.

When you finish the assigned reading, try to answer the "Review Questions" for the sections you covered. They are short and are designed to help you see if you have assimilated the basic factual material of the assignment. Try to do this without looking back into the chapter, but if you can't remember, look it up rather than skip over the question. You might find it helpful to write out short answers to the questions.

Having read the material once, go back and try to work through the math parts. Then try some of the mathematical "Problems" to see if you can work through the material on your own. "Thought Questions" challenge you to think more deeply about the readings, and you can use the multiple-choice "Test Yourself" questions to check your understanding.

If you get stuck at any point, see your teaching assistant or professor for help. Don't be shy about asking questions. Learning is a thousand times easier if you ask questions when you get stuck.

Seeing a clear night sky spangled with stars is a wondrous experience. And yet the beauty and sense of wonder can be enriched even more by an appreciation of the complex processes that make the Universe work. We hope this book will similarly increase your appreciation of our Universe's wonders.

If you find mistakes or have suggestions about how to make this book better, please contact one of us. Write T. Arny at P.O. Box 545, Patagonia, AZ 85624, or by email at tarny@theriver.com; or S. Schneider at Department of Astronomy, 536 Lederle Tower, Amherst, MA 01003, or by email at schneider@astro.umass.edu.

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REVIEWERS OF THIS AND PREVIOUS EDITIONS

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