PREFACE

What Sets This Book Apart?

Creating Informed Citizens

Integrated Science is a straightforward, easy-to-read, but substantial introduction to the fundamental behavior of matter and energy in living and nonliving systems. It is intended to serve the needs of nonscience majors who must complete one or more science courses as part of a general or basic studies requirement.

Integrated Science provides an introduction to a scientific way of thinking as it introduces fundamental scientific concepts, often in historical context. Several features of the text provide opportunities for students to experience the methods of science by evaluating situations from a scientific point of view. While technical language and mathematics are important in developing an understanding of science, only the language and mathematics needed to develop central concepts is used. No prior work in science is assumed.

Many features, such as Science and Society readings, as well as basic discussions of the different branches of science help students understand how the branches relate. This allows students to develop an appreciation of the major developments in science and an ability to act as informed citizens on matters that involve science and public policy.

Flexible Organization

The *Integrated Science* sequence of chapters is flexible, and the instructor can determine topic sequence and depth of coverage as needed. The materials are also designed to support a conceptual approach or a combined conceptual and problem-solving approach. The *Integrated Science* Instructor's Manual offers suggestions for integrating the text's topics around theme options. With laboratory studies, the text contains enough material for the instructor to select a sequence for a one- or two-semester course.

> *"I like the general approach of this text. With respect to goals, writing style, information presented, and overall appeal to the nonmajor, I think this textbook is the best available in the marketplace today."*
>
> —Sarah Cooper, Arcadia University

The Goals of Integrated Science

1. **Create an introductory science course aimed at the nonscience major.** The origin of this book is rooted in our concern for the education of introductory-level students in the field of science. Historically, nonscience majors had to enroll in courses intended for science or science-related majors such as premeds, architects, or engineers. Such courses are important for these majors but are mostly inappropriate for introductory-level nonscience students. To put a nonscience student in such a course is a mistake. Few students will have the time or background to move through the facts, equations, and specialized language to gain any significant insights into the logic or fundamental understandings; instead, they will leave the course with a distaste for science. Today, society has a great need for a few technically trained people but a much larger need for individuals who understand the process of science and its core concepts.

2. **Introduce a course that presents a coherent and clear picture of all science disciplines through an interdisciplinary approach.** Recent studies and position papers have called for an interdisciplinary approach to teaching science to nonmajors. For example, the need is discussed in *Science for All Americans—Project 2061* (American Association for the Advancement of Science), *National Science Education Standards* (National Research Council, 1994), and *Science in the National Interest* (White House, 1994). Interdisciplinary science is an attempt to broaden and humanize science education by reducing and breaking down the barriers that enclose traditional science disciplines as distinct subjects.

3. **Help instructors build their own mix of descriptive and analytical aspects of science, arousing student interest and feelings as they help students reach the educational goals of their particular course.** The spirit of interdisciplinary science is sometimes found in courses called "General Science," "Combined Science," or "Integrated Science." These courses draw concepts from a wide range of the traditional fields of science but are not concentrated around certain problems or questions. For example, rather than just dealing with the physics of energy, an interdisciplinary approach might consider broad aspects of

energy—dealing with potential problems of an energy crisis—including social and ethical issues. A number of approaches can be used in interdisciplinary science, including the teaching of science in a *social, historical, philosophical,* or *problem-solving* context, but there is no single best approach. One of the characteristics of interdisciplinary science is that it is not constrained by the necessity of teaching certain facts or by traditions. It likewise cannot be imposed as a formal discipline, with certain facts to be learned. It is justified by its success in attracting and holding the attention and interest of students, making them a little wiser as they make their way toward various careers and callings.

4. **Humanize science for nonscience majors.** Each chapter presents historical background where appropriate, uses everyday examples in developing concepts, and follows a logical flow of presentation. A discussion of the people and events involved in the development of scientific concepts puts a human face on the process of science. The use of everyday examples appeals to the nonscience major, typically accustomed to reading narration, not scientific technical writing, and also tends to bring relevancy to the material being presented. The logical flow of presentation is helpful to students not accustomed to thinking about relationships between what is being read and previous knowledge learned, a useful skill in understanding the sciences.

> *"The philosophy behind the text is appropriate in that the authors provide an avenue to understanding science for the nonscience major. . . . This text is written to engage the student, and once interest in the subject has been generated, then the motivation to learn follows. In this regard, this text is an excellent introduction to science. The stated goals of the authors are very similar to my teaching goals, and I know of no other text that quite meets these goals in such a successful manner."*
>
> —Jay R. Yett, Orange Coast College

Valued Input Went into Striving to Meet Your Needs

Text development today involves a team that includes authors and publishers and valuable input from instructors who share their knowledge and experience with publishers and authors through reviews and focus groups. Such feedback has shaped this edition, resulting in reorganization of existing content and expanded coverage in key areas. This text has continued to evolve as a result of feedback from instructors actually teaching integrated science courses in the classroom. Reviewers point out that current and accurate content, a clear writing style with concise explanations, quality illustrations, and dynamic presentation materials are important factors considered when evaluating textbooks. Those criteria have guided the revision of the *Integrated Science* text and the development of its ancillary resources.

New to This Edition

This third edition has several added features that develop sociocultural connections and highlight the integrated nature of science in order to underscore the relevance of science to students' everyday lives:

- A core concept map has been added to the beginning of each chapter. This concept map identifies the central theme of the chapter and shows how the content of the chapter supports that theme. In addition, it shows how the content of the chapter is related to concepts discussed elsewhere in the text. The core concept map, combined with the chapter outline and overview, help to give the student the big picture of the chapter content and the even bigger picture of the integrated nature of science.
- Science and Society boxes relate the chapter's content to current societal issues. Many of these boxes also include questions that are designed to promote classroom discussion and encourage student participation.
- Myths, Mistakes, and Misunderstandings boxes provide brief scientific explanations to dispel a societal myth or a home experiment or project that enables students to see the fallacy of the myth.
- For Further Analysis exercises have also been added to the end of each chapter. This set of exercises may include analysis or discussion questions, independent investigations, or activities intended to emphasize societal issues and develop critical thinking skills and a deeper understanding of the chapter content.
- Invitation to Inquiry exercises have been added to the end of each chapter. These consist of short, open-ended activities meant to pique student interest in the chapter content.

A number of organizational changes have also been made and new topic areas added to the text:

- Some computational examples have been added back into the Third Edition, often with an optional heading, to offer instructors material to place a greater emphasis on problem solving in their courses, if so desired.

Chapter 1 What Is Science?: The section on pseudoscience has been expanded, and a Concepts Applied on inverse square law has also been added.

Chapter 2 Motion: A discussion of fundamental forces was added. The scope of Newton's third law has been expanded.

Chapter 3 Energy: A new section on alternative sources of energy has been included.

Chapter 4 Heat and Temperature: The section on thermometers was reorganized, while the content on plasma and the thermodynamics section were expanded.

Chapter 5 Wave Motions and Sound: A Connections box on red shift was added.

Chapter 6 Electricity: New Connections boxes on Michael Faraday and Thomas Edison have been included.

Chapter 7 Light: A new Concepts Applied on why the sky is blue has been added.

Chapter 9 Chemical Reactions: The section on mixtures has been expanded.

Chapter 11 Nuclear Reactions: There are new Closer Look boxes on Marie Curie and on how half-life is determined.

Chapter 12 The Universe: The section on apparent magnitude scale has been expanded. The material on COBE, WMAP and the age of the universe has been updated. A Closer Look on Hubble's Law has also been added.

Chapter 13 The Solar System: A discussion of the *MESSENGER* spacecraft mission has been added, while the information on more recent missions, such as the *Cassini-Huygens* mission, *Mars Exploration Rovers, Spirit* and *Opportunity,* has been updated. New photos from the *Mars Exploration Rover* mission have also been included.

Chapter 14 Earth in Space: This chapter has been restored and updated from the previous edition. A Closer Look on the celestial sphere has also been added.

Chapter 15 The Earth (previously chapter 14): There are expanded sections of coverage, including the rock cycle and surface earthquake waves. A new section on "ridge-push" and "slab-pull" models of plate tectonics has been added, complete with illustrations.

Chapter 16 The Earth's Surface (previously chapter 15): The section on earthquakes has been reorganized and expanded. The coverage of the Mount St. Helens volcano has been updated.

Chapter 19 Organic and Biochemistry (previously chapter 18): The section on nomenclature has been simplified. The discussions of cholesterol and lipoproteins, stereo isomers as drugs, and thermoplastic polymers have all been updated. There are also several revised graphics and a new Connections box on generic drugs as stereo isomers.

Chapter 20 The Nature of Living Things (previously chapter 19): The discussion of photosynthesis and cellular respiration has been moved into the text and expanded to improve the coverage and simplify the discussion. A new table describing the levels of organization for living things has been added. Additional information on microscopes, and iso-, hyper-, and hypotonic solutions has been incorporated. New sections on what enzymes are and how they work, and on energy transfer molecules of living things—ATP—have also been added. This revised chapter also includes a greatly modified presentation on mitosis, additional information on cancer, and an abundance of new figures intended to better address the interests of the nonscience major.

Chapter 21 The Origin and Evolution of Life (previously chapter 20): There is a new section on the contributions of Louis Pasteur. A new Closer Look box on the life of Darwin has been added. Two contemporary examples of the process of evolution—changes in beak size of Darwin's finches and the evolution of insecticide resistance in poultry houses—have also been incorporated. There is a new section on the Hardy-Weinberg concept. The section on domains was rewritten, and the material on the central dogma was deleted. A new Closer Look on emerging viral diseases and a Science and Society box on how human behavior contributes to the development of antibiotic resistance have been included.

Chapter 22 The History of Life on Earth (previously chapter 21): This chapter includes a new section on radioactive isotope half-lives and their importance to radioactive dating. The section on human evolution has been updated with more recent findings. There are also several new figures and many new section headings to help the reader better follow the discussion.

Chapter 23: Ecology and Environment (previously chapter 22): Several new sections including a discussion of the phosphorus cycle, a comparison of the population characteristics of more-developed and less-developed countries, and a discussion of how human population growth affects the global ecosystem have been added. There are also many new and revised illustrations intended to better address the interests of the nonscience major.

Chapter 24 Human Biology: The coverage of materials exchange and control mechanisms includes many revisions suggested by reviewers. A new section on skin and a new Closer Look on the dynamic skeleton have been added. The material on nutrition from chapter 23 in the second edition has been moved to this chapter to improve the flow of the discussion and to better associate the coverage of nutrition and the human digestive system. The nutrition material has also been substantially rewritten.

Chapter 25 Sex and Sexuality: This is a dramatically revised chapter, partially created from a version of the previous chapter 23. Both the text and graphics are essentially new to this edition. See the table of contents for a complete listing of topics.

Chapter 26 Mendelian and Molecular Genetics (previously chapter 25): A new section, Using DNA to Our Advantage, has been added. This section presents such topics as biotechnology, recombinant DNA, genetically modified foods, gene therapy, the PCR reaction, genetic fingerprinting, and cloning. There are also many new and revised illustrations intended to better address the interests of the nonscience major.

The Learning System

To achieve the goals stated, this text includes a variety of features that should make your study of *Integrated Science* more effective and enjoyable. These aids are included to help you clearly understand the concepts and principles that serve as the foundation of the integrated sciences.

Overview to Integrated Science

Chapter 1 provides an overview or orientation to integrated science in general, and this text in particular. It also describes the fundamental methods and techniques used by scientists to study and understand the world around us.

Multidisciplinary Approach

Chapter Outlines

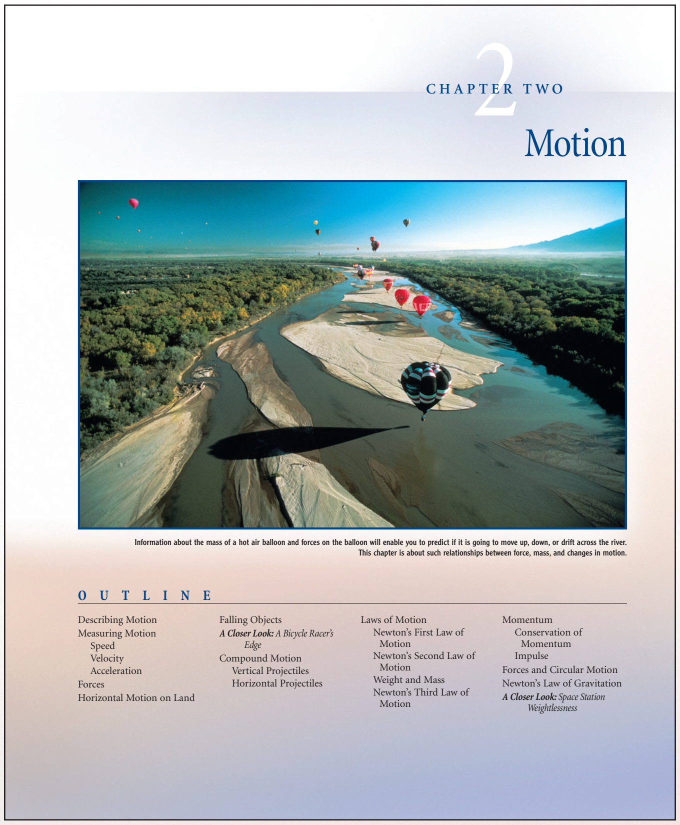
The chapter outline includes all the major topic headings and subheadings within the body of the chapter. It gives you a quick glimpse of the chapter's contents and helps you locate sections dealing with particular topics.

Core Concept Map

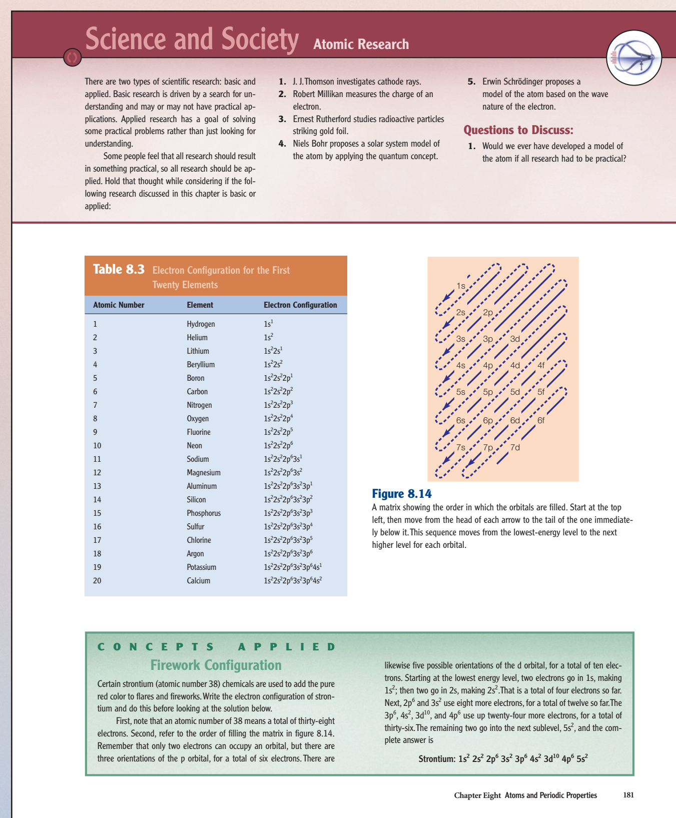
NEW! The concept map identifies a core idea for the chapter and shows how the topics in the chapter are related to this core idea. It also outlines that idea's relationship to other science disciplines throughout the text. The core concept map, combined with the chapter outline and overview, help you to see the big picture of the chapter content and the even bigger picture of how that content relates to other science discipline areas.

Chapter Overviews

Each chapter begins with an introductory overview. The overview previews the chapter's contents and what you can



expect to learn from reading the chapter. It adds to the general outline of the chapter by introducing you to the concepts to be covered. It also expands upon the core concept map, facilitating in the integration of topics. Finally, the overview will help you to stay focused and organized while reading the chapter for the first time. After reading this introduction, browse through the chapter, paying particular attention to the topic headings and illustrations so that you get a feel for the kinds of ideas included within the chapter.



Applying Science to the Real World

Concepts Applied

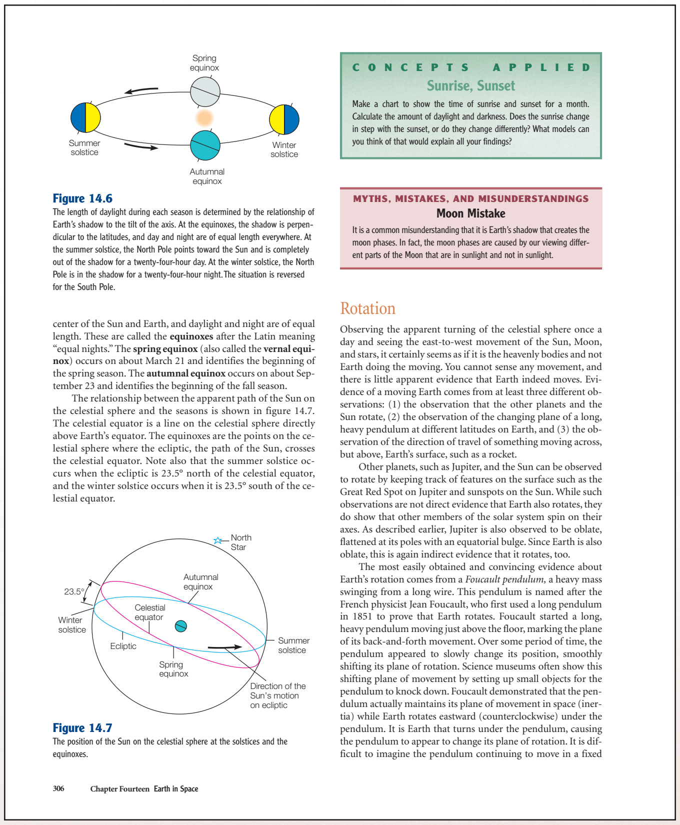
As you look through each chapter, you will find one or more Concepts Applied boxes. These activities are simple exercises that you can perform at home or in the classroom to demonstrate important concepts and reinforce your understanding of them. This feature also describes the application of those concepts to your everyday life.

Science and Society

NEW! These readings relate the chapter's content to current societal issues. Many of these boxes also include Questions to Discuss that provide an opportunity to discuss issues with your peers.

Myths, Mistakes, and Misunderstandings

NEW! These brief boxes provide short, scientific explanations to dispel a societal myth or a home experiment or project that enables you to dispel the myth on your own.



Closer Look and Connections

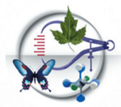
Each chapter of *Integrated Science* also includes one or more **Closer Look** readings that discuss topics of special human or environmental concern, topics concerning interesting technological applications, or topics on the cutting edge of scientific research. These readings enhance the learning experience by taking a more detailed look at related topics and adding concrete examples to help you better appreciate the real-world applications of science.

In addition to the **Closer Look** readings, each chapter contains concrete interdisciplinary **Connections** that are highlighted. **Connections** will help you better appreciate the interdisciplinary nature of the sciences. The **Closer Look** and **Connections** readings are informative materials that are supplementary in nature. These boxed features highlight valuable information beyond the scope of the text and relate intrinsic concepts discussed to real-world issues, underscoring the relevance of integrated science in confronting the many issues we face in our day-to-day lives. They are identified with the following icons:

> *"A Closer Look: The Compact Disc was, again, an excellent application of optics to everyday life and to something modern students thrive on—CDs and DVDs."*
>
> —Treasure Brasher, West Texas A&M University

> *"Connections—wonderful!!!. . . .great addition. . . . A Closer Look . . . excellent. Clear, interesting, good figures. You have presented crucial information in a straightforward and uncompromising way."*
>
> —Megan M. Hoffman, Berea College

General: This icon identifies interdisciplinary topics that cross over several categories; for example, life sciences and technology.



Life: This icon identifies interdisciplinary life science topics, meaning connections concerning all living organisms collectively: plant life, animal life, marine life, and any other classification of life.

Technology: This icon identifies interdisciplinary technology topics, that is, connections concerned with the application of science for the comfort and well being of people, especially through industrial and commercial means.

Measurement, Thinking, Scientific Methods: This icon identifies interdisciplinary concepts and understandings concerned with people trying to make sense out of their surroundings by making observations, measuring, thinking, developing explanations for what is observed, and experimenting to test those explanations.

Environmental Science: This icon identifies interdisciplinary concepts and understandings about the problems caused by human use of the natural world and remedies for those problems.

End-of-Chapter Features

At the end of each chapter you will find the following materials:

- *Summary:* highlights the key elements of the chapter
- *Summary of Equations* (chapters 1–9, 11): highlights the key equations to reinforce your retention of them
- *Key Terms:* page-referenced where you will find the terms defined in context
- *Applying the Concepts:* a multiple choice quiz to test your comprehension of the material covered
- *Questions for Thought:* designed to challenge you to demonstrate your understandings of the topic
- *Parallel Exercises* (chapters 1–9, 11): There are two groups of parallel exercises, Group A and Group B. The Group A parallel exercises have complete solutions worked out, along with useful comments in appendix D. The Group B parallel exercises are

SUMMARY

Stars are theoretically born in clouds of hydrogen gas and dust in the space between other stars. Gravity pulls huge masses of hydrogen gas together into a *protostar,* a mass of gases that will become a star. The protostar contracts, becoming increasingly hotter at the center, eventually reaching a temperature high enough to start *nuclear fusion* reactions between hydrogen atoms. Pressure from hot gases balances the gravitational contraction, and the average newborn star will shine quietly for billions of years. The average star has a dense, hot *core* where nuclear fusion releases radiation, a less dense *radiation zone* where radiation moves outward, and a thin *convection zone* that is heated by the radiation at the bottom, then moves to the surface to emit light to space.

The brightness of a star is related to the amount of energy and light it is producing, the size of the star, and the distance to the star. The *apparent magnitude* is the brightness of a star as it appears to you. To compensate for differences in brightness due to distance, astronomers calculate the brightness that stars would have at a standard distance. This standard-distance brightness is called the *absolute magnitude.*

Stars appear to have different colors because they have different surface temperatures. A graph of temperature by spectral types and brightness by absolute magnitude is called the *Hertzsprung-Russell diagram,* or H-R diagram for short. Such a graph shows that normal, mature stars fall on a narrow band called the *main sequence* of stars. Where a star falls on the main sequence is determined by its brightness and temperature, which in turn are determined by the mass of the star. Other groups of stars on the H-R diagram have different sets of properties that are determined by where they are in their evolution.

The life of a star consists of several stages, the longest of which is the *main sequence* stage after a relatively short time as a *protostar.* After using up the hydrogen in the core, a star with an average mass expands to a *red giant,* then blows off the outer shell to become a *white dwarf star,* which slowly cools to a black lump of carbon. The blown-off outer shell forms a *planetary nebula,* which disperses over time to become the gas and dust of interstellar space. More massive stars collapse into *neutron stars* or *black holes* after a violent *supernova* explosion.

Galaxies are the basic units of the universe. The Milky Way galaxy has three distinct parts: (1) the *galactic nucleus,* (2) a rotating *galactic disk,* and (3) a *galactic halo.* The galactic disk contains subgroups of stars that move together as *galactic clusters.* The halo contains symmetrical and tightly packed clusters of millions of stars called *globular clusters.*

All the billions of galaxies can be classified into groups of four structures: *elliptical, spiral, barred,* and *irregular.* Evidence from four different astronomical and physical "clocks" indicates that the galaxies formed some 13.7 billion years ago, expanding ever since from a common origin in a *big bang.* The *big bang theory* describes how the universe began by expanding.

KEY TERMS

absolute magnitude (p. **261**)
apparent magnitude (p. **260**)
big bang theory (p. **269**)
black hole (p. **266**)
Cepheid variable (p. **263**)
convection zone (p. **260**)
core (p. **260**)
dark energy (p. **270**)
dark matter (p. **271**)
galactic clusters (p. **267**)
galaxy (p. **266**)
globular clusters (p. **267**)
Hertzsprung-Russell diagram (p. **262**)
light-year (p. **259**)
main sequence stars (p. **262**)
nebulae (p. **259**)
neutron star (p. **265**)
protostar (p. **259**)
pulsar (p. **266**)
radiation zone (p. **260**)
red giant stars (p. **262**)
supernova (p. **265**)
white dwarf stars (p. **263**)

APPLYING THE CONCEPTS

1. Stars twinkle and planets do not twinkle because
a. planets shine by reflected light, and stars produce their own light.
b. all stars are pulsing light sources.
c. stars appear as point sources of light, and planets are disk sources.
d. All of the above are correct.

2. Which of the following stars would have the longer life spans?
a. the less massive
b. between the more massive and the less massive
c. the more massive
d. All have the same life span.

3. A bright blue star on the main sequence is probably
a. very massive.
b. less massive.
c. between the more massive and the less massive.
d. None of the above is correct.

4. The basic property of a main sequence star that determines most of its other properties, including its location on the H-R diagram, is
a. brightness.
b. color.
c. temperature.
d. mass.

5. All the elements that are more massive than the element iron were formed in a
a. nova.
b. white dwarf.
c. supernova.
d. black hole.

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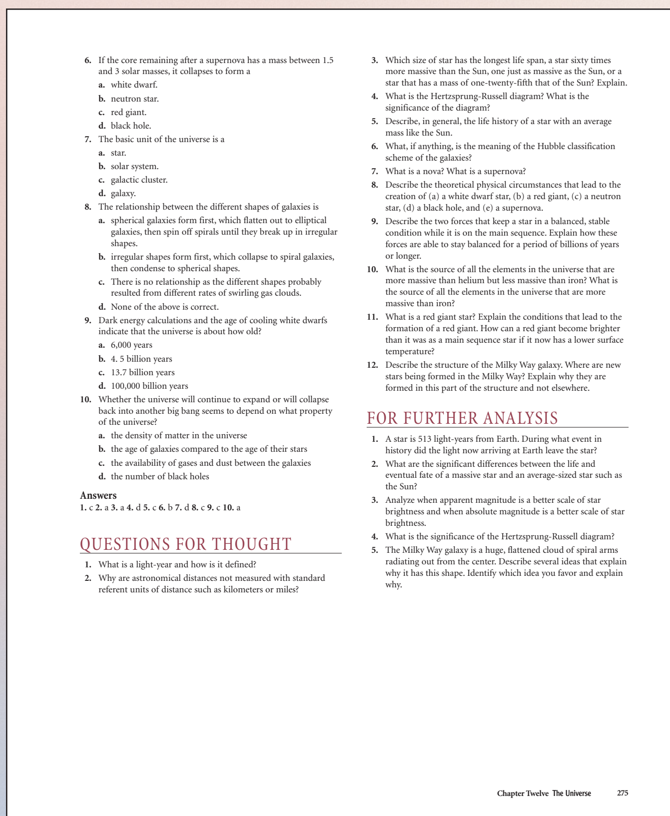

6. If the core remaining after a supernova has a mass between 1.5 and 3 solar masses, it collapses to form a
a. white dwarf.
b. neutron star.
c. red giant.
d. black hole.

7. The basic unit of the universe is a
a. star.
b. solar system.
c. galactic cluster.
d. galaxy.

8. The relationship between the different shapes of galaxies is
a. spherical galaxies form first, which flatten out to elliptical galaxies, then spin off spirals until they break up in irregular shapes.
b. irregular shapes form first, which collapse to spiral galaxies, then condense to spherical shapes.
c. There is no relationship as the different shapes probably resulted from different rates of swirling gas clouds.
d. None of the above is correct.

9. Dark energy calculations and the age of cooling white dwarfs indicate that the universe is about how old?
a. 6,000 years
b. 4. 5 billion years
c. 13.7 billion years
d. 100,000 billion years

10. Whether the universe will continue to expand or will collapse back into another big bang seems to depend on what property of the universe?
a. the density of matter in the universe
b. the age of galaxies compared to the age of their stars
c. the availability of gases and dust between the galaxies
d. the number of black holes

Answers
1. c **2.** a **3.** a **4.** d **5.** c **6.** b **7.** d **8.** c **9.** c **10.** a

QUESTIONS FOR THOUGHT

1. What is a light-year and how is it defined?
2. Why are astronomical distances not measured with standard referent units of distance such as kilometers or miles?
3. Which size of star has the longest life span, a star sixty times more massive than the Sun, one just as massive as the Sun, or a star that has a mass of one-twenty-fifth that of the Sun? Explain.
4. What is the Hertzsprung-Russell diagram? What is the significance of the diagram?
5. Describe, in general, the life history of a star with an average mass like the Sun.
6. What, if anything, is the meaning of the Hubble classification scheme of the galaxies?
7. What is a nova? What is a supernova?
8. Describe the theoretical physical circumstances that lead to the creation of (a) a white dwarf star, (b) a red giant, (c) a neutron star, (d) a black hole, and (e) a supernova.
9. Describe the two forces that keep a star in a balanced, stable condition while it is on the main sequence. Explain how these forces are able to stay balanced for a period of billions of years or longer.
10. What is the source of all the elements in the universe that are more massive than helium but less massive than iron? What is the source of all the elements in the universe that are more massive than iron?
11. What is a red giant star? Explain the conditions that lead to the formation of a red giant. How can a red giant become brighter than it was as a main sequence star if it now has a lower surface temperature?
12. Describe the structure of the Milky Way galaxy. Where are new stars being formed in the Milky Way? Explain why they are formed in this part of the structure and not elsewhere.

FOR FURTHER ANALYSIS

1. A star is 513 light-years from Earth. During what event in history did the light now arriving at Earth leave the star?
2. What are the significant differences between the life and eventual fate of a massive star and an average-sized star such as the Sun?
3. Analyze when apparent magnitude is a better scale of star brightness and when absolute magnitude is a better scale of star brightness.
4. What is the significance of the Hertzsprung-Russell diagram?
5. The Milky Way galaxy is a huge, flattened cloud of spiral arms radiating out from the center. Describe several ideas that explain why it has this shape. Identify which idea you favor and explain why.

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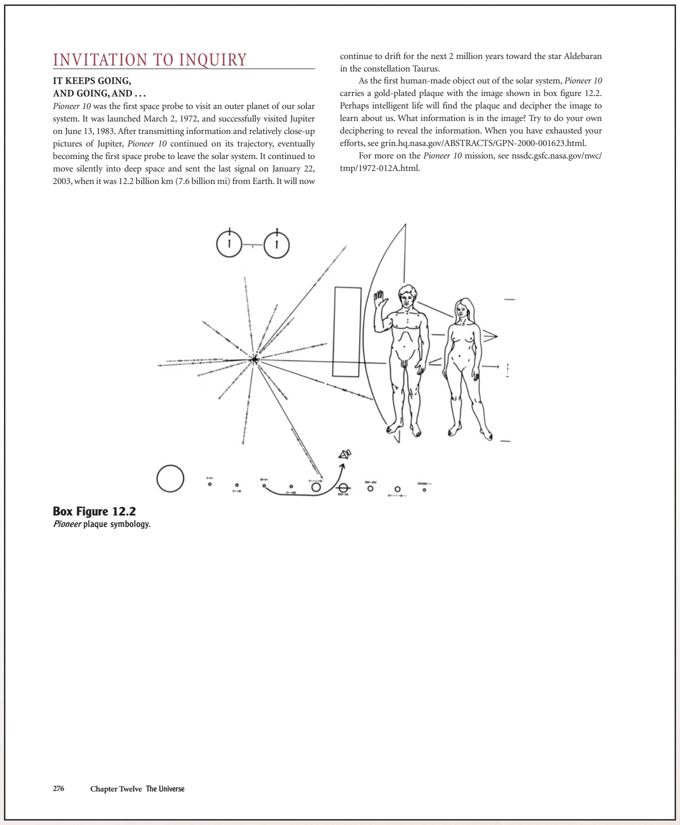

INVITATION TO INQUIRY

IT KEEPS GOING, AND GOING, AND . . .

Pioneer 10 was the first space probe to visit an outer planet of our solar system. It was launched March 2, 1972, and successfully visited Jupiter on June 13, 1983. After transmitting information and relatively close-up pictures of Jupiter, *Pioneer 10* continued on its trajectory, eventually becoming the first space probe to leave the solar system. It continued to move silently into deep space and sent the last signal on January 22, 2003, when it was 12.2 billion km (7.6 billion mi) from Earth. It will now continue to drift for the next 2 million years toward the star Aldebaran in the constellation Taurus.

As the first human-made object out of the solar system, *Pioneer 10* carries a gold-plated plaque with the image shown in box figure 12.2. Perhaps intelligent life will find the plaque and decipher the image to learn about us. What information is in the image? Try to do your own deciphering to reveal the information. When you have exhausted your efforts, see grin.hq.nasa.gov/ABSTRACTS/GPN-2000-001623.html.

For more on the *Pioneer 10* mission, see nssdc.gsfc.nasa.gov/nwc/tmp/1972-012A.html.

Box Figure 12.2
Pioneer plaque symbology.

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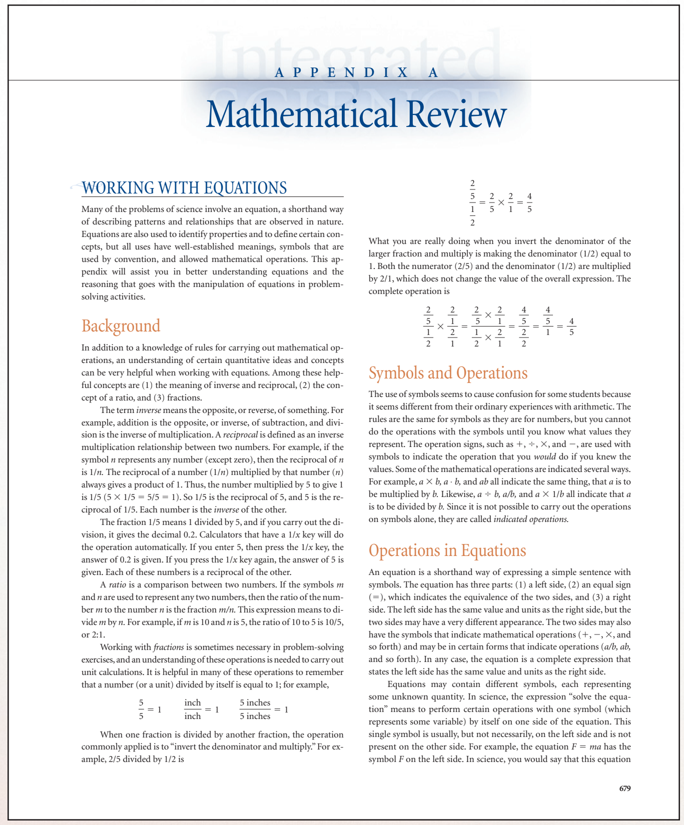

APPENDIX A

Mathematical Review

WORKING WITH EQUATIONS

Many of the problems of science involve an equation, a shorthand way of describing patterns and relationships that are observed in nature. Equations are also used to identify properties and to define certain concepts, but all uses have well-established meanings, symbols that are used by convention, and allowed mathematical operations. This appendix will assist you in better understanding equations and the reasoning that goes with the manipulation of equations in problem-solving activities.

Background

In addition to a knowledge of rules for carrying out mathematical operations, an understanding of certain quantitative ideas and concepts can be very helpful when working with equations. Among these helpful concepts are (1) the meaning of inverse and reciprocal, (2) the concept of a ratio, and (3) fractions.

The term *inverse* means the opposite, or reverse, of something. For example, addition is the opposite, or inverse, of subtraction, and division is the inverse of multiplication. A *reciprocal* is defined as an inverse multiplication relationship between two numbers. For example, if the symbol n represents any number (except zero), then the reciprocal of n is $1/n$. The reciprocal of a number ($1/n$) multiplied by that number (n) always gives a product of 1. Thus, the number multiplied by 5 to give 1 is 1/5 ($5 \times 1/5 = 5/5 = 1$). So 1/5 is the reciprocal of 5, and 5 is the reciprocal of 1/5. Each number is the *inverse* of the other.

The fraction 1/5 means 1 divided by 5, and if you carry out the division, it gives the decimal 0.2. Calculators that have a $1/x$ key will do the operation automatically. If you enter 5, then press the $1/x$ key, the answer of 0.2 is given. If you press the $1/x$ key again, the answer of 5 is given. Each of these numbers is a reciprocal of the other.

A *ratio* is a comparison between two numbers. If the symbols m and n are used to represent any two numbers, then the ratio of the number m to the number n is the fraction m/n. This expression means to divide m by n. For example, if m is 10 and n is 5, the ratio of 10 to 5 is 10/5, or 2:1.

Working with *fractions* is sometimes necessary in problem-solving exercises, and an understanding of these operations is needed to carry out unit calculations. It is helpful in many of these operations to remember that a number (or a unit) divided by itself is equal to 1; for example,

$$\frac{5}{5} = 1 \qquad \frac{\text{inch}}{\text{inch}} = 1 \qquad \frac{5\ \text{inches}}{5\ \text{inches}} = 1$$

When one fraction is divided by another fraction, the operation commonly applied is to "invert the denominator and multiply." For example, 2/5 divided by 1/2 is

$$\frac{\frac{2}{5}}{\frac{1}{2}} = \frac{2}{5} \times \frac{2}{1} = \frac{4}{5}$$

What you are really doing when you invert the denominator of the larger fraction and multiply is making the denominator (1/2) equal to 1. Both the numerator (2/5) and the denominator (1/2) are multiplied by 2/1, which does not change the value of the overall expression. The complete operation is

$$\frac{\frac{2}{5}}{\frac{1}{2}} \times \frac{\frac{2}{1}}{\frac{2}{1}} = \frac{\frac{2}{5} \times \frac{2}{1}}{\frac{1}{2} \times \frac{2}{1}} = \frac{\frac{4}{5}}{\frac{2}{2}} = \frac{\frac{4}{5}}{1} = \frac{4}{5}$$

Symbols and Operations

The use of symbols seems to cause confusion for some students because it seems different from their ordinary experiences with arithmetic. The rules are the same for symbols as they are for numbers, but you cannot do the operations with the symbols until you know what values they represent. The operation signs, such as $+$, $\div$, $\times$, and $-$, are used with symbols to indicate the operation that you *would* do if you knew the values. Some of the mathematical operations are indicated several ways. For example, $a \times b$, $a \cdot b$, and ab all indicate the same thing, that a is to be multiplied by b. Likewise, $a \div b$, a/b, and $a \times 1/b$ all indicate that a is to be divided by b. Since it is not possible to carry out the operations on symbols alone, they are called *indicated operations*.

Operations in Equations

An equation is a shorthand way of expressing a simple sentence with symbols. The equation has three parts: (1) a left side, (2) an equal sign (=), which indicates the equivalence of the two sides, and (3) a right side. The left side has the same value and units as the right side, but the two sides may have a very different appearance. The two sides may also have the symbols that indicate mathematical operations ($+$, $-$, $\times$, and so forth) and may be in certain forms that indicate operations (a/b, ab, and so forth). In any case, the equation is a complete expression that states the left side has the same value and units as the right side.

Equations may contain different symbols, each representing some unknown quantity. In science, the expression "solve the equation" means to perform certain operations with one symbol (which represents some variable) by itself on one side of the equation. This single symbol is usually, but not necessarily, on the left side and is not present on the other side. For example, the equation $F = ma$ has the symbol F on the left side. In science, you would say that this equation

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similar to those in Group A but do not contain answers in the text. By working through the Group A parallel exercises and checking the solution in appendix D, you will gain confidence in tackling the parallel exercises in Group B and thus reinforce your problem-solving skills.

- **NEW!** *For Further Analysis:* exercises include analysis or discussion questions, independent investigations, and activities intended to emphasize critical thinking skills and societal issues, and develop a deeper understanding of the chapter content.
- **NEW!** *Invitation to Inquiry:* exercises that consist of short, open-ended activities that allow you to apply investigative skills to the material in the chapter.

"I look for summaries that touch on all the high points and that lead students to recognize the most important aspects of the chapter. Any exercises should take the material that the students have learned and require applying that material to a new situation. . . . I also appreciate having a number of objective-type questions that the students can answer to see if they have mastered the terminology and data presented in the chapter. The end-of-chapter material is well done."

—Jay R. Yett, Orange Coast College

End-of-Text Material

At the back of the text, you will find appendices that will give you additional background details, charts, and answers to chapter exercises. There are also a glossary of all key terms, an index organized alphabetically by subject matter, and special tables printed on the inside covers for reference use.

GLOSSARY

A

abiotic factors nonliving parts of an organism's environment

absolute humidity a measure of the actual amount of water vapor in the air at a given time—for example, in grams per cubic meter

absolute magnitude a classification scheme to compensate for the distance differences to stars; calculations of the brightness that stars would appear to have if they were all at a defined, standard distance

absolute scale temperature scale set so that zero is at the theoretical lowest temperature possible, which would occur when all random motion of molecules has ceased

absolute zero the theoretical lowest temperature possible, which occurs when all random motion of molecules has ceased

abyssal plain the practically level plain of the ocean floor

acceleration a change in velocity per change in time; by definition, this change in velocity can result from a change in speed, a change in direction, or a combination of changes in speed and direction

accretion disk fat bulging disk of gas and dust from the remains of the gas cloud that forms around a protostar

acetylcholine a neurotransmitter secreted into the synapse by many axons and received by dendrites

acetylcholinesterase an enzyme present in the synapse that destroys acetylcholine

achondrites homogeneously textured stony meteorites

acid any substance that is a proton donor when dissolved in water; generally considered a solution of hydronium ions in water that can neutralize a base, forming a salt and water

acid-base indicator a vegetable dye used to distinguish acid and base solutions by a color change

acquired characteristics characteristics an organism gains during its lifetime that are not genetically determined and therefore cannot be passed on to future generations

active transport use of a carrier molecule to move molecules through a cell membrane in a direction opposite that of the concentration gradient; the carrier requires an input of energy other than the kinetic energy of the molecules

adenine a double-ring nitrogenous-base molecule in DNA and RNA; the complementary base of thymine or uracil

adenosine triphosphate (ATP) a molecule formed from the building blocks of adenine, ribose, and phosphates; it functions as the primary energy carrier in the cell

aerobic cellular respiration the biochemical pathway that requires oxygen and converts food, such as carbohydrates, to carbon dioxide and water; during this conversion, it releases the chemical-bond energy as ATP molecules

air mass a large, more or less uniform body of air with nearly the same temperature and moisture conditions throughout

air mass weather the weather experienced within a given air mass; characterized by slow, gradual changes from day to day

alcohol an organic compound with a general formula of ROH, where R is one of the hydrocarbon groups; for example, methyl or ethyl

aldehyde an organic molecule with the general formula RCHO, where R is one of the hydrocarbon groups; for example, methyl or ethyl

alkali metals members of family IA of the periodic table, having common properties of shiny, low-density metals that can be cut with a knife and that react violently with water to form an alkaline solution

alkaline earth metals members of family IIA of the periodic table, having common properties of soft, reactive metals that are less reactive than alkali metals

alkanes hydrocarbons with single covalent bonds between the carbon atoms

alkenes hydrocarbons with a double covalent carbon-carbon bond

alkyne hydrocarbon with a carbon-carbon triple bond

alleles alternative forms of a gene for a particular characteristic (e.g., attached-earlobe and free-earlobe are alternative alleles for ear shape)

alpha particle the nucleus of a helium atom (two protons and two neutrons) emitted as radiation from a decaying heavy nucleus; also known as an alpha ray

alpine glaciers glaciers that form at high elevations in mountainous regions

alternating current an electric current that first moves one direction, then the opposite direction with a regular frequency

alternation of generations a term used to describe that aspect of the life cycle in which there are two distinctly different forms of an organism; each form is involved in the production of the other, and only one form is involved in producing gametes

alveoli tiny sacs that are part of the structure of the lungs where gas exchange takes place

amino acids organic molecules that join to form polypeptides and proteins

amp unit of electric current; equivalent to C/s

ampere full name of the unit amp

amplitude the extent of displacement from the equilibrium condition; the size of a wave from the rest (equilibrium) position

anaphase the third stage of mitosis, characterized by dividing of the centromeres and movement of the chromosomes to the poles

androgens male sex hormones produced by the testes that cause the differentiation of typical internal and external genital male anatomy

angle of incidence angle of an incident (arriving) ray or particle to a surface; measured from a line perpendicular to the surface (the normal)

angle of reflection angle of a reflected ray or particle from a surface; measured from a line perpendicular to the surface (the normal)

angular momentum quantum number in the quantum mechanics model of the atom, one of four descriptions of the energy state of an electron wave; this quantum number describes the energy sublevels of electrons within the main energy levels of an atom

annular eclipse occurs when the penumbra reaches the surface of Earth; as seen from Earth, the Sun forms a bright ring around the disk of the Moon

anorexia nervosa a nutritional deficiency disease characterized by severe, prolonged weight loss for fear of becoming obese

Antarctic Circle parallel identifying the limit toward the equator where the Sun appears above the horizon all day for six months during the summer; located at 66.5°S latitude

anther the sex organ in plants that produces the pollen that contains the sperm

antibody a globular protein molecule made by the body in response to the presence of a foreign or harmful molecule called an antigen; these molecules are capable of

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". . . many books addressing similar disciplines have a tendency to talk over a student's head, making a student frustrated further in a class they do not want to be attending. . . . Personally I would admit that Integrated Science has a slight edge. The glossary seems up-to-date and centers in on words many nonscience majors may not understand."

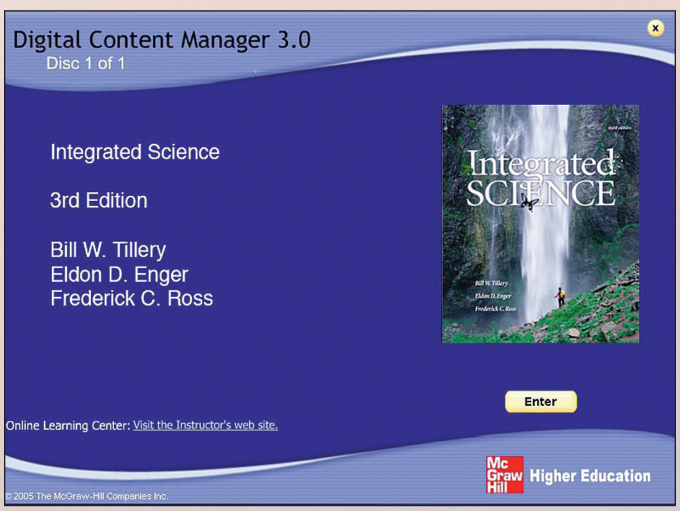
—David J. DiMattio, St. Bonaventure University

Multimedia Supplements

Digital Content Manager CD

Electronic art at your fingertips! This cross-platform CD ROM provides you with visuals from the text in multiple formats. You can easily create customized classroom presentations, visually based tests and quizzes, dynamic content for a course website, or attractive printed support materials. Available on this CD are the following resources in digital formats. These items have also been placed into PowerPoint files for ease of use:

- **Art and Photo Library:** Full-color digital files of all of the illustrations and many of the photos in the text can be readily incorporated into lecture presentations, exams, or custom-made classroom materials.
- **Worked Example Library and Table Library:** Access the worked examples and tables from the text in electronic format for inclusion in your classroom resources.
- **Animations Library:** Files of animations and videos covering various topics are included so that you can easily make use of these animations in a lecture or classroom setting.
- **Lecture Outlines:** Lecture notes, incorporating illustrations and animated images, have been written to the third edition text. They are provided in PowerPoint format so that you may use these lectures as written or customize them to fit your lecture.



Classroom Performance System

The **Classroom Performance System** (CPS) by eInstruction brings interactivity into the classroom or lecture hall. It is a wireless response system that gives the instructor and students immediate feedback from the entire class. The wireless response pads are essentially remotes that are easy to use and engage students. CPS allows instructors to motivate student preparation, interactivity, and active learning. Instructors receive immediate feedback to gauge which concepts students understand. Questions covering the content of the *Integrated Science* text and formatted for the CPS eInstruction software are available on the *Integrated Science* Online Learning Center.

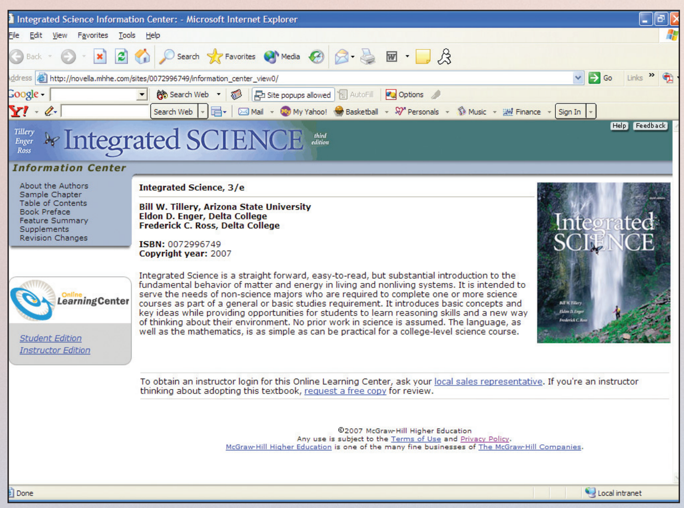
Online Learning Center

The **Online Learning Center** is an online repository for teaching and learning aids for the *Integrated Science* text. It houses downloadable and printable versions of traditional ancillaries plus a wealth of online content in an instructor's edition and a student edition.

Instructor's Edition of the Online Learning Center:
The text-specific Online Learning Center includes the fully downloadable instructor's manual. The instructor's manual, written by the text authors, provides chapter outlines, an introduction and summary for each chapter, suggestions for discussion and demonstrations, and multiple-choice questions (with answers) that can be used as resources for cooperative learning. It also includes answers and solutions to all end-of-chapter questions and exercises not provided in the text. Additionally, the instructor's edition of the online learning center features integration theme ideas and syllabi contributed by instructors who are presently teaching the Integrated Science course across the country.

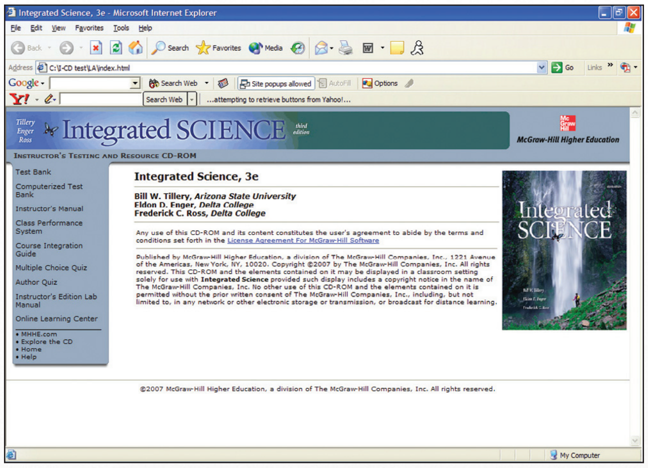
The Online Learning Center also contains the instructor's edition of the lab manual, visuals from the text in jpeg format, over two hundred animations, questions for use with personal response systems, a feedback page, and many other features.

Student Edition of the Online Learning Center:
Students can use the Online Learning Center to study in a variety of ways, including: scorable practice quizzes, additional self-assessment quizzes, animations, puzzles and flashcards that use key terms and definitions from the text, an online glossary, a career center, and web links.



Instructor's Testing and Resource CD-ROM

The **Instructor's Testing and Resource CD-ROM** contains the *Integrated Science* test bank (over seven hundred test questions in a combination of true/false and multiple choice formats) within McGraw-Hill's EZ Test testing software. EZ Test is a flexible and



easy-to-use electronic testing program. The program allows instructors to create tests from book specific items. It accommodates a wide range of question types and instructors may add their own questions. Multiple versions of the test can be created and any test can be exported for use with course management systems such as WebCT, BlackBoard or PageOut. EZ Test Online is a new service and gives you a place to easily administer your EZ Test created exams and quizzes online. The program is available for Windows and Macintosh environments. Also located on the Instructor's Testing and Resources CD-ROM are Word and PDF files of the test bank, the instructor's manual, the instructor's edition lab manual quizzes from the Online Learning Center, and personal response system questions. The Word files for the test bank, instructor's manual, Online Learning Center quizzes, and personal response system questions can be used in combination with the testbank software or independently.

Printed Supplementary Materials

Laboratory Manual

The laboratory manual, written and classroom-tested by the authors, presents a selection of laboratory exercises specifically written for the interest and abilities of nonscience majors. Each lab begins with an open-ended "***Invitations to Inquiry,***" designed to pique student interest in the lab concept. This is followed by laboratory exercises that require measurement and data analysis for work in a more structured learning environment. When the laboratory manual is used with *Integrated Science,* students will have an opportunity to master basic scientific principles and concepts, learn new problem-solving and thinking skills, and understand the nature of scientific inquiry from the perspective of hands-on experiences. There is also an **instructor's edition lab manual** available on the *Integrated Science* Online Learning Center and Instructor's Testing and Resource CD-Rom.

Transparencies

A set of one hundred full-color transparencies features images from the text. The images have been modified to ensure maximum readability in both small and large classroom settings.

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Meet the Authors

Bill W. Tillery

Bill W. Tillery is a professor in the Department of Physics and Astronomy at Arizona State University, where he has been a member of the faculty since 1973. He earned a bachelor's degree at Northeastern State University (1960) and master's and doctorate degrees from the University of Northern Colorado (1967). Before moving to Arizona State University, he served as director of the Science and Mathematics Teaching Center at the University of Wyoming (1969–73) and as an assistant professor at Florida State University (1967–69). Bill has served on numerous councils, boards, and committees and was honored as the "Outstanding University Educator" at the University of Wyoming in 1972. He was elected the "Outstanding Teacher" in the Department of Physics and Astronomy at Arizona State University in 1995.

During his time at Arizona State, Bill has taught a variety of courses, including general education courses in science and society, physical science, and introduction to physics. He has received more than forty grants from the National Science Foundation, the U. S. Office of Education, private industry (Arizona Public Service), and private foundations (Flinn Foundation) for science curriculum development and science teacher inservice training. In addition to teaching and grant work, Bill has authored or co-authored more than sixty textbooks and many monographs, and has served as editor of three newsletters and journals between 1977 and 1996.

Bill also maintains a website dedicated to providing resources for science teachers. This site, Science Education Resource Page (SERP), is funded by a grant from the Flinn Foundation. The URL is *http://serp.la.asu.edu.*

Eldon D. Enger

Eldon D. Enger is professor emeritus of biology at Delta College, a community college near Saginaw, Michigan. He received his B.A. and M.S. degrees from the University of Michigan. Professor Enger has over thirty years of teaching experience, during which he has taught biology, zoology, environmental science, and several other courses. He has been very active in curriculum and course development.

Professor Enger is an advocate for variety in teaching methodology. He feels that if students are provided with varied experiences, they are more likely to learn. In addition to the standard textbook assignments, lectures, and laboratory activities, his classes are likely to include writing assignments, student presentation of lecture material, debates by students on controversial issues, field experiences, individual student projects, and discussions of local examples and relevant current events. Textbooks are very valuable for presenting content, especially if they contain accurate, informative drawings and visual examples. Lectures are best used to help students see themes and make connections, and laboratory activities provide important hands-on activities.

Professor Enger has been a Fulbright Exchange Teacher to Australia and Scotland, received the Bergstein Award for Teaching Excellence and the Scholarly Achievement Award from Delta College, and participated as a volunteer in Earthwatch Research Programs in Costa Rica, the Virgin Islands and Australia. During 2001, he was a member of a People to People delegation to South Africa.

Professor Enger is married, has two adult sons, and enjoys a variety of outdoor pursuits such as cross-country skiing, hiking, hunting, kayaking, fishing, camping, and gardening. Other interests include reading a wide variety of periodicals, beekeeping, singing in a church choir, and preserving garden produce.

Frederick C. Ross

Fred Ross is professor emeritus of biology at Delta College, a community college near Saginaw, Michigan. He received his B.S. and M.S. from Wayne State University, Detroit, Michigan, and has attended several other universities and institutions. Professor Ross has over thirty years' teaching experience, including junior and senior high school, during which he has taught biology, cell biology and biological chemistry, microbiology, environmental science, and zoology. He has been very active in curriculum and course development. These activities included the development of courses in infection control and microbiology, and AIDS and infectious diseases, and a PBS ScienceLine course for elementary and secondary education majors in cooperation with Central Michigan University. In addition, he was involved in the development of the wastewater microbiology technician curriculum offered by Delta College.

He was also actively involved in the National Task Force of Two Year College Biologists (American Institute of Biological Sciences) and in the National Science Foundation College Science Improvement Program, and has been an evaluator for science and engineering fairs, Michigan Community College Biologists, a judge for the Michigan Science Olympiad and the Science Bowl, a member of a committee to develop and update blood-borne pathogen standards protocol, and a member of Topic Outlines in Introductory Microbiology Study Group of the American Society for Microbiology.

Professor Ross involved his students in a variety of learning techniques and has been a prime advocate of the writing-to-learn approach. Besides writing, his students are typically engaged in active learning techniques including use of inquiry-based learning, the Internet, e-mail communications, field experiences, classroom presentation, as well as lab work. The goal of his classroom presentations and teaching is to actively engage the minds of his students in understanding the material, not just memorization of "scientific facts." Professor Ross is married and recently a grandfather. He enjoys sailing, horseback riding, and cross-country skiing.