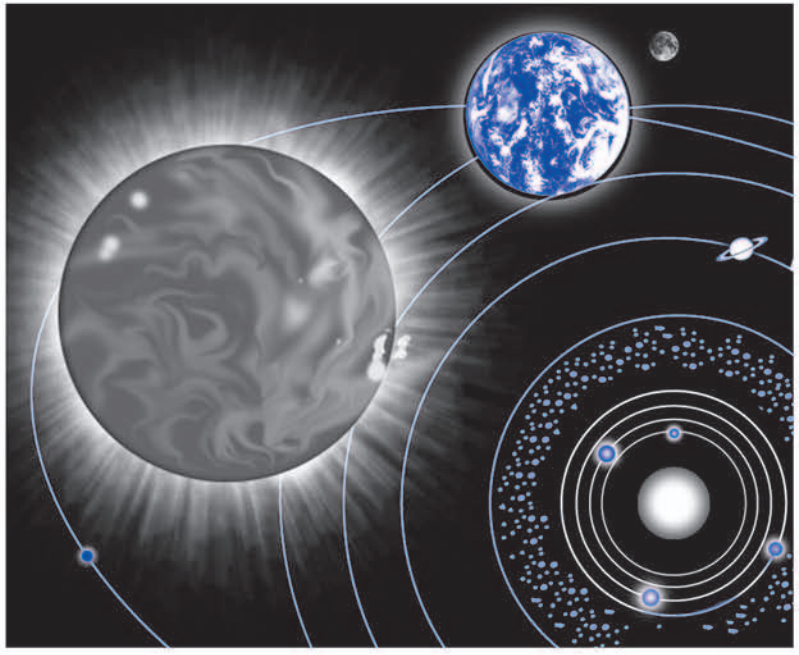


Introduction to

Earth and Space Science

Tom Hsu, Ph.D.

FIRST EDITION
CPO Science
Peabody, Massachusetts 01960

cpo science

Dramatic is a good word to describe both this cover and the study of Earth and space science. The cover is a universal-scale palette of what you will find in this text. On the front, we witness Earth's interior and see magnetic field lines radiating from the core. Following the magnetic field lines to the back cover, you will encounter the arcing solar prominences on the sun's fiery surface. Central in our solar system, the sun provides a source of energy that drives our weather, seasons, ocean currents, and food synthesis as long as there is water to cycle from place to place. Water moves on the cover in the images of a brewing storm, global cloud patterns, and the curl of an ocean wave reaching shore. In the deeper blues of the cover are images of nebulae, the birthplace of stars. Not surprisingly the nebula on the back cover is called the Horsehead Nebula. In striking contrast with the drama that unfolds on Earth, we have our moon, a familiar "face" in the sky. Earth's surface has changed again and again over its long history due to the powerful and slow movement of tectonic plates and the relatively fast effects of water and wind. The moon does not experience plate tectonics. It, therefore, remains unchanged and an excellent "lab" to study ancient rocks and land formations. With today's technology, we can see billions of years into the past and bring astronomically distant regions of the universe closer to us. We at CPO Science with Bruce Holloway, the spirited illustrator of the cover, hope these images will bring you closer to the wonders of Earth and space science and scientific discovery.

The CPO Science Development Team

Introduction to Earth and Space Science

ISBN 1-58892-063-1
1 2 3 4 5 6 7 8 9 - QWE - 05 04 03

CPO Science
26 Howley Street
Peabody, MA 01960
(800) 932-5227
http://www. cpo.com

Printed and Bound in the United States of America

Science Through Discovery

The universe is like a safe to which there is a combination, but the combination is locked up in the safe.
Peter de Vries

In many learning situations, you are expected to study prescribed materials and come up with correct answers by yourself. Usually, you read the information and then, in a laboratory, you try out the knowledge you acquired. With the CPO program, you will find that science is an opportunity for you to discover and solve problems—though they sometimes seem like mysteries more than "problems"—while working with others as a team.

Working with your fellow students, you will conduct Investigations to answer key questions, decide if your findings can be backed up with data and facts, and learn how to prove and justify your end results.

What you learn in school should be connected to what you know about the world around you. These connections will contribute to your success in life, sometimes in obvious ways, and many times in quite surprising ways. In today's workplace and in future educational pursuits, you will need to ask insightful questions, plan and organize your work, look for and analyze information, try out your ideas, and then be able to rethink a problem and try again. You must also be able to work on a team, to come up with a system for organizing information, and to feel comfortable about tackling new problems.

The CPO program provides the opportunity for you to practice answering questions, working with others, and finding your own system for solving problems. In the student text, you will find knowledge and skills needed to answer key questions and explore a variety of science topics. Along with each reading, you will complete an investigation activity so that part of your discovery of science is done with others. Some people may think exactly like you, while others might find different ways of approaching the same problem.

Finally, the ability to communicate effectively is one of the most valued skills in the world today. As a result, analyzing and communicating your findings to others in written, verbal or illustration form will be a major part of the learning process throughout the CPO program.

About the Student Text

There are *three* Major Science Units covered in this book. Each Unit contains *chapters* which are divided into multiple *sections*. The chapters and sections are organized so that you will learn basic skills and then build your knowledge to more complex understanding. You will notice that many of the important science concepts are repeated in different ways throughout the sections. Numerous illustrations, charts, graphs, and data tables support your reading and assist you in grasping its content. Also, there are short subheadings on the left margin of each page to help you study the main ideas and find information quickly.

Student Text Main Components

Main text: In addition to reading about science concepts and skills, you will discover brief stories about important scientists, inventions, real world connections, environmental issues, and interesting facts.

Chapter pages: Each chapter starts with two pages that outline what you will learn in the chapter. These pages provide you with a brief summary, the key questions for each Investigation, vocabulary, and learning goals.

Review questions: After each section, there are review questions that evaluate what you have learned and support you and your teacher in choosing what needs to be reviewed and which concepts to discuss further.

Glossary: The glossary is where you will find the meaning of words that are important science concepts and essential vocabulary. You can also find references to important people who are discussed in your reading.

Index: This section helps you find more specific topic information by giving page numbers that refer to the topic. You can use the index while studying to find information.

Reference Tables: A quick reference guide provides you with safety information, problem solving techniques (dimensional analysis), a conversion chart, table of formulas, and a list of physical constants. The inside back cover of the book is a quick reference periodic table and explanation of how to interpret it.

Student Text Pages

Sidenotes (idea headers): In the left margin of each page you will find phrases, short sentences, and questions to guide you in understanding the most important ideas. These sidenotes will also help you skim the text and quickly find information when you are reviewing and studying for tests.

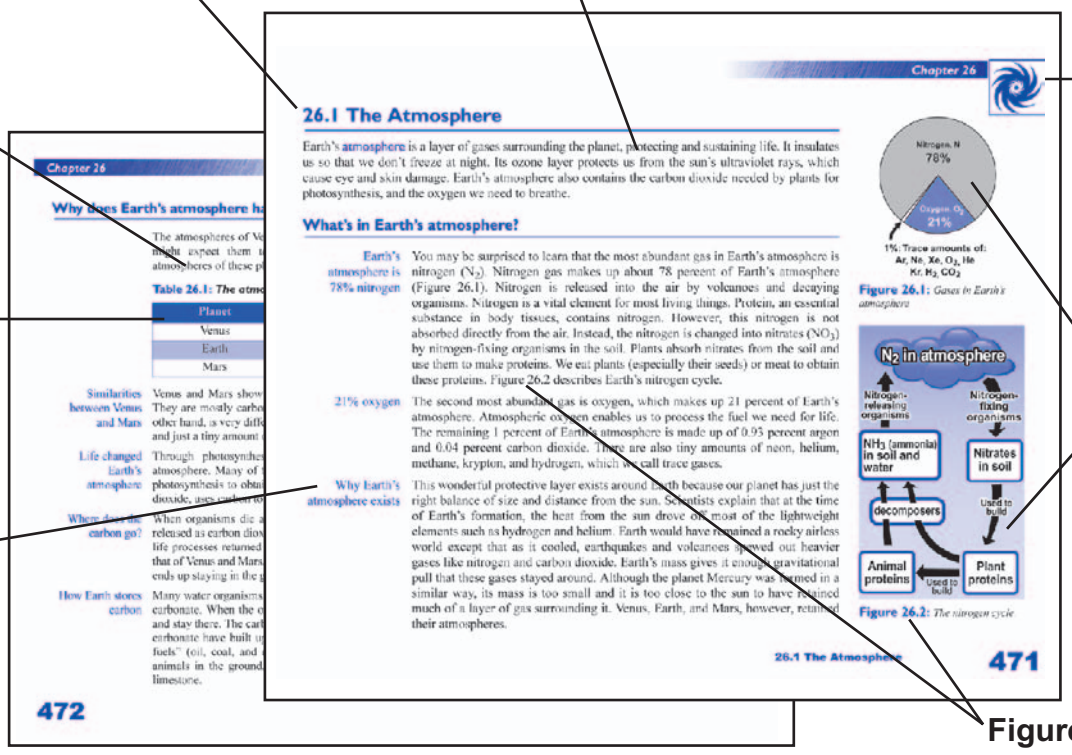
Illustrations: Use the illustrations, graphs, charts, and data tables to help you understand the reading. These reading tools help most students improve their understanding of the key concepts.

Vocabulary words: The vocabulary words are highlighted in blue. You need to understand their meanings to be successful in science and will find the same vocabulary used in many contexts and repeated throughout the text. The definitions can be found in the glossary.

Data tables: These tables will help you understand complex information, organize numerical data, and provide examples of how to collect and present data.

Figure number/captions: As you are reading, notice the references to the word *Figure* followed by a number. These figures are found on the right side of the page in the form of an illustration, picture, or chart. The figure number indicates which figure goes with the text you are reading and gives you another way to understand the information in the reading.

STUDENT TEXT PAGES



Section number and title

Introduction to section content

Main text including highlighted vocabulary words

Table: organizing important concepts and data

Side note highlighting new ideas in reading

Icon representing unit topic

Illustrations and charts that support content

Figure number is referenced from the text

Investigation Text

Hear and you forget;see and you remember; do and you understand.
Confucius

Investigations are hands-on activities that accompany the student text. For each section of the text, you will complete a hands-on activity, answer key questions, and find results. The *Investigation Manual* is a softcover book that contains Investigation activities that accompany each section you are reading. Sometimes you will read the student text before doing an Investigation activity, but usually you will complete the Investigations before you read the section.

The Investigations are the heart of the CPO program. We believe that you will learn and remember more if you have many opportunities to explore science through hands-on activities that use equipment to collect data and solve problems. Most of the Investigations rely on the use of CPO equipment to collect accurate data, explore possibilities and answer the key question. The equipment is easy to set up, and your teacher will help you learn how to use the equipment properly.

Features of the Investigation

Key question: Each Investigation starts with a key question that conveys the focus of the lesson. This question tells you what information you need to collect in order to answer the questions at the end of the Investigation.

Data tables: Data tables help you collect and organize your data in a systematic manner.

Learning objectives (goals): At the top of each investigation are the learning goals. These statements will explain what you will have learned and what you be able to do after completing the Investigation.

Brief introduction: This information helps you understand why the exercise is important to complete and, in most cases, how it connects to other sections of your reading.

Icons and section title: The icon is a reminder of the unit that you are studying. The section title corresponds to the reading in your student text.

Numbered steps: The Investigation sequence numbers point out the sequence of steps you will need to follow to successfully complete the Investigation. These steps highlight specific stages of the scientific method such as: following directions, completing hands-on experiments, collecting and analyzing data and presenting the results. The *Applying your Knowledge* step asks you to reflect on what you have learned and to explain your findings.

Illustrations: The illustrations support your understanding of the Investigation procedures.

Fill-in answer sheets: Your teacher will provide you with answer sheets to fill in the data tables and written responses. At times your teacher may collect this data to compile class results. You can also use the sheets to reinforce your reading in your student text.

INVESTIGATION PAGES

Section number referenced from the student text

Section title reference from the student text

Unit topic

Major learning objective for the investigation

Key question

Icon representing unit topic

Explanation of investigation content

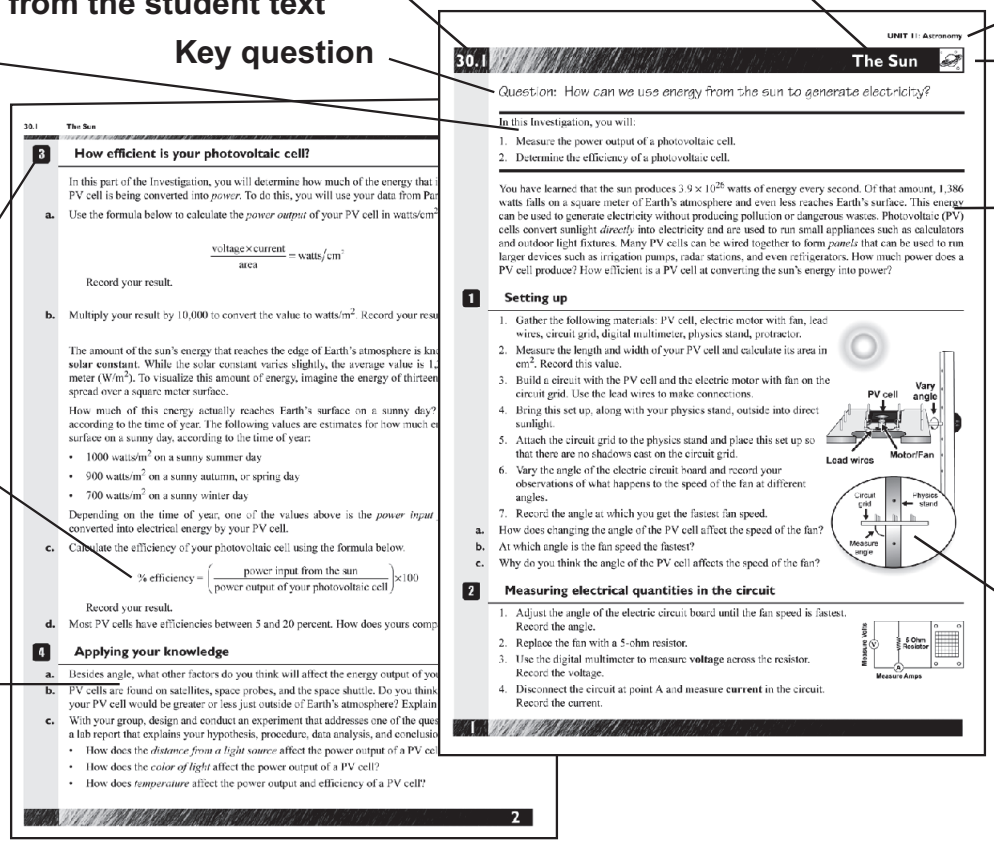
Investigation sequence numbers

Detailed explanations of investigation procedures, equipment set up, and data collection

Example space for data*

Thought-provoking question

Illustrations and charts that support content



UNIT 1: Astronomy

30.1 The Sun

Question: How can we use energy from the sun to generate electricity?

In this Investigation, you will:

1. Measure the power output of a photovoltaic cell.
2. Determine the efficiency of a photovoltaic cell.

You have learned that the sun produces 3.9×10^{25} watts of energy every second. Of that amount, 1,386 watts falls on a square meter of Earth's atmosphere and even less reaches Earth's surface. This energy can be used to generate electricity without producing pollution or dangerous wastes. Photovoltaic (PV) cells convert sunlight *directly* into electricity and are used to run small appliances such as calculators and outdoor light fixtures. Many PV cells can be wired together to form *panels* that can be used to run larger devices such as irrigation pumps, radar stations, and even refrigerators. How much power does a PV cell produce? How efficient is a PV cell at converting the sun's energy into power?

1 Setting up

1. Gather the following materials: PV cell, electric motor with fan, lead wires, circuit grid, digital multimeter, physics stand, protractor.
2. Measure the length and width of your PV cell and calculate its area in cm^2. Record this value.
3. Build a circuit with the PV cell and the electric motor with fan on the circuit grid. Use the lead wires to make connections.
4. Bring this set up, along with your physics stand, outside into direct sunlight.
5. Attach the circuit grid to the physics stand and place this set up so that there are no shadows cast on the circuit grid.
6. Vary the angle of the electric circuit board and record your observations of what happens to the speed of the fan at different angles.
7. Record the angle at which you get the fastest fan speed.

a. How does changing the angle of the PV cell affect the speed of the fan?
b. At which angle is the fan speed the fastest?
c. Why do you think the angle of the PV cell affects the speed of the fan?

PV cell
Vary angle
Load wires
Motor/Fan
Circuit grid
Physics stand
Measure angle

2 Measuring electrical quantities in the circuit

1. Adjust the angle of the electric circuit board until the fan speed is fastest. Record the angle.
2. Replace the fan with a 5-ohm resistor.
3. Use the digital multimeter to measure voltage across the resistor. Record the voltage.
4. Disconnect the circuit at point A and measure current in the circuit. Record the current.

Measure Volts
5 Ohm Resistor
Measure Amps

30.1 The Sun

3 How efficient is your photovoltaic cell?

In this part of the Investigation, you will determine how much of the energy that i PV cell is being converted into *power*. To do this, you will use your data from Par

a. Use the formula below to calculate the *power output* of your PV cell in watts/cm²

$$\frac{\text{voltage} \times \text{current}}{\text{area}} = \text{watts/cm}^2$$

Record your result.

b. Multiply your result by 10,000 to convert the value to watts/m^2. Record your resu

The amount of the sun's energy that reaches the edge of Earth's atmosphere is kn **solar constant**. While the solar constant varies slightly, the average value is 1, meter (W/m^2). To visualize this amount of energy, imagine the energy of thirteen spread over a square meter surface.

How much of this energy actually reaches Earth's surface on a sunny day? according to the time of year. The following values are estimates for how much e surface on a sunny day, according to the time of year:

- 1000 watts/m^2 on a sunny summer day
- 900 watts/m^2 on a sunny autumn, or spring day
- 700 watts/m^2 on a sunny winter day

Depending on the time of year, one of the values above is the *power input* converted into electrical energy by your PV cell.

c. Calculate the efficiency of your photovoltaic cell using the formula below.

$$\% \text{ efficiency} = \left(\frac{\text{power input from the sun}}{\text{power output of your photovoltaic cell}} \right) \times 100$$

Record your result.

d. Most PV cells have efficiencies between 5 and 20 percent. How does yours comp

4 Applying your knowledge

a. Besides angle, what other factors do you think will affect the energy output of yo
b. PV cells are found on satellites, space probes, and the space shuttle. Do you think your PV cell would be greater or less just outside of Earth's atmosphere? Explain
c. With your group, design and conduct an experiment that addresses one of the ques a lab report that explains your hypothesis, procedure, data analysis, and conclusio
   - How does the *distance from a light source* affect the power output of a PV cel
   - How does the *color of light* affect the power output of a PV cell?
   - How does *temperature* affect the power output and efficiency of a PV cell?

2

* Note: All data and answers to questions will be written on a separate fill-in answer sheet

Student Text Chapter Pages

Each *Unit* has several sections which make up a *Chapter*. *Chapter pages* outline what you will learn in the Chapter and the Investigations (hands-on activities) that complement the readings. The Chapter pages serve as a map that directs you to the major concepts that will be covered. It is important to refer back to these pages to help you focus your learning on the most important ideas introduced in the chapter.

Features of the Chapter Pages

Introduction: The Chapter page introduction summarizes what you will have learned when you finish all the sections and Investigations. Refer back to this summary after you finish the chapter to check your understanding, and use this summary when studying for exams.

Chapter contents and Investigations: This listing with the chapter numbers outlines the key questions and the content of the Investigations that accompany your student readings. When you read the questions and Investigation descriptions, you will be able to see how the Investigations help you understand the skills and concepts introduced in each chapter.

Learning goals: These goals are the major ideas that you will explore throughout the chapter. You should check your learning by going back to this page to make sure you can explain each of these concepts in writing or to another person.

Vocabulary: The list of vocabulary words at the beginning of the chapter will familiarize you with the words in the chapter. Understanding the science vocabulary will help you learn the concepts in the readings. Thinking and guessing about the meaning of the words before reading and then seeing how close you were to the correct meaning is a good learning tool.

Unit Icons Guide

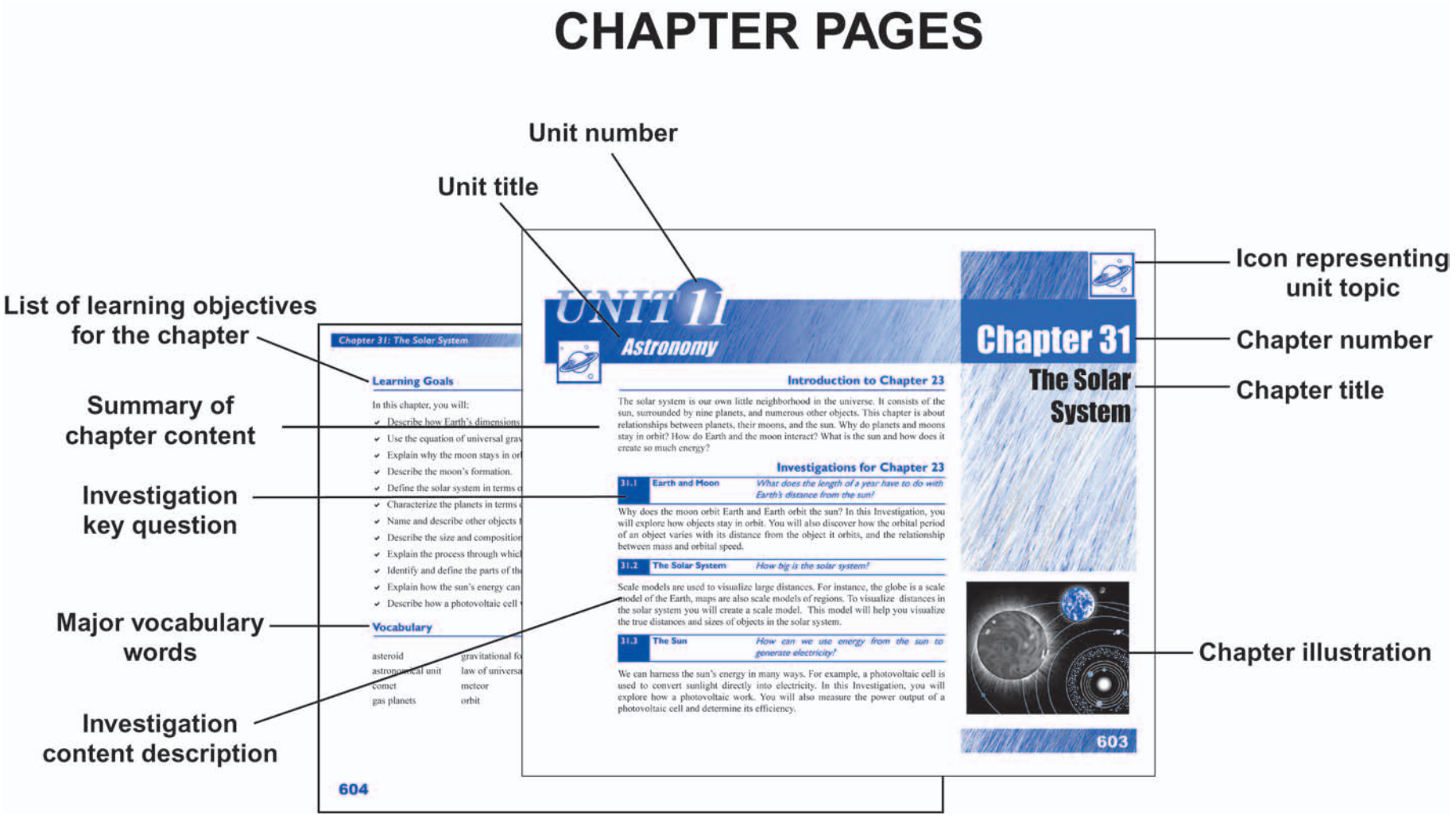
Unit icons are used to identify what unit topic you are studying. You will see these icons on the Chapter and Investigation corners.

Unit One: Energy in the Earth System

Unit Two: Earth Science

Unit Three: Astronomy

CHAPTER PAGES



Using Icons to Locate Information

Icons are small pictures that convey meaning without words. In the CPO program, we use icons to point out things such as safety considerations, real-world connections, and when to find information in the reference pages, complete a writing assignment, or work in a team. The chart below lists the icons that refer to instruction and safety and the meaning of each one:

The mind is not a vessel to be filled but a fire to be kindled
Plutarch

	**Reading:** you need to read for understanding.		**Real-world connections:** you are learning how the information is used in the world today.
	**Hands-on activity:** you will complete a lab or other activity.		**Teamwork:** you will be working in a team to complete the activity.
	**Time:** tells how much time the activity may take.		**Economics:** you are learning how science impacts the economy.
	**Research:** you will need to look up facts and information.		**Formula:** you are reading information about a formula or you will need to use an equation to solve a problem.
	**Setup:** directions for equipment setup are found here.		**Use extreme caution:** follow all instructions carefully to avoid injury to yourself or others.
	**History:** you are reading historical information.		**Electrical hazard:** follow all instructions carefully while using electrical components to avoid injury to yourself or others.
	**Environment:** you are reading information about the environment or how to protect our environment.		**Wear safety goggles:** requires you to protect your eyes from injury.
	**Writing:** you need to reflect and write about what you have learned.		**Wear a lab apron:** requires you to protect your clothing and skin.
	**Project:** you need to complete an assignment that will take longer than one day.		**Wear gloves:** requires you to protect your hands from injury from heat or chemicals.
	**Apply your knowledge:** refers to activities or problems that ask you to use your skills in different ways.		**Clean-up:** includes cleaning and putting away reusable equipment and supplies, and disposing of leftover materials.