

# *Physical Science*

*with Earth and  
Space Science*

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**FIRST EDITION**  
CPO Science  
Peabody, Massachusetts 01960

**cpo**  
science

The cover colorfully combines illustrations of the forces of nature studied in the various fields of the physical sciences. Here, the "evolving tapestry of conceptual thinking" begins with water. Water droplets dance with the planets including our own watery planet and Saturn with its icy rings. Water reappears in the combustion reaction of methane, as the substance on which plants depend, as pounding waves, and, on the back cover, as the darkening clouds of a coming storm. From this cycle of water, a modern bicycle rolls into a graphical interpretation of white light split into its rainbow of wavelengths and a fiber optic. You may lose yourself in many of these images which represent hundreds of years of scientific and technological innovation. Nevertheless, that our innovations are inextricably woven into and from the natural world is illustrated by the images of Earth and the spiral connection between the DNA helix and a bicyclist ever-moving forward. On the back cover, images from physics, chemistry, and earth and space science move around a chambered nautilus seen through the windows of the Golden Rectangle. We at CPO Science with Bruce Holloway, the spirited illustrator of the cover, hope these images will inspire your interest and excitement about the discovery of science.

*The CPO Science Development Team*

Foundations of Physical Science with Earth and Space Science

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ISBN 1-58892-059-3

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Printed and Bound in the United States of America

## Science Through Discovery

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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 use very accurate equipment 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 *Eleven* Major Science Units covered in the CPO student text. 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.

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

*Peter de Vries*

## 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

Chapter number

Main text including highlighted vocabulary words

Icon representing unit topic

Illustrations and charts that support content

Table: organizing important concepts and data

**Chapter 20**

**20.1 Bonding and Molecules**

Most of the matter around you and inside of you is in the form of compounds. For example, your body is made up of about 80 percent water. You learned in the last unit that water, H<sub>2</sub>O, is made up of hydrogen and oxygen atoms combined in a 2:1 ratio. If a substance is made of a pure element, like an iron nail, chances are (with the exception of the noble gases) it will eventually react with another element or compound to become something else. Why does iron rust? Why is the Statue of Liberty green, even though it is made of copper? The answer is fairly simple: Most atoms are unstable unless they are combined with other atoms. In this section, you will learn how, and why, atoms combine with other atoms to form molecules. Molecules are made up of more than one atom. When atoms combine to make molecules, they form chemical bonds.

**Why do atoms form chemical bonds?**

The outer electrons are involved in bonding. Electrons in atoms are found in energy levels surrounding the nucleus in the form of an electron cloud. The higher the energy level, the more energy is required in order for an electron to occupy that part of the electron cloud. The outermost region of the electron cloud contains the valence electrons and is called the valence shell. The maximum number of valence electrons that an atom can have is eight. The exception to this rule is the first energy level, which only holds two electrons. Valence electrons are the ones involved in forming chemical bonds.

All atoms want eight valence electrons. All atoms strive to have eight valence electrons. When an atom has eight valence electrons, it is said to have an octet of electrons. Figure 20.1 shows neon with a complete octet. In order to achieve this octet, atoms will lose, gain, or share electrons. An atom with a complete octet is chemically stable. An atom with an incomplete octet, like sodium (figure 20.2) is chemically unstable. Atoms form bonds with other atoms by either sharing them, or transferring them in order to complete their octet and become stable. This is known as the octet rule.

**Figure 20.1:** A neon atom is chemically stable because it has a complete octet, or eight valence electrons.

**Figure 20.2:** A sodium atom is chemically unstable because it has only one valence electron.

**Table 20.1: Elements, number of valence electrons, and number needed to complete the octet**

element	valence electrons	number needed
H	1	1
He	2	0
Li	1	7
Be	2	6
B	3	5
C	4	4
N	5	3
O	6	2
F	7	1

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Side note highlighting new ideas in the reading

Figure number is referenced from the text

## Investigation Text

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.

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

*Confucius*

# INVESTIGATION PAGES

**Section number referenced from the student text**

**Section title reference from the student text**

**Unit topic**

**Icon representing unit topic**

**Key question**

**Major learning objective for the investigation**

**Investigation sequence numbers**

**Example data table \***

**Thought-provoking question**

**Explanation of investigation content.**

**Illustration and charts that support content**

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

\* 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: Force and Motion		Unit Five: Light and Optics		Unit Nine: Energy in the Earth System
	Unit Two: Work and Energy		Unit Six: Properties of Matter		Unit Ten: Earth Science
	Unit Three: Electricity and Magnetism		Unit Seven: Changes in Matter		Unit Eleven: Astronomy
	Unit Four: Sound and Waves		Unit Eight: Water and the Environment		

# CHAPTER PAGES

The diagram illustrates the layout of a chapter page, divided into two main sections: a table of contents page (left) and a chapter introduction page (right).

**Table of Contents Page (Left):**

- Unit number:** 11
- Unit title:** Astronomy
- Chapter 31: The Solar System**
- Learning Goals:**
  - In this chapter, you will:
    - Describe how Earth's dimensions
    - Use the equation of universal gravitation
    - Explain why the moon stays in orbit
    - Describe the moon's formation.
    - Define the solar system in terms of the sun and planets
    - Characterize the planets in terms of their size and composition
    - Name and describe other objects in the solar system
    - Describe the size and composition of the sun
    - Explain the process through which the sun's energy is generated
    - Identify and define the parts of the solar system
    - Explain how the sun's energy can be used on Earth
    - Describe how a photovoltaic cell works
- Vocabulary:**
  - asteroid
  - astronomical unit
  - comet
  - gas planets
  - gravitational force
  - law of universal gravitation
  - meteor
  - orbit
- Page number:** 604





















**Chapter Introduction Page (Right):**

- Icon representing unit topic:** A small icon of a planet with a ring.
- Chapter number:** Chapter 31
- Chapter title:** The Solar System
- Introduction to Chapter 23:** The solar system is our own little neighborhood in the universe. It consists of the sun, surrounded by nine planets, and numerous other objects. This chapter is about relationships between planets, their moons, and the sun. Why do planets and moons stay in orbit? How do Earth and the moon interact? What is the sun and how does it create so much energy?
- Investigations for Chapter 23:**
  - 31.1 Earth and Moon:** *What does the length of a year have to do with Earth's distance from the sun?* Why does the moon orbit Earth and Earth orbit the sun? In this Investigation, you will explore how objects stay in orbit. You will also discover how the orbital period of an object varies with its distance from the object it orbits, and the relationship between mass and orbital speed.
  - 31.2 The Solar System:** *How big is the solar system?* Scale models are used to visualize large distances. For instance, the globe is a scale model of the Earth, maps are also scale models of regions. To visualize distances in the solar system you will create a scale model. This model will help you visualize the true distances and sizes of objects in the solar system.
  - 31.3 The Sun:** *How can we use energy from the sun to generate electricity?* We can harness the sun's energy in many ways. For example, a photovoltaic cell is used to convert sunlight directly into electricity. In this Investigation, you will explore how a photovoltaic work. You will also measure the power output of a photovoltaic cell and determine its efficiency.
- Chapter illustration:** A large illustration showing the sun, planets, and moons in the solar system.
- Page number:** 603

## 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

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