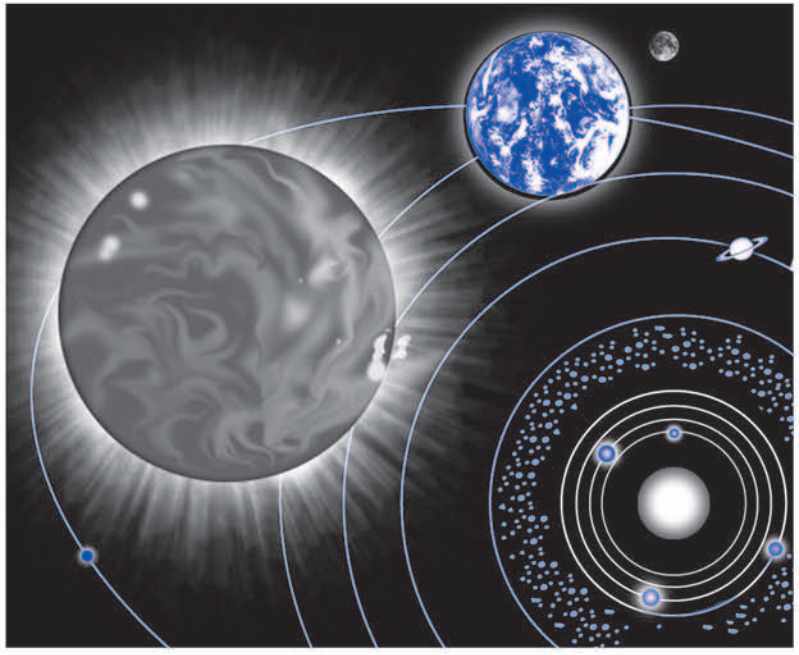

Introduction to

# 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

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# The CPO Science Program

*"The whole of science is nothing more than a refinement of everyday thinking."*

*Albert Einstein*

One of the great scientists in history, Albert Einstein stated, "The whole of science is nothing more than a refinement of everyday thinking." This great thinker and theorist explained that science is not just the memorization of complex facts or the rote learning of complicated ideas but a process by which we discover and explore the things, concepts, and mysteries we see around us.

The CPO Introduction to Earth and Space Science Program is created from the premise that science is an exploration and discovery of ideas about the universe, and that ideas and knowledge connect and enhance our lives. The program is presented and sequenced in a way that moves the student through an inquiry-based learning approach. For example, each Investigation begins with a key question that forms the foundation for the learning in that Investigation. In some sections, students complete experiments and hands-on activities before conceptualizing ideas in the student readings. Threaded throughout all the instruction are probing questions that students answer through exploration, posing new questions, finding data to prove theories, and expressing their findings to others.

## Scope and sequence

Unlike other textbooks that match content to National Science Education Standards, the CPO Science Program was written directly to your state standards. The standards form the benchmark criteria from which each science topic, specific content requirement, and science process was developed. The program provides numerous opportunities for students, teachers, and schools to meet the standards and state testing program. Matching the standards to CPO Unit topics ensures that students will receive the highest quality in science instruction to the depth and breadth necessary to meet your teaching needs.

If requested, CPO Science staff will send your state correlation index. This document demonstrates the alignment between the your standards and the CPO Science Program. The index lists specific page numbers from the CPO Student Edition and Investigation Lab Manual where examples of correlations are found. The CPO Scope and Sequence found in this reference guide demonstrates the careful consideration and detail of content match between the Student Edition and accompanying Investigations. These charts can be reviewed as a quick reference to the teaching and learning objectives covered in this program.

## Meeting all students' needs

Learning science is an active process allowing students to gain abstract, conceptual knowledge through discovery. Most students learn best when reading is enhanced by doing. The CPO Science Program combines strong, in-depth coverage of Earth and space science content with abundant hands-on learning activities to meet the variety of learning styles. Real-world examples and historical perspectives provide students the authenticity that validates their connection to the content and topics. Teaching tips are found in the teacher's guide as suggestions for remediation and skill development practice with challenge problems for students who are prepared to tackle more difficult concepts.

# The Multilevel Classroom of Today

Classrooms are composed of learners who are at different instructional levels and who process information through multiple learning styles. The CPO Science Program has been designed to meet the challenge of bringing in-depth, accurate science to all students. To teach in-depth science concepts and skills, the design of the Student Edition reflects instructional aids and strategies to meet that diversity of student needs. Careful consideration has been taken to include reading, math, and learning techniques to help all students grasp science concepts and skills.

## Reading and concept-learning strategies

**Main idea indicators** — Main idea indicators appear in the left margin of each paragraph in the Student Edition to help students find information and understand the main concepts in the instruction. Students can use the indictors in the following ways:

- Read all the main idea indicators before reading the section as a pre-reading activity.
- List the major points of the section.
- Create outlines and concept maps.
- Find answers to questions by skimming and scanning the indicators for a quick review.

**Highlighted vocabulary** — As in any discipline or occupation, people must understand the subject's terminology and know how to use it correctly. Terms, units of measurement, and concepts are highlighted in blue for students to easily identify key words as reading clues and for vocabulary development.

**Bold highlighted points** — Major scientific concepts, vocabulary, and laws appear in large print and blue type. These statements identify the major learning points and what to review when studying.

## Building problem-solving skills by using key questions

Asking questions before starting an activity focuses students on what they will learn during the experiment or reading. Each Investigation begins with a key question that students need to answer after the activity. Students build problem-solving and critical thinking skills as they tackle each Investigation question. The following is a suggested sequence to use when deciphering questions:

- Have the student reread the question.
- Underline the action words and explain what is being asked.
- Identify the important words (usually vocabulary words).
- Have the students rewrite the question in their own words.
- Help students decide what they will need to know in order to answer the question.

## Reading illustrations and graphics

Some students learn best through visual clues and illustrations. Others need the dual support of text and visual clues in order to comprehend science concepts and theories. Our Student Edition and Investigations manual have numerous content-rich illustrations, charts, tables, and graphics. Suggestions for using the visual clues include:

- Give students enough time to analyze the graphics and illustrations. Decoding the meaning of a visual is like reading text.
- Ask the students to verbally explain what they see in the graphic and what is being demonstrated.
- Teach students to read data tables and graphs so that they understand how to organize and represent data. Numerous examples and questions requiring completion of tables are presented with explanations.
- In teams, have students illustrate a concept or create graphics for the section. Other team members decide which concept or section is being illustrated.

## Reading, understanding, and using math formulas

Formulas help students describe relationships between quantities. After students understand the basis for formulas and how they represent relationships, they can use them as tools for solving problems or predicting outcomes. We emphasize understanding relationships rather than simply memorizing formulas.

- Math formulas are connected to the data collection process during hands-on activities. The formulas are all in the context of the Investigation, and as a result, students apply math formulas to actual science experiences.

Important math formulas are highlighted, written in large print, and also explained in the text.

- Example problems illustrate how to use the formula and how it can be applied to the most common situations. Students' learning of the formulas is reinforced throughout the Student Edition and in the assessment sections.
- Only the most relevant math formulas are presented in the text and explained in depth.

## Expressing learning in a variety of ways

Students learn differently and use various avenues for expressing their knowledge. In the review questions in the Student Edition, students are asked to answer *Applying Your Knowledge* questions. These questions allow students to express their knowledge and demonstrate learning in several modalities. Examples include designing an experiment, researching information, building a model, writing an essay, creating an advertisement, preparing a pamphet or brochure, discussing and presenting ideas, creating sketches, interviewing someone, creating a handout for young children, and using the Internet.

## Evaluation and Assessment

*"Anyone who has never made a mistake has never tried anything new."*

*Albert Einstein*

The CPO Science Program is committed to presenting material in a variety of ways to meet the diversity of student learning styles. Students learn in a combination of modalities and demonstrate understanding through a variety of modes. A combination of evaluation methods is available to ensure multilevel and diverse opportunities. A variety of methods is necessary in order for students to demonstrate science content knowledge, application skills, performance abilities, and scientific process and problem-solving skills to the best of their ability. Below are descriptions of the different evaluation and assessment instruments.

### Evaluating with review questions — formative assessment

Review questions are found at the end of each chapter to evaluate student progress and reflect on key chapter objectives. These questions provide opportunities to test and practice vocabulary, concept knowledge, skill understanding, computational ability, problem solving, and application. Many questions require a written response in order to better evaluate the student's abstract understanding. The review questions are a useful teaching tool to benchmark individual progress and to aid class discussions that review and reflect on chapter objectives.

### Assessing broader knowledge with assessment questions — summative assessment

The assessment questions have been carefully designed to test all the important topics covered in a unit. The assessment questions evaluate the student's knowledge that correlates with the unit. Included in the questions are examples of graphs, charts, and computational information needed to answer questions and demonstrate application skills. The assessment questions consist of multiple choice and multi-format questions that cover computation, skill attainment, and concept understanding. These questions are designed to reflect typical standardized test questions. Exposure and practice in answering multiple-choice type questions has proved helpful to students in states using formal standardized testing. Assessment tests and answers are in a booklet found on the Teacher's Resource CD-ROM.

### Learning and applying skills — performance assessment

Being able to justify conclusions based on active experimentation and data collection is a powerful skill in today's technological world. Performance assessment measures how well a student can solve problems and demonstrate understanding through application. The CPO Science Program builds the self-confidence that students need to tackle problems in a thoughtful and sequenced manner.

An Investigation is completed with each teacher's guide section and includes questions and activities that allow teachers to observe the students' ability to think and demonstrate understanding. Most Investigations rely on team participation and hands-on learning. Students are continuously exposed to a systematic problem-solving method that encourages students to discover, observe, collect data and justify findings. A sample observation evaluation form is provided in the *Teaching Tools* section of the Teacher's Guide to help determine the students' progress with performance tasks. A student reflection form can also be found in the *Teaching Tools* section.

## Organization of the Program

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

*Confucius*

The program is composed of four components: Student Edition, Investigations, Teacher's Guide, and Equipment. These components reflect the connections between inquiry-based learning, hands-on discovery, and grasping science concepts through reading. Abstract concepts and skill development opportunities are presented in a variety of ways to address diverse and multiple learning styles. Enhancing the instruction are clear, precise illustrations that reinforce the learning of abstract concepts. By the end of each section, students have completed a hands-on activity or experiment, answered essential questions, and mastered science skills and content through reading.

The Teacher's Guide includes teacher's guides (one for each Investigation) and support materials. The support materials are as follows: glossary, index, review answer keys, teaching tools, and equipment setup. Each teacher's guide includes a sample lesson that demonstrates how to teach the lesson with accompanying Investigation sheets and answers. Teaching tips, challenge questions, and student reinforcement of skills are also present.

## Student Edition

The basic organizational structure of the Student Edition is the unit. There are three units that are broken down into topic chapters containing two to five content-specific sections. The unit themes covered in the CPO Introduction to Earth and Space Science Program were chosen because of their relevance to CPO's commitment to in-depth coverage of science concepts. The glossary and index have been designed so students can quickly skim for page numbers and definitions. Each student section contains pertinent content and skills-development reading with numerous illustrations for reading support. Each chapter contains an extensive review question section that evaluates the student's progress in areas such as: vocabulary development, concept understanding, computation skills, and application. Special features of the Student Edition:

- **Chapter pages:** These introductory pages present the major components of the student reading, including Investigation descriptions, what the student will learn from the section, and the pertinent vocabulary.
- **Side heading outlines:** Developing literacy skills in math and reading is stressed throughout the instruction. Left-margin side headings highlight the main ideas in the text and help the student grasp reading concepts through skimming, scanning, and key word identification.
- **Highlighted vocabulary:** Science vocabulary mastery is paramount for science concept understanding. Science vocabulary can be highly technical and abundant. Vocabulary words are highlighted for easy identification and defined in a variety of ways.
- **Numerous visual teaching tools:** The Student Edition contains graphics, charts, illustrations, and data tables supporting abstract conceptual learning. These teaching tools reinforce instruction and aid in visual representation of material necessary for addressing multiple learning styles. The visuals are precise in content and presentation and reflect CPO's commitment to accuracy, science content excellence, and inquiry-based instruction.

## Investigations

The Investigations are the heart of the CPO Science Program. We believe that most students learn best and are motivated to learn through direct experience and exploration activities. Key questions focus the student on the main point of the learning and what they should be able to answer after the experiment. There is at least one Investigation for each student reading section. The student reading and Investigation closely compliment the science instruction and reinforce the same principles.

Each Investigation is introduced with a key question that the students will be able to answer after completing the hands-on activity. Students are also given learning goals for each Investigation and a short informational piece to get them thinking about the content of the Investigation. Student answer pages are found in the teacher's blackline master notebook. The teacher can duplicate the forms for students to complete and answer the questions.

*"The strongest arguments prove nothing so long as the conclusions are not verified by experience. Experimental science is the queen of sciences and the goal of all speculation."*

*Roger Bacon*

Each Investigation begins with a key question and uses leading questions to aid in skill development, reflection, and application. An observation form is found in the *Teaching Tools* section of the Teacher's Guide to aid the teacher in evaluating Investigations as performance-based tasks.

Investigations are usually completed before the accompanying student reading section. The CPO philosophy is based on the premise that through discovery, the students will begin to understand foundation skills and concepts. The student readings strengthen the students' knowledge of theory and aid in their understanding. For certain Investigations, the student reading must be read first so that students have the basic knowledge necessary to complete the Investigation. Whether a section should be read before or after an Investigation is explained under the reading synopsis heading in the teacher's guide pages for each section.

## Special Features

- **Data collection, graphing skills and the scientific process:** These skills are emphasized and reinforced throughout the program and students are frequently encouraged to practice these skills as self-learners.
- **Lesson planning page:** The information you need to know to teach and conduct the Investigation is available in the teacher's guide section pages. The learning goals and questions, equipment setup requirements, consumable materials list, teaching sequence, and a synopsis of the student reading are all in found on the lesson introduction pages.
- **Icons:** Throughout the Investigations, icons are used to point out safety requirements and to reference important information for the students. A reference sheet of the icons and the meaning of each is found in the Student Edition and the teacher's guides.
- **Equipment:** Specialized equipment has been designed to accompany the teaching of the Investigations. The equipment is durable and provides consistent accurate results.

## Teacher's guides

*"The most important thing in science is not so much to obtain new facts as to discover new ways to think about them."*

*William Bragg*

The individual teacher's guides (collected in the Teacher's Guide) are constructed around the same premise as the student instructional materials: inquiry-based learning. The guides include a sample demonstration lesson for each Investigation written as a dialogue between the teacher and the class. These samples demonstrate how to teach the Investigation using inquiry-based teaching and student group discovery. The sample demonstration is only one example of teaching the Investigation with possible student responses. Teaching tips, the accompanying student section synopsis, projects, and teaching strategies are also included.

The first two pages of each teacher's guide section contain a clear, concise overview of the Investigation. It is our belief that a quick guide is useful in outlining the learning objectives, setting up the Investigation, and mapping the sequence of the Investigation procedures. These pages contain a brief synopsis of the student reading, review of the leading question, learning objectives, and a clear equipment and consumable materials list. The equipment setup instructions are identified with an equipment icon and are found in this volume under the *Equipment Setup* section.

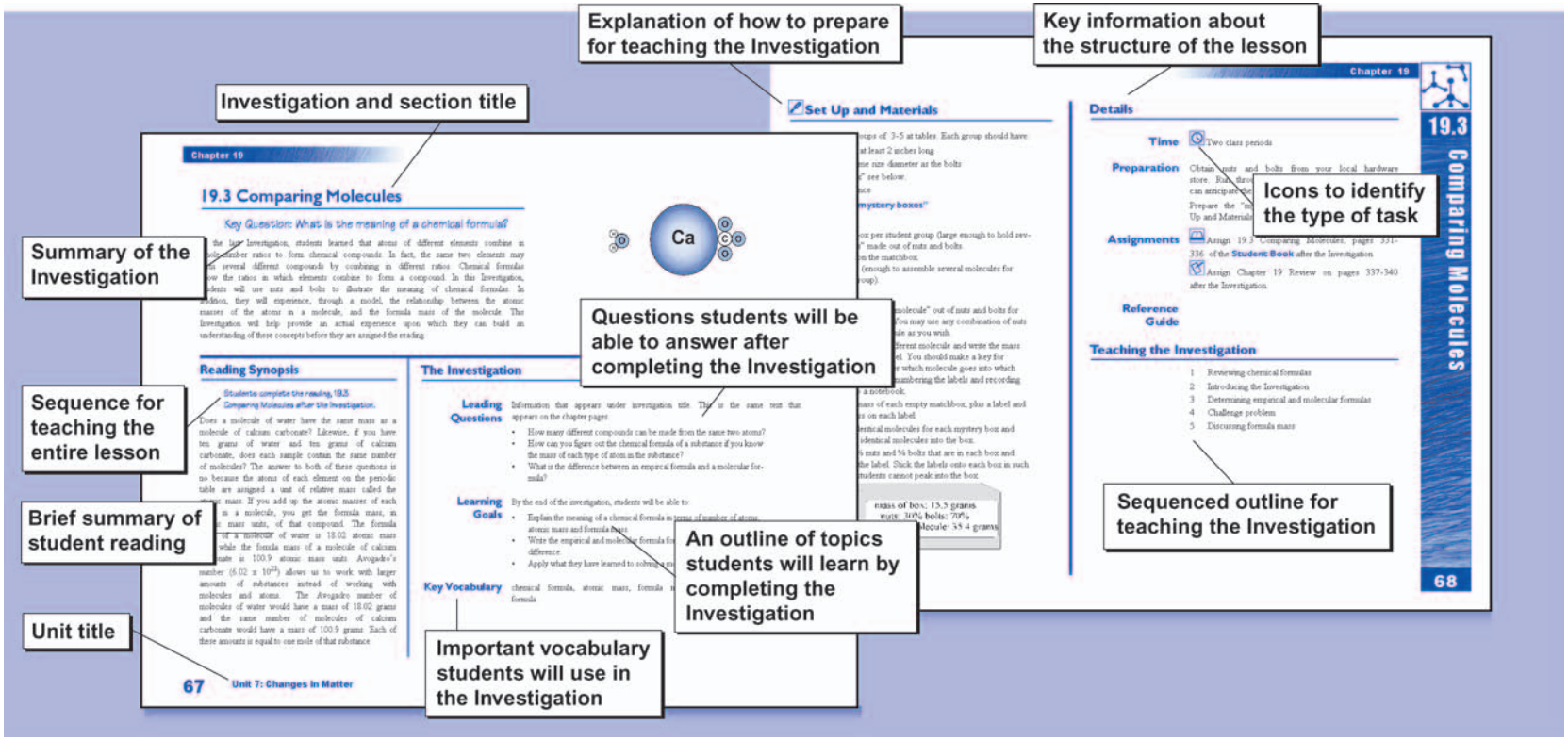
The Investigation lesson pages present a sample teaching scenario written as a dialogue between the teacher and class. The dialogues present lessons taught from the teacher's point of view, as well as possible student responses. The dialogues provide excellent support for teachers who are new to the subject area, as they identify possible student misconceptions and highlight important learning content. The dialogues provide teaching tips such as:

- What to put on the chalkboard.
- How to teach by questioning.
- What reactions the students may have and how to respond.
- Interesting stories to make connections between key concepts and everyday life.
- Computational information.

# The Teacher's Guide Investigation Overview Pages

The teacher's guide for each Investigation begins with the overview pages. The overview pages correspond to each section of the Student Edition and each Investigation in the CPO Science Program. These pages review the instructional components, beginning with a summary of what the students will learn in the Investigation. Included are a synopsis of the reading, pertinent vocabulary from the Investigation, learning goals, and the key and leading questions that students will be able to answer after completing the Investigation. It is important to note that below the heading for the reading synopsis, there is a suggested sequence for teaching the student section and the Investigation. The student reading section frequently follows the completion of the hands-on Investigation. In some sections, the student reading must be completed first in order for students to assimilate the skills and concepts required to complete the Investigations.

The second page outlines the equipment and material needed, teacher's guide section considerations, and the sequence of teaching steps.



# Teacher's Guide Demonstration Lessons

Each teacher's guide demonstration lesson contains an outline of the lesson, a "sample dialogue," and teaching strategies and tips. These pages also include the Investigation and sample answers to the activity. In the facing-page format, you can review the sample dialogue between the teacher and students, the Investigation page, and sample data and answers. All the information you will need to teach the Investigation is easily skimmed in this format.

Below are the features of the dialogue, Investigation answer page, and sidebar teacher notes.

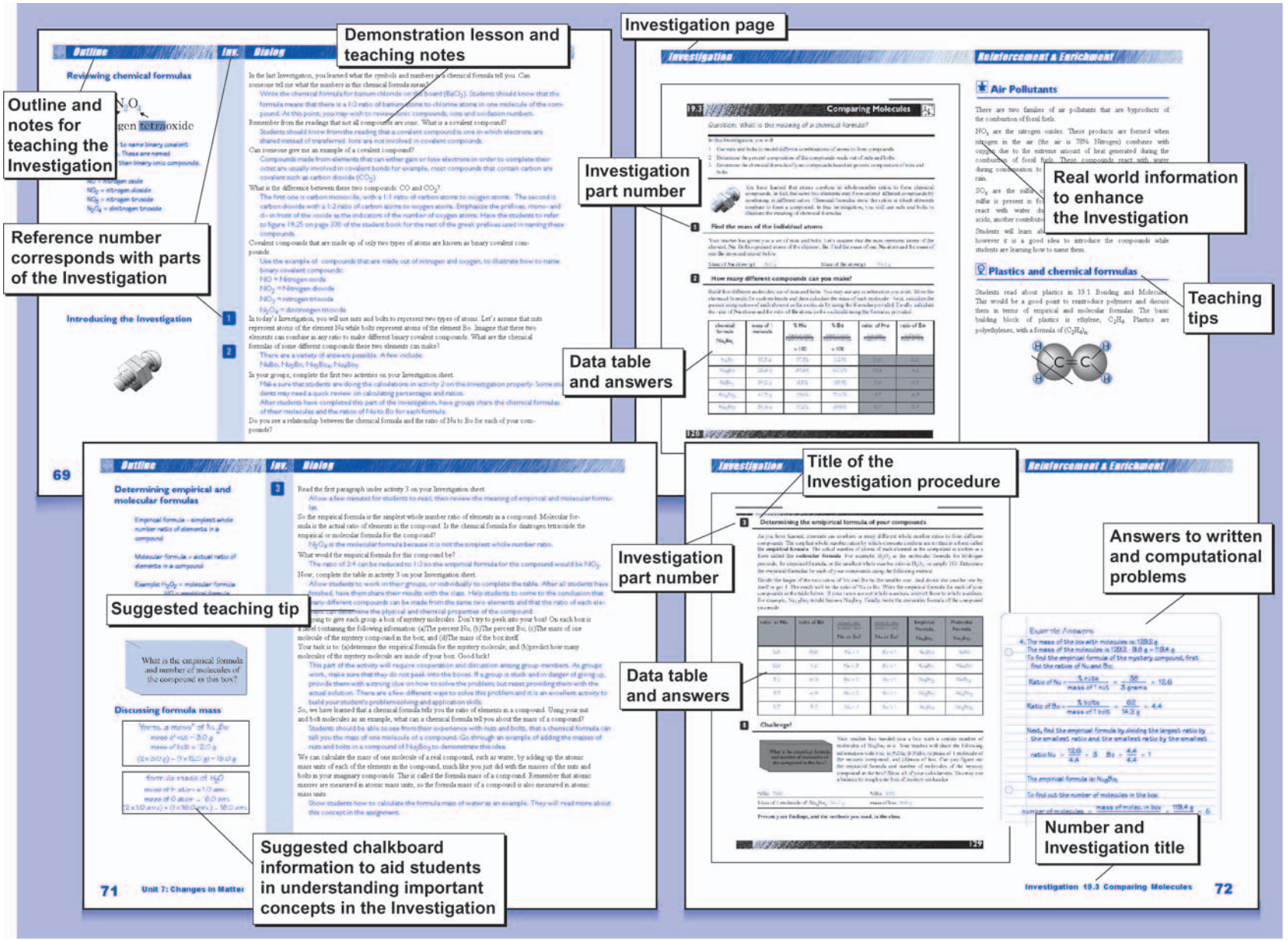
**Outline:** This section contains an at-a-glance sequence of steps that a teacher can skim. It is a quick guide to what is taught in the Investigation and notes on the Investigation.

**Inv.:** In this column the teacher will find a reference number that matches the parts of the Investigation page. These corresponding numbers guide you to the part that is discussed in the dialogue.

**Dialogue:** This section is presented as an exchange between the teacher and the class. This sample lesson outlines what the teacher would actually say to the class and typical responses from the students. Helpful teaching ideas and tips such as: "Students will need access to water," "Group supervision is important at this point" are included. The teacher's directions and comments to the students are printed in black, and responses and directions are in blue text. It is our hope that teachers will review the dialogue before presenting the Investigations to the class, as a supportive tool and to help clarify the goals and important points of each Investigation.

**Investigation:** This is a miniaturized Investigation page that is referenced in the dialogue. The Investigation page includes answers to data tables and written responses. The teacher can refer to the numbers at the left of the Investigation page and match them to the opposite page as numbers under the column "Inv." These numbers indicate what section of the Investigation the dialogue is referring to. The data and some of the reflective answers are only examples of data and responses that can be given by the students.

**Reinforcement and Enrichment:** This section includes teaching tips, challenge questions, and more reinforcement ideas for students who may need extra time learning concepts. Ideas for future study and short interesting pieces are also found in this right-hand margin area.


Demonstration lesson and teaching notes
Investigation page
Outline and notes for teaching the Investigation
Investigation part number
Real world information to enhance the Investigation
Reference number corresponds with parts of the Investigation
Teaching tips
Data table and answers
Title of the Investigation procedure
Investigation part number
Answers to written and computational problems
Suggested teaching tip
Data table and answers
Suggested chalkboard information to aid students in understanding important concepts in the Investigation
Number and Investigation title

## Safety

Safety is highlighted throughout the CPO Science Program by the use of safety icons and safety tips in the Investigations. The Investigations activities and experiments have been written to reduce safety concerns in the laboratory. Supplies and chemicals needed for the Investigations (that are used in addition to the Earth and Space Science Equipment Kit) can be purchased readily in a grocery or hardware store. In cases where you are concerned about safety and proper use or disposal of chemicals, we strongly recommend that you obtain the Materials Safety Data Sheets (MSDS) for the chemicals. These are easily obtained by calling the manufacturer of the product.

The CPO Science Program introduces students to safety through an information Safety Skill Sheet. In addition to this sheet, we have provided a quiz as an evaluation tool to be administered to the students after you have covered safety in the laboratory. We recommend devoting an entire lesson to safety in the classroom and laboratory and responsibilities for maintaining a safe environment. Use the Safety Skill Sheet as a guide for your lesson and fill in any information and guidelines that are particular to your classroom and school. In the skill sheet section of this book you will find a student safety contact. Safety is a crucial concern when working in a laboratory environment. Having students sign a contract will help emphasize that safety in the science lab is everyone's responsibility.

## Units and Measurement

The CPO Science Program was designed to prepare students to be successful in any career, not just academia. Students need to be fluent with scientific skills in any system of units prevalent in the workplace. Virtually all engineering and industrial careers require proficiency in both English and metric units. Even metric measures are not standardized. Research scientists use two varieties of metric: meter-kilogram-second (MKS) for physics and centimeter-gram-second (CGS) for chemistry. Ocean and air transportation industries use nautical miles. Medicine uses both Fahrenheit and Celsius temperature scales. Astronomers use light-years. The message to take from this diversity is that students need to learn and practice science in several systems of units because they will encounter different systems outside the classroom.

Because of their extensive practical use, the Student Edition and Investigations include both English and metric (MKS) units. This was done to connect the student's common experience and also to provide a bridge between the systems. Almost all concepts are presented in metric units, with an occasional reference to other systems when appropriate. All of the assessments use only metric units, which is common practice for standardized tests. It is our opinion that a basic high school science education should be focused on developing practical quantitative reasoning, problem solving, and observational skills. By presenting a mixture of units as they occur in the real world, we help prepare students for success in any endeavor that requires scientific thinking, such as business, industry, or education, as well as for further study in science.

# Teacher's Resource CD-ROM

The Teacher's Guide for CPO Science Introduction to Earth and Space Science comes with a Teacher's Resource CD-ROM. The components found on the CD are described below.

## Skill and Practice Worksheets

The Skill and Practice Worksheets are in PDF format. You will need Adobe Acrobat Reader® (version 4.0 or higher) to open this file. This software can be downloaded free of charge from the Adobe website (www.adobe.com). Once you have downloaded the software, simply open the file and print out the document. You may also print out individual worksheets as needed by selecting the appropriate pages for printing. The table of contents for the Skill and Practice Worksheets is found at the beginning of the file. The worksheets are numbered according to which chapters they belong. Each Teacher's Guide tells you which worksheets apply to that particular lesson.

## Blackline Masters

The Blackline Masters are also in PDF format and can be opened using Adobe Acrobat Reader®. These are meant to be used as answer sheets for the Investigations. The Blackline Masters have spaces for students to record answers to questions. They also have larger data tables and grids for making graphs.

## Color Teaching Tools

The Color Teaching Tools are a collection of color images designed to help you teach the Introduction to Earth and Space Science Program. The images relate closely to the Student Text. At least two color images are provided for each chapter. The Color Teaching Tools are in two file formates—jpg and PDF. Use the jpg files by importing them into your documents and presentations. PDF files are best for printing handouts and making overheads. The individual files are named according to chapter, section, and topic.

## Unit Exams

Unit Exams are provided in two formats: multiple choice and multi-format. The multi-format exams contain matching, short answer, problems, and essays. Answer keys are also provided for each exam. These exams are in PDF format and can be opened and printed using Adobe Acrobat Reader®.