

Foundations of

Physical Science Investigations

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FIRST EDITION

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science

The cover is an evocative montage of historical and scientific achievements that demonstrate the incredible persistence of the human intellect. Around the border, daVinci's graphics reflect an evolving tapestry of conceptual thinking as they interweave with more contemporary themes. DaVinci's fantastical mechanisms become the modern bicycle, a quintessential machine, which rolls into a graphical interpretation of wavelength division multiplexing on a fiber optic. The images follow 500 years of scientific and technological innovation. The Earth and DNA symbolize the interdependence of the built world and the natural world. The exquisite blend of form and function revealed in the elegant geometry of the chambered nautilus folds into a spiral defined by the Golden Rectangle. The interplay of organic and architectural forms represents the balance we seek between the power of technology and the fragility of our lives and our world. I hope this colorful interplay of images will inspire interest and excitement about the discovery of science.

Bruce Holloway - Senior Creative Designer

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












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USING ICONS TO LOCATE INFORMATION

Icons are symbols that have meaning. They 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 for each one.

	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 about how science impacts the economy.
	Research: you will need to look up facts and information.		Formula: you are reading information about a formula or 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 due to heat or chemicals.
	Apply your knowledge: refers to activities or problems that ask you to use your skills in different ways.		Cleanup: includes cleaning and putting away reusable equipment and supplies, and disposing of leftover materials.

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 soft cover book containing 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 Investigation 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 main focus of the learning. This question tells you what information you need to collect to answer the questions at the end of the Investigation.

Data Tables: Data tables help you organize and collect 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 can do after completing the investigation.

Brief introduction: This information helps you understand why the exercise is important and, in most cases, how it connects to other sections you have read or will be reading.

Icons and Section title: The icon reminds you of the unit that you are studying and the section title. This section title corresponds to the reading in your Student Edition.

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.

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 the written responses and may collect your information. You can also use the sheets to reinforce your reading in your student text.

INVESTIGATION PAGES

Section title reference from the student text

Unit topic

Section number referenced from the student text

Icon representing unit topic

Key question

Major learning objective for the Investigation

Explanation of Investigation content

Illustration and charts that support content

Investigation sequence numbers

Example data table*

Thought-provoking question

Detailed explanations of Investigation procedures, equipment setup, and data collection

16.1 Classifying Matter

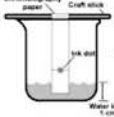
Question: How can a homogeneous mixture be separated?

In this investigation, you will:

- Use a procedure called paper chromatography to separate ink into its components.

Ink is a homogeneous mixture. It consists of a *solute*, which is a collection of colored dyes, and a *solvent*, which is the liquid that dissolves the solute(s). In this investigation, you will use a technique called paper chromatography to separate various samples of *water-soluble* ink in order to see the dyes contained in each ink.

1 What is paper chromatography?



Paper chromatography is used to separate mixtures into their components. A sample of the mixture (ink, in our case) is placed on the bottom edge of the paper is placed in a liquid. As the liquid moves up the paper, it drags some of the solute particles (the dyes) with it. Solute particles have different strengths of attraction to the cellulose fibers in the paper. These characteristics of the solute particles cause them to separate from each other on the paper. Some dyes travel a long distance and some travel very little.

2 Preparing the samples

- Cut three strips of chromatography or filter paper. Each strip should be 3 centimeters wide and a little longer than the height of the containers you will be using.
- On each paper strip, draw a line 1.5 centimeters from one end with a pencil. This end of the paper strip will be called the "ink dot" end. On the other end of the paper, write one of the colors of ink that you will be using (black, blue or green) and your initials in pencil.
- Measure the height of the cup you will be using for the Investigation. On each paper strip, mark this length (the height of the cup) with a pencil. Measure from the "ink dot" end.
- Place a small dot of black ink (2 or 3 millimeters in diameter) in the center of the line made in step 2 (b). On the second strip, place a blue dot, and on the third, a green dot.
- Attach each paper strip to a coffee stirrer by rolling the paper strip around the stirrer as shown in the diagram. Roll the paper until you come to the mark you made in step 2 (c). Use your fingers to press the paper that is wrapped around the stirrer so that the paper does not unroll. You may want to use a small piece of tape to secure the paper to the coffee stirrer.

3 Setting up the experiment

- In each of the three cups, pour a small amount of water. The water level should be no higher than 1 centimeter from the bottom of the cup. Use a ruler to measure the water level.
- Place one paper strip into each cup as shown in the diagram. The paper strip should hang straight down into the water without touching the sides of the cup. Make adjustments to the water level or

4 Recording your results

a. In the first column of the table below, list the colors of ink that you used. In the second column, list the colors of dye that were present in each ink. In the third column, record the distance each color of dye (Dc). Make this measurement from the "ink dot" end. In the fourth column, record the distance traveled by the solvent (Ds). Calculate the *retention factor* for each dye by dividing the distance traveled by the dye (Dc) by Ds.

Ink color	Dye colors present	Distance dye traveled (Dc)	Distance solvent traveled (Ds)	Retention factor (Rf)
black				
blue				
green				

5 Analyzing your data

- Which ink contained the greatest number of dye colors? Which colors did it contain?
- Did the manufacturer use the same dye color in more than one marker? How do you know?

Draw a bar chart for the green ink with one other group's chart. Did you see the same separation? Did your dye colors travel the same distance? Did your dye colors have similar retention factors? If you repeated the procedure using a 20 cm paper strip, would your retention factors be the same? Why or why not?

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







SAFETY

In scientific investigations, you often work with equipment and supplies. These are fun to use, especially because they help you make discoveries. However, using equipment and carrying out certain procedures in an investigation always require safety. Safety is a very important part of doing science. The purpose of learning and discussing safety in the lab is to help you learn how to be safe at all times.

The Investigations that you will be doing as part of the CPO Integrated Physics and Chemistry curriculum are designed to reduce safety concerns in the laboratory. The physics Investigations use equipment that is stable and easy to use. The chemistry Investigations use household supplies and chemicals. Although these chemicals might be familiar to you, they still must be used safely.

You will be introduced to safety by completing a skill sheet to help you observe the safety aids and important information in your science laboratory. In addition to this skill sheet, you may be asked to check your safety understanding and complete a safety contract. Your teacher will decide what is appropriate for your class.

Throughout the Investigation Guide, safety icons and words and phrases like “caution” and “Safety Tip” are used to highlight important safety information. Read the description of each safety icon carefully and look out for them when reading your Student Edition and Investigation Guide.

	Use extreme caution: follow all instructions carefully to avoid injury to yourself or others.
	Electrical hazard: follow all instructions carefully while using electrical components to avoid injury to yourself or others.
	Wear safety goggles: requires you to protect your eyes from injury.
	Wear a lab apron: requires you to protect your clothing and skin.
	Wear gloves: requires you to protect your hands from injury due to heat or chemicals.
	Cleanup: includes cleaning and putting away reusable equipment and supplies, and disposing of leftover materials.

Safety in the science lab is the responsibility of everyone! Help create a safe environment in your lab by following the safety guidelines from your teacher as well as the guidelines discussed in this document.