Phases of Matter

Dr. Dave's Teaching Manual

Second Edition

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Contents

Introduction

This manual will give you, the teacher, everything you need to teach a unit on the the phases of matter. From the first topic to the last class, it describes how to set up teaching presentations so that they are dynamic, exciting, and meaningful for students. You will see how easy it is to prepare for classes, and you will discover that this teaching approach allows students to experience real learning and real academic success.

Science is a wonderful topic to teach to children. Instead of lecturing for long periods or bogging students down with an avalanche of worksheets, this manual shows you how to make your presentations interesting and challenging to the mind of a child. This is easy to do—once you know how to do it. Children already possess a natural curiosity for science. This manual shows you how to take advantage of their curiosity and to present lessons in a way that creates an exciting learning environment in your classroom.

This unit is rich in content and easy-to-run student activities. In many ways, what students learn by examining the properties of water is the foundation to elementary science; the time therefore is well-spent. The students will learn about the fundamental concepts of mass and volume, and many of the student activities will build measurement skills. Several of the student activities are inquiry based, use the scientific method, and foster critical-thinking skills.

Water is the most important substance on our planet, and teaching about its characteristics addresses many physical science concepts. Children can learn about these characteristics in an interesting, hands-on way by studying the relationship between liquid water and ice. As students learn about water, they will also learn about the properties of liquids, the solubility of salt and sugar, and crystal structure. Some of the activities will introduce students to double-pan balances, thermometers, and stereoscopes. Of course, no unit on the phases of matter is complete without giving students the opportunity to explore the characteristics of slime. There are three separate recipes in this manual for this wonderful substance, which represents the essence of a positive, hands-on, elementary science experience.

Evaporation and condensation are more challenging topics for children to learn about, as these concepts involve gases. Gases, by their nature, tend to be an abstract topic, and many children hold misconceptions about them. This manual will show you how to correct those misconceptions. It also covers additional earth and space science topics such as the composition of the atmosphere and the flow of water through the water cycle.

This manual is flexible, and there are many opportunities for integration of core subjects. In addition, you can choose from many demonstrations, visual projects, experiments, group projects, and research projects.

This manual also offers suggestions for assessment and shows examples of exemplary student work. In addition, it provides tips on classroom management, critical-thinking questions, modifications, clean-up, and safety. The Teacher Resources section contains a variety of downloadable worksheets that you can use as homework or as in-class assignments; these are available from the Royal Fireworks Press website (rfwp.com). Many of the images in this book can be projected for the students to see and will help them to understand and internalize the concepts being taught; these are available for download as well.

Slime

Objectives

- Students will observe the properties of a substance that has characteristics of both a solid and a liquid.
- Students will use their senses to explore the relationship between solids and liquids.

Key Points

- Some substances have properties of both solids and liquids.
- Solids keep their shape.
- Liquids are fluid and can be poured.
- Cornstarch and water combine to form a type of slime.

Vocabulary Words

Water	Properties
Slime	Cornstarch

Start the Class

Display one or all of these items to the students: ketchup, mustard, mayonnaise, toothpaste. Elicit observations from the students by asking if these substances are solids or liquids. Review the properties of solids and liquids. Put a dollop of one of the substances on a table to gain attention and to show how it flows as compared to water and other liquids. Ask the students if it seems to keep its shape, and then ask them to consider again whether it is a solid or a liquid.

Tell the students that it is possible for substances to have *properties* of both solids and liquids. For example, a glob of ketchup looks like it might keep its shape, but over time it will slowly spread. There are many substances in the refrigerator that the students will recognize that have similar characteristics as those of ketchup. These include mustard, mayonnaise, jelly, and many sauces.

Inform the students that you will be making a strange substance: *slime*. Show the students a box of *cornstarch* and a cup of *water*. Tell them that when you mix these two substances together, they produce an amazing substance that has properties of both a solid and a liquid.

Hold a class discussion about the slime. Ask the students the following questions:

- How is it like a solid?
- How is it like a liquid?
- Can you pick it up?
- Can you stretch it?
- Can you pour it?
- Can you hold it?
- Can you roll it into a ball?
- What happens when you slowly press a finger into the substance? What about when you poke it quickly?
- Is it easier to mix it slowly or quickly with your finger?

There are several theories as to why cornstarch behaves like this in water, although scientists are not entirely certain. A mixture of cornstarch and water is known as a *suspension*. Interested students could learn that this kind of suspension is called a *colloid*.

Eventually it is time to clean up. Typically, some children enjoy the experience so much that they are reluctant to stop playing with the slime. Once the slime is cleaned up and the students have washed their hands, have them record their observations, either by writing them down or by drawing pictures of what they saw and felt. Guide the students through a discussion in which they talk about their observations with the rest of the class.

> *Clean-Up Tip: Walk around and help gather the newspapers on the students' desks and discard them into a trash can. Have plenty of paper towels, water, and a sponge available.*

Student Activity: Word Searches

There are two different word searches to give to the students as homework or as an in-class assignment. Choose the one that is appropriate for your students. See pages 70-73 in the Teacher Resources section of this manual for downloadable pages and answer keys.

Student Activities: Thinking about Slime

There are a variety of activities for students to do concerning slime. Here are some examples:

- Have the students write a short story about a slime monster.
- Have the students create slime poems. You can decide if you want to require a certain length or type of poem.
- Young students will enjoy acting out being slime in a bodily-kinesthetic way. Perhaps they could choreograph an act to one of their short stories or poems, if you choose to have them do either of those activities.
- Have the students draw pictures with a slime theme. For example, the picture could be of a slime monster. This illustration could be for the slime stories they write, if you choose to have them do that activity.
- Have the students pretend that they are describing slime to someone who has never seen it before. Alternatively, students could pretend to interview another student who plays the role of slime.
- Have the students read the book *Bartholomew and the Oobleck* by Dr. Seuss.

Student Activity: Temperatures of Water

For this simple activity, have the students measure the temperature of very warm, warm, cool, and ice water. Have them record their results in a table like the one below.

Water	Temperature °C	Temperature °F
Very warm water	55° C	131° F
Warm water	37° C	99° F
Cool water	18° C	64° F
Ice water	5° C	41° F

Safety Tip: Always use thermometers that contain colored alcohol instead of mercury when working with young students.

Science Connection: The temperature of the human body is approximately 37° C.

Student Activity: Does Salt Change the Rate of Ice Melting?

This excellent inquiry activity takes about an hour, but it utilizes the scientific method and develops good laboratory skills. Have the students design an experiment to discover if salt makes ice melt more rapidly. Students who live in areas where it snows will probably know that salt is put on the roads when it snows or ices up.

Fact: Salt is spread on roads because it lowers the freezing and melting point of ice.

Materials

small cups
crushed ice
salt (NaCl or CaCl)
graduated cylinders

Show the students how to fill two cups with identical amounts of snow or crushed ice. Into one cup they will add 20 grams of salt, while the other cup remains untreated as the *control*. It is important for the students to recognize the importance of the control cup; there must be a reference for comparison in order for the experiment to mean anything scientifically.

Activity Tip: Cubes that come in store-bought bags of ice are easier to crush than homemade ice cubes, which are thicker. Check to see if your cafeteria has an ice machine that makes these cubes.

Activity Tip: Table salt (NaCl) works fine for this experiment. You can also use commercial ice-melting salt (CaCl). Perhaps you can have the students compare the two different types.

Measurement Tip: For an excellent demonstration, show the students how to measure the mass of 20g of salt. The easiest way is to put two identical cups on both sides of a double-pan balance and then add a 20g chip to one side. The salt that you add to the other cup truly represents 20g.

Divide the students into pairs, and pass out a cup of the mixture to each pair. Also give each student a magnet, a screen, a cup of water, an empty cup, a spoon, and a large paper plate. Lead a class discussion on how to separate the individual components of the mixture.

Materials

iron filings	sand
sugar	gravel
screens	magnets
cups	water
paper plates	spoons

It is easy to separate the solids using various methods. The gravel can be removed by putting the mixture through a screen (or manually by hand). Have the students hold the screen above the paper plate and then carefully pour the mixture through the screen. The gravel will be too big to fall through.

The iron filings can be removed with a magnet. If the students have never seen a magnet pick up iron filings, demonstrate this technique for them.

> *Teaching Tip: Children love to use magnets to remove iron filings. The magnets are easier to clean afterward if you cover them with a paper towel first.*

Last of all, have the students pour the remaining mixture into the cup of water. The sugar will dissolve, while the sand will sink to the bottom of the cup. They can then scoop the sand out of the bottom of the cup, or they could pour the sugar water carefully into the empty cup.

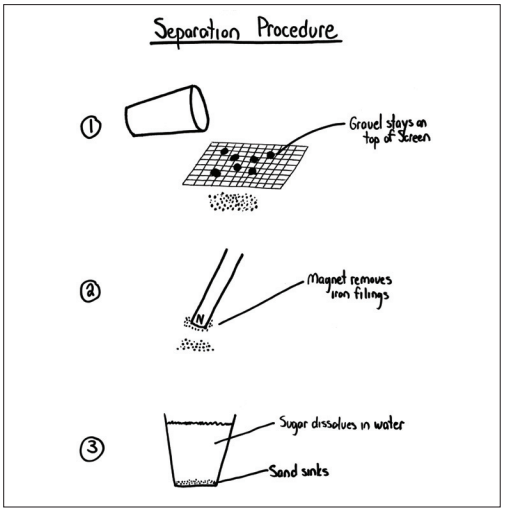
> *Modification Tip: If time is an issue, you could reduce the number of substances in the mixture. For example, you might omit the sugar, leaving just the gravel, iron filings, and sand.*

This activity provides an opportunity for the students to write out the steps of the procedure. This is a good way to introduce the concept of lab reports in science. One of the components of a lab report is the procedure. (A full lab report contains an introduction, materials, procedure, results, and a conclusion.) Have the students write out the procedure of the activity separating solids.

You could also give the students the choice of drawing a labeled diagram of the separation procedure instead of writing out the steps. This makes the assignment more attractive to visual-spatial learners.

Procedure

1. Pour mixture through screen
2. Remove gravel
3. Use magnet to remove iron
4. Add water
5. Stir to dissolve sugar
6. Scoop wet sand out of cup



Extensions

1. Adding a fifth component to the mixture, such as pepper or glitter, makes the separation more challenging. Students might try the static electricity approach: rubbing a small plastic stirrer and holding it above the mixture. The lighter pepper particles will jump up to the stirrer. However, if the students hold the stirrer too close, then the sand and sugar will also be attracted. Students could also try the static electricity approach using a balloon. Alternatively, they could try to separate the materials by buoyancy. No single method seems to work completely. Perhaps the students will think of a unique method to separate these substances.
2. There are test strips available that will turn color when dipped into a sugar solution; these would allow the students to prove that the sugar is dissolved in the water. If you choose to extend the lesson in this direction, you must use glucose instead of table sugar. Fortunately, glucose is inexpensive and can be ordered from many companies. Alternatively, you could let the water evaporate from the cups to prove that sugar is present, although this will take additional time.

Student Activity: Stereomicroscopes and Crystals

This activity uses stereomicroscopes (also called stereoscopes). Stereoscopes are different from traditional microscopes in that they have two eyepieces, whereas most microscopes have only one eyepiece. If you don't have one in your classroom, you can use magnifying glasses for this activity, although they don't magnify as well. If you only have one stereoscope, use it in a science center in the classroom.

Most stereoscopes have light sources above and below the samples, offering flexibility with viewing. They are easy to use, but you should first demonstrate to the students how to use the focusing knobs. The magnification on most stereoscopes ranges from 20x to 50x.

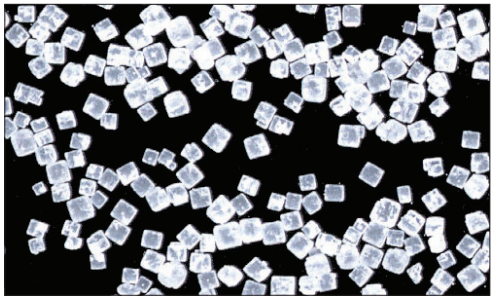
Use samples of sand, salt, and sugar for this activity. Remind the students that these are all solid objects. Sand, salt, and sugar crystals look distinct when magnified and can easily be distinguished from one another.

Activity Tip: Put the crystals into a small plastic Petri dish that you place under the stereoscope. This protects the stereoscope and makes viewing the crystals easier. Use a small paintbrush to move the crystals into the viewing area under the lens. Place the crystals on a black background for good viewing.

Sand Crystals

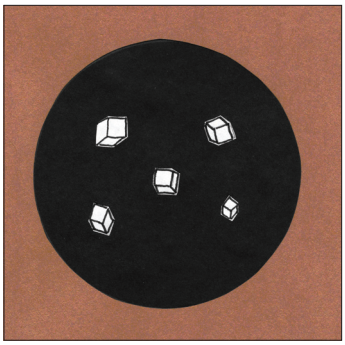
www.microscopeworld.com

Salt Crystals



Andrew Alden

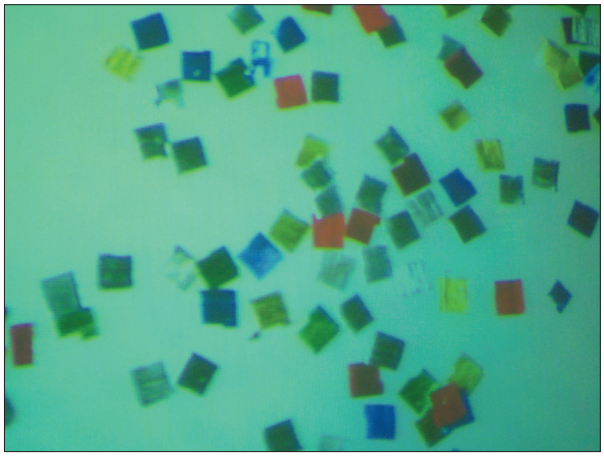
Crystals of sand, salt, and sugar look interesting and offer a good way to integrate art into this lesson. Have the students draw pictures of what they see on plain white paper. Alternatively, have them cut out circular pieces of black construction paper to use for a background, as shown at right. They can either draw the crystals using white paint markers or make white paper cutouts and paste them on. You might also have the students describe the crystals using the words they have learned from this unit so far.



Math Integration: The crystals can be described using such geometrical terms as straight lines, cubes, angles, and surfaces.

Extensions

1. For an excellent identification activity, have stereoscopes set up at a learning center where there are three similar but different crystals that are labeled, as well as one unknown crystal. First, the students observe each of the known crystals and create an identification chart containing diagrams of the three samples. They then try to identify the mystery crystal, which is one of the original three.
2. If you have access to sand from three different beaches, you could conduct the same identification activity using sand. Most beaches have sand that looks different from the sand of other beaches when viewed under a stereoscope. Have the students determine which beach an unknown sample of sand came from after observing three samples that are identified.
3. Multi-colored glitter is a fun sample to look at under a stereoscope. Many students enjoy making colored diagrams of this substance.



Teacher Demonstration: Volume of Liquids

Explain to the students that the volume of liquids is easily measured in a graduated cylinder. Measure out 100 ml of water in a graduated cylinder in front of the students, and pour it into a cup. Stress that you are measuring the volume—the amount of space that the liquid takes up—and not the mass of the liquid. Be sure to state that volume is measured in *liters* or *milliliters*. Take this opportunity to review how liquids take the shape of their container.

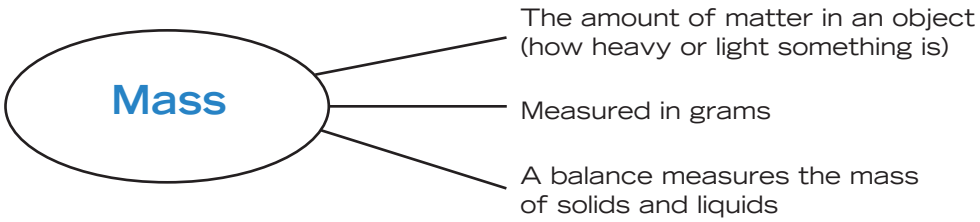
Teaching Tip: A common misconception among children is thinking that a graduated cylinder measures the mass of a liquid.

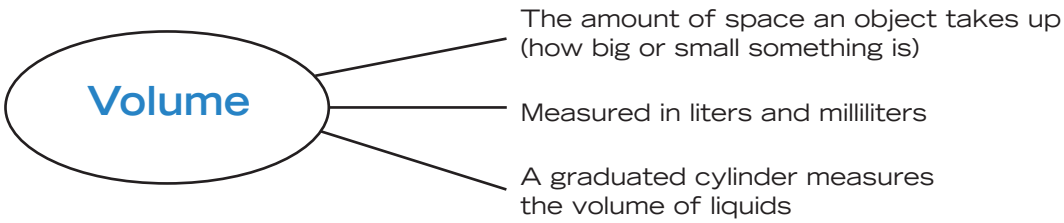
Can a graduated cylinder measure the mass of a liquid?
No weigh!

Teacher Demonstration: Mass of Liquids

Show the students a cup of water, and ask another critical-thinking question: "How can we measure the mass of just the water, but not the cup?" There are a few different ways of achieving this; the easiest way is to have an identical empty cup on the other side of the balance so that its mass is accounted for. Another way is to measure the mass of the cup and then to subtract that mass from the mass of the cup and the water together.

Summarize the content covered so far by projecting the images below.





Student Activity: Measuring the Mass of Solids

The students can use the balances to compare the masses of several solid objects and to order them in the correct sequence of increasing mass. This activity can be run in groups, or it can be done at a learning center.

Student Activity: Using Graham Crackers to Make Gram Chips

Most young students enjoy making gram chips from graham crackers. Have the students place a 1-gram weighing chip on one side of the balance and then balance it with a piece of a graham cracker. They can also make 2-, 5-, and 10-gram chips.

Classroom Management: Usually the students will want to eat the graham crackers. Tell them that you will have a "gram" graham cracker party after the activity.

Student Activity: Measuring the Mass of Solids

Divide the students into pairs, and give each pair a variety of objects to measure the mass of. This activity is easier to run and assess if each student group measures the mass of the same objects. Have the students record their measurements on a table like the one below. They could draw the table on paper using a ruler, or they could use a computer to make it. Afterward, discuss the results with the entire class.

What Is the Mass?	
Object	**Mass (grams)**
Wooden block	
Marble	
Pencil	
Lead sinker	
Spoon	
Cup	
100 ml of water*	
X-object	

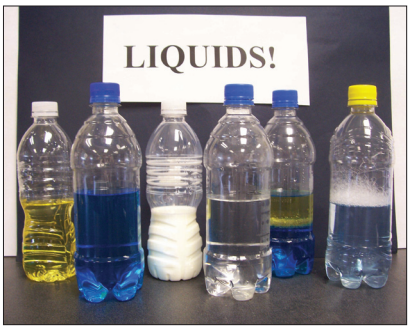
*You can run this activity without using water. If you do use water, this is a preview of a future activity, during which the students measure the mass of different liquids.

Teaching Tip: The x-object is any object that the students choose. Offering students choices whenever possible is motivating for them.

Materials

Plastic bottles filled with the following liquids:

- water
- oil
- detergent water
- colored water
- corn syrup
- rubbing alcohol
- oil and water
- milk



Ask the students the following questions about the liquids:

- How are the liquids the same? Which ones are most similar, and in what way?
- How are the liquids different? Which ones are the most different?
- Which liquids are transparent?
- Do the bottles all have the same weight?
- Do the liquids all move in the same way?
- Are there any differences when you tip the bottles on their sides or turn them upside down?
- What happens if you gently shake the bottles?

Student Activity: What Is the Mass of 100 ml of Liquid?

For this activity, the students will measure out the same volume of different liquids to discover that their masses are different, proving that liquids can be physically different from one another. This activity is an excellent opportunity to review the difference between mass and volume. It could be also extended to lessons on density and buoyancy.

Materials Tip: A bottle or two of corn syrup is handy to have in the science classroom. Corn syrup is an extremely thick sugar solution, and by adding some water to it, you can quickly make a dense sugar water solution to use for this activity and others like it.

Materials

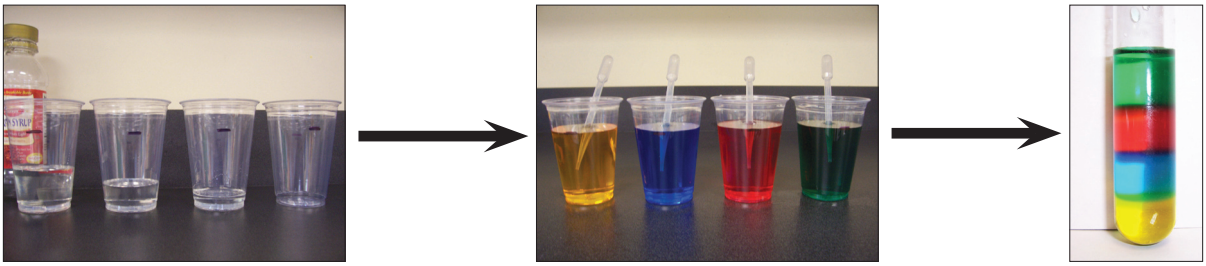
- water
- rubbing alcohol
- sugar water
- graduated cylinder
- cups
- balances

Divide the students into pairs, and give each pair a graduated cylinder, a container of water, a container of rubbing alcohol, a container of sugar water, three cups, and a balance. Have the students measure out 100 ml of water, alcohol, and sugar water individually into the cups and determine the mass of each liquid on the balance. They can record their results in a table like the one on the next page, or they could create a simple graph.

Activity Tip: Students could also measure oil as a fourth liquid, although oil is extremely messy if spilled. However, it is useful for the follow-up activity after this one, so it may be wise to include it.

Student Activity: Sugar Water Layers

For this activity, the students will use a pipette to layer different solutions of sugar water into a test tube to form a rainbow-layered tube. To set up this activity, pour decreasing amounts of corn syrup or sugar water into four beakers or cups. The last cup will contain no sugar water. Add water to each cup so that they are all filled to the same level, and then add a different color of food coloring to each cup. The four colored sugar solutions can now be layered in a small test tube.



Demonstrate how to use a pipette to layer the solutions. The key is not to drip the solutions into the test tubes but to place the tip of the pipette as close to the surface of the liquid in the tube as possible and then gently squeeze the bulb. Have the students wear safety goggles while they are using the pipettes.

Teacher Demonstration: Freezing Different Liquids

An interesting demonstration for the students is to fill an ice cube tray with water, oil, and alcohol and then to make predictions about the rate at which they will freeze. Once you have the results, have a class discussion about why the results came out as they did.

Teacher Demonstration: Glitter Globes

This is a fun demonstration. Fill a clear plastic bottle half with water and half with oil. Pour in some glitter, and there you go! Turning the bottle upside down produces an effect similar to that of a lava lamp.

> *Activity Tip: The bottle cap should be screwed on tightly—a spilled glitter globe is a real mess.*

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