Category V Physical Science Examples

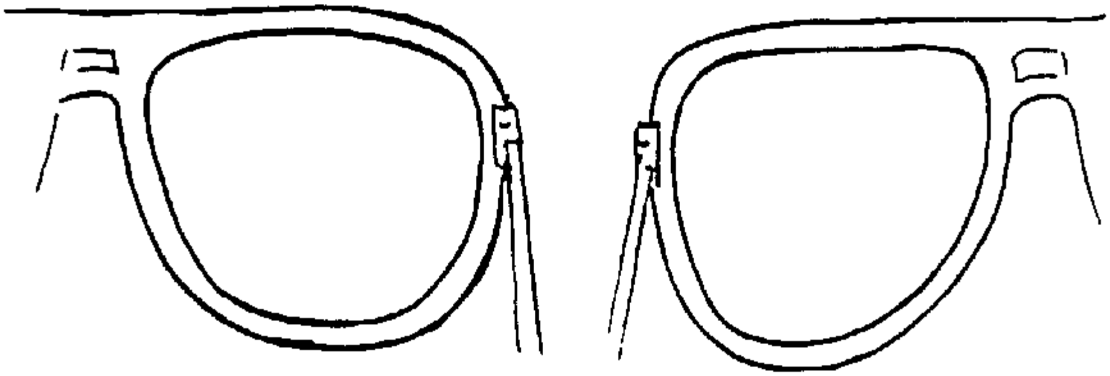
Encouraging students to explain their ideas

Matter and Molecules

The *Activity Book* includes in every lesson cluster at least one set of activity sheets containing questions that prompt students to express, and sometimes justify and represent, their ideas. For example, in Lesson Cluster 4, students are asked to express their ideas on whether it would be easier to push the molecules together in a gas or in a liquid, justify their responses, and represent their thoughts about how molecules of air would be arranged in a syringe when the plunger is all the way out (*Activity Book*, pp. **18–19s**). In addition, *every* lesson cluster includes a set of overhead transparencies that are designed to help teachers develop class discussions about the key ideas in the unit (*Science Book*, pp. **T-8-9**, **T-53**). The material provides opportunities for *each* student to state his or her views by including activity sheets on which all students are asked to record their ideas about the questions posed. The importance of giving feedback to students is stressed in the introduction to the *Science Book*, and several mechanisms for providing feedback to students are proposed (p. **T-7-8**). In addition, the student book includes text that can give students feedback on their ideas about the activities. After students describe and explain phenomena using their own ideas on the activity sheets, they are frequently asked to read the text that explains the phenomena they observed (*Activity Book*, pp. **25–26s**, *Science Book*, pp. **34–35s**, **43s**). Moreover, in contrast to curricular materials that merely state that “student answers will vary” or provide the correct answer, the teacher notes in *Matter and Molecules* often include brief descriptions of likely erroneous answers, the misconceptions on which they are based, and how the teacher can respond to them.

Activity 4.2: Compressing Air and Water

Before we begin this activity, let's review what we've learned about how molecules are arranged and how they move in liquids and gases. Draw in one of the magic eyeglasses below how molecules are arranged in a liquid like water, and in the other magic eyeglasses how molecules are arranged in a gas like air.



WATER (LIQUID) AIR (GAS)

1. How far apart are the molecules of a gas compared to a liquid? ________________

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2. In which of these two states of matter do you think it would be easier to push the molecules together? ________________________ Why?

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The following activity will help you see if your prediction is correct.

Your teacher will give you a plastic syringe and a cup of water. Look carefully at the syringe and move the plunger in and out. Notice that the end of the plunger has a seal so that no air can get past the plunger. Air can move in and out only through the hole in the tapered end. While you are moving the plunger in and out, feel the air coming out of the syringe.

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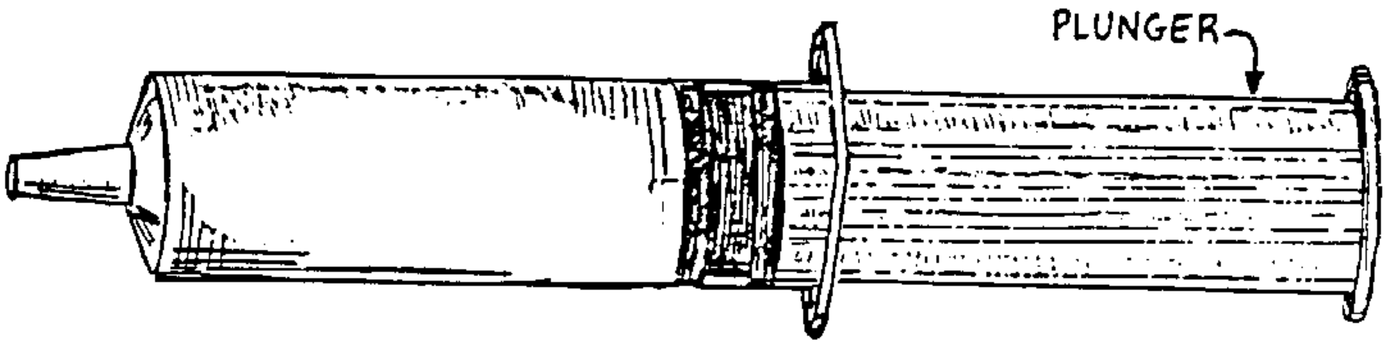
3. Below is a drawing of a syringe. How would molecules of air be arranged in the syringe when the plunger is all the way out? Draw the air molecules in the syringe.



4. Now fill your syringe with water. Hold it over the cup. Now carefully place your thumb over the end of the syringe so that no water can escape and try to push the plunger in. Can you push the plunger in when the syringe is filled with water?

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5. Now try the same experiment with air instead of water and pull the plunger out as far as it will go. Place your thumb firmly over the end of the syringe. Keep your thumb on the syringe tightly so no air can escape. Try to push the plunger in. What happened?

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3. Students can check each other's papers. It is possible for students to learn a great deal from a class discussion that focuses on what qualities make an answer acceptable or unacceptable.

4. Student answers can be used as a basis for class discussion rather than individual checking. You can solicit a variety of answers from the students, and lead the class in a discussion of the merits of each answer.

You can probably think of a variety of other arrangements that will work equally well. What is important is that students keep writing and discussing their descriptions and explanations, with enough feedback from you or from each other to help them understand their mistakes and improve the quality of their descriptions and explanations.

Some questions are intended primarily for the purpose of eliciting students' ideas about topics that they have not yet studied and may only partially understand. These questions should not be graded on a right-or-wrong basis; they should be used as a basis for discussion by small groups of students or by the whole class.

Lesson Cluster Review Questions and Tests: Monitoring and feedback. The last question set in each lesson cluster contains questions reviewing the content of the entire lesson cluster. If you grade those question sets, which are packaged separately so that they can be taken up or used as tests, you should be able to do an adequate job of monitoring the progress of individual students.

Your materials also include two tests, one covering Lesson Clusters 1-4, the second covering Lesson Clusters 5-9. Since each lesson cluster builds on ideas from previous lesson clusters, you should review or reteach ideas that your students are having trouble understanding, as revealed by their performance on the review question sets or the tests.

Overhead Transparencies: Discussing important questions. The unit also contains a set of overhead transparencies that are designed to help you develop class discussions about key ideas in the unit. These transparencies are listed immediately after the Table of Contents of this Teacher's Guide. Each transparency is illustrated and discussed at the lesson where we feel that it could appropriately be introduced. (Although we encourage you to use transparencies whenever you feel appropriate, several times, if necessary.)

Each of the transparencies has two layers. The bottom layer poses a question about a situation. You should encourage students to express their ideas about that situation and the answer to the question. After your students have tried to answer the question and you are aware of how they think, you can flip down the overlay to give them a scientific answer to the question.

You will find that your students' answers are sometimes very different from those in the science book. These differences are often the result of misconceptions that a surprisingly large number of students firmly believe. For the students to see the differences, it is essential for the students to have a chance to answer the questions and discuss the contrasts. Students must see these contrasts explicitly so they understand the need for abandoning their naive ideas in favor of the more sophisticated scientific conceptions.

The transparencies will work most effectively if you encourage an atmosphere in your classroom where students feel safe in expressing ideas they are not sure of, and where students know that their ideas are valued even if they are not entirely correct.

Activities and Demonstrations: Connecting Scientific Ideas With the Real World

Every lesson cluster includes at least one hands-on activity for students to do or a demonstration for students to observe; most lesson clusters have more than one. The Activity Book contains questions for students to answer about each activity and demonstration. The materials and teaching suggestions for each activity and demonstration are listed in the section on that lesson in this Teacher's Guide. A master list of materials for all lessons is included as an appendix at the end of this Teacher's Guide.

These activities and demonstrations give students a chance to make careful observations of a variety of phenomena and to use the kinetic molecular theory to describe and explain those phenomena. Thus they play an essential role in helping students connect scientific ideas with the real world.

Charts and Posters: Helping students remember and organize key ideas. The unit also includes one chart (on the inside back cover of the Science Book and this Teacher's Guide) and three posters (listed after the Table of Contents). These charts and posters present in tabular or graphic form some key ideas that your students will need to refer to over and over throughout the unit. We therefore recommend that you introduce each of these charts and posters as it becomes relevant, then refer to it whenever appropriate after that time.

Videotape: Illustrating key ideas. Some ideas, especially those involving molecular motion, are difficult to envision from still pictures. We therefore have selected a videotape that illustrates these ideas in a more active way.

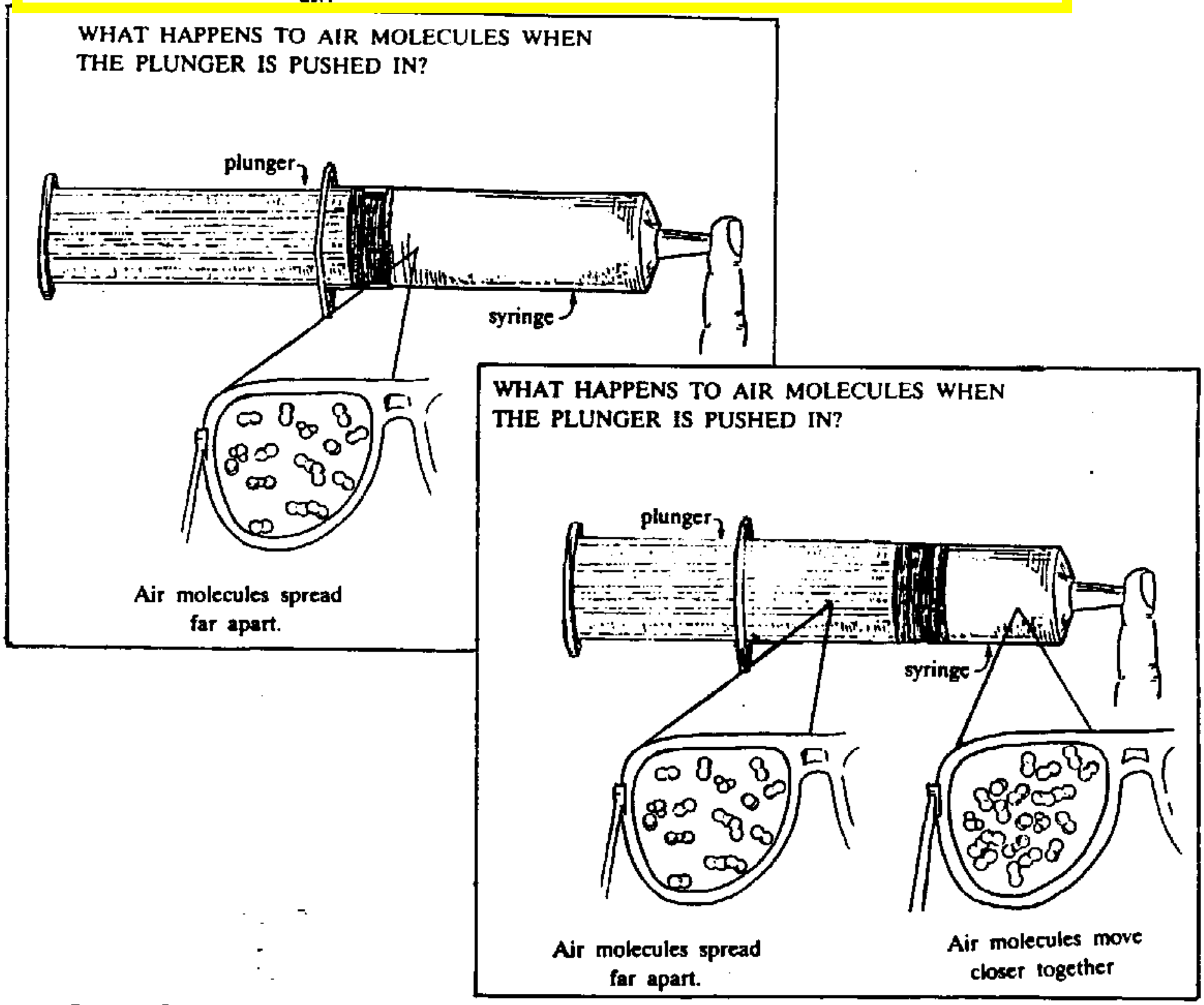
The videotape is an episode entitled "Making Dew" taken from The Voyage of the Mimi television series. This segment shows how the crew of the Mimi designed and used solar stills when they were shipwrecked on an island that contained no fresh water. This section should be shown in connection with Lesson 9.3.

Scheduling

The length of this unit depends, of course, on how quickly or how thoroughly you teach. The lessons are generally designed to take about one 45-minute class period each. Since there are 35 lessons in the unit, you should probably allow at least 7 weeks to teach the entire unit. Tests, reteaching difficult ideas, and supplemental activities could make the unit last longer.

Use Transparency 7 here:

TRANSPARENCY 7: WHAT HAPPENS TO AIR MOLECULES WHEN THE PLUNGER IS PUSHED IN?



<u>Bottom Layer</u>

Many students believe that air molecules will escape or try to escape when the plunger of a syringe is pushed in. Some think all or most of the molecules are pushed to the opening of the syringe.

<u>Overlay</u>

Students hold the above misconceptions because they do not understand the idea of compressibility of air. You should point out to students that molecules of air have large, empty spaces between them. This means that when air is compressed, molecules merely move closer together. The molecules remain evenly distributed and are not all at one end of the syringe.

4. Predicting: making predictions about the contents of the next lesson or passage that they will read.

We would add to Palincsar and Brown's list a fifth activity, applying, or trying to figure out how the ideas in the text can be used to describe, or predict, or explain events or observations that the students make about the world around them.

There are a variety of strategies that you can use to help your students engage in these important activities. The simplest is just to use these activities as a guide to class discussions of the Science Book. After you and the class have finished reading each lesson, call on students in your class and ask them to summarize, generate questions, clarify, make predictions, and apply the ideas in the lessons that they just read.

There are also other ways that you can involve students in these activities. You might want to have students write summaries, questions, clarifications, predictions, or applications, then share what they have written with the class. You could also sometimes have the students working with each other in small groups, sharing summaries, questions, clarifications, predictions, and applications with each other. Regardless of how you do it, though, you can greatly enhance the effectiveness of the Science Book by helping your students to engage in these activities as they read it.

The Activity Book: Writing descriptions and explanations. This unit is based on a basic belief about the nature and purposes of scientific knowledge: We believe that science was developed for the purpose of describing and explaining natural phenomena. This means that an important part of teaching science consists of giving students the chance to practice their own descriptions and explanations. For that reason, this unit includes an Activity Book containing many questions that require students to write out descriptions or explanations.

Although this writing is essential for student learning, it is also a lot of work, for the students and for you. We would like to give you a few suggestions about how to make the work load manageable while still giving the students plenty of practice in developing descriptions and explanations.

You do not have to check every activity and question set yourself (though you certainly can if you want to). It is important for students to answer all of the questions, but there are a variety of ways that they can get practice and feedback in answering these questions without your having to read every student answer. For example:

1. Students can answer their questions individually, then meet in groups of three to compare their answers and develop a group consensus answer. The group consensus answers can then be compared in a class discussion.

2. Groups of students working together on a question set of a laboratory activity can develop a group consensus answer. The group consensus answers can then be compared in a class discussion.

3. Students can check each other's papers. It is possible for students to learn a great deal from a class discussion that focuses on what qualities make an answer acceptable or unacceptable.

4. Student answers can be used as a basis for class discussion rather than individual checking. You can solicit a variety of answers from the students, and lead the class in a discussion of the merits of each answer.

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LESSON CLUSTER 5

Explaining Dissolving

Activity 5.1: Where Did The Sugar Go?

1. Look at a tea bag and some grains of sugar with a magnifying glass. Draw how they look below.

TEA BAG	GRAINS OF SUGAR

a. Does the tea bag have holes in it? ____________________

b. Are the holes in the tea bag big enough for a grain of sugar to get through? (If you aren't sure, try it and see! Put some sugar in the tea bag and shake it. Does any come out?)

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c. Do you think the holes in the tea bag are big enough for molecules of sugar to get through? Explain your answer.

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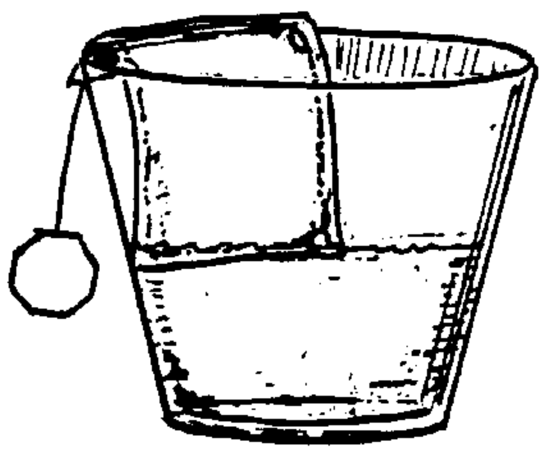
2. Put half a spoonful of sugar in the tea bag. Drape it over the rim of the cup. Add just enough water to reach the bottom of the tea bag.



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a. What do you see happening underneath the tea bag? (You can draw on the picture on the previous page to illustrate your answer if you want.)

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b. Taste the water. What do you taste? ______________________________

c. Why can't you see the sugar anymore? ______________________________

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d. How do you think the sugar got out of the tea bag?

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Now look back at your text. See how your explanation compares with the one there!

e. If you let this cup stand overnight, would the sugar rise to the top, settle to the bottom, or spread evenly throughout the water?

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Talk about molecules to explain your answer. ______________________________

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LESSON CLUSTER 5
Explaining Dissolving

Lesson 5.1: How Did the Sugar Get Out?

A long time ago, in Lesson Cluster 2, you studied pure substances and mixtures. Do you remember the difference? Pure substances, like pure water and pure oxygen, are made of only one kind of molecule. Mixtures, like salt water and air, contain several different kinds of molecules.

This is a lesson cluster about mixtures. One kind of mixture is formed by dissolving a solid in a liquid. When a solid dissolves in a liquid, the molecules of the liquid hit the solid, breaking apart the solid into invisible molecules. These molecules spread evenly throughout the liquid.

In this lesson cluster you will dissolve several solids in water, you will find out how to make solids dissolve faster or slower, and you will learn to explain what happens to the molecules of both the liquid and solid in dissolving. The first step, though, is to watch something dissolve and describe what you see. So let's get started!

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Do Activity 5.1 in your Activity Book

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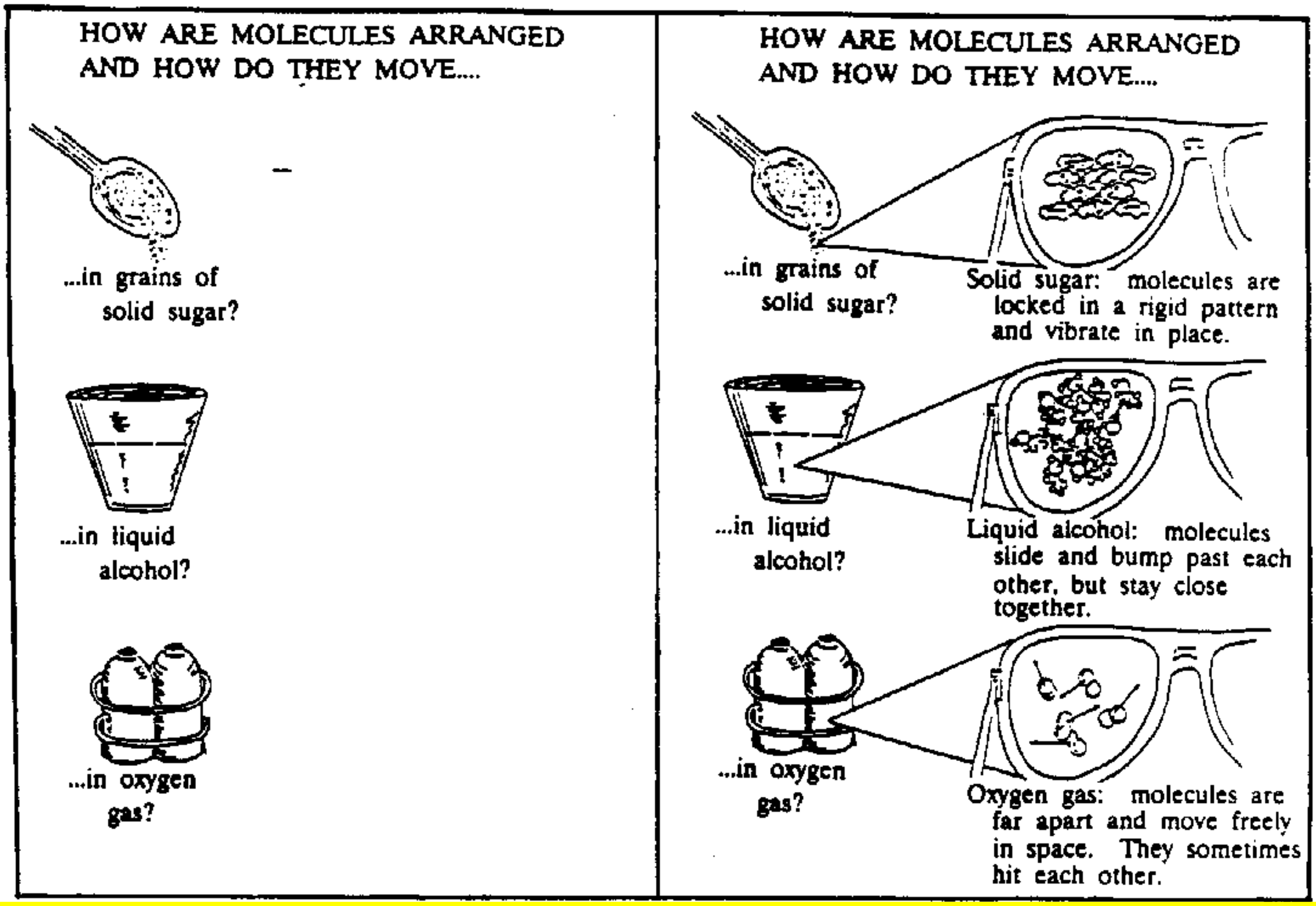
Did you say that you could see wavy lines under the tea bag and taste the sugar in the water? That is true. We cannot see the tiny molecules of sugar or the tiny molecules of water; but we can taste the sugar in the water. The sugar did not disappear forever, but the sugar grains broke into separate, tiny molecules, so that we could no longer see the sugar. Just because we cannot see the sugar does not mean it is not there. The water tastes sweet, so it must still be there.

How did the sugar get out the tea bag? You can answer this question if you think about the size of sugar molecules. The holes in the tea bag are much smaller than a grain of sugar, but much larger than a molecule of sugar. As the water molecules hit the solid sugar, the molecules of sugar break away rapidly and mix with the water molecules. The tiny molecules easily pass through the holes in the tea bag. The wavy lines under



TRANSPARENCY 4: HOW ARE MOLECULES ARRANGED AND HOW DO THEY MOVE?

<u>Bottom Layer</u>

Even though students have learned about how molecules move and how molecules are arranged in water, they often cannot transfer these ideas to other substances. Also, many students still have difficulty with movement of molecules in solids.

<u>Overlay</u>

You should contrast students' naive thinking with the overlay, which gives a scientific view of molecules. Emphasize that even though the molecules of one substance (like sugar) may be different than the molecules of another substance (like ice), the molecules are still arranged and move in the same way in the solid state. This is what makes substances solids, liquids, or gases. Pay particular attention to movement of molecules in solids, as student have difficulty with this concept.

<u>Supplemental Activities</u>

1. Look up the molecular formulas of other pure substances, such as propane gas, ammonia, salt, baking soda, and make or draw models of a molecule of each.
2. You can show that milk (and other substances) are mixtures by freezing them. The water freezes before other substances in the mixture freeze.

Lesson 6.3: The Thermometer

In the last two lessons you have learned that the molecules of all substances move faster when the substances are heated, and that solids expand when they are heated and contract when they are cooled. What about liquids? Do you think that they expand and contract the way solids do? Try Activity 6.3 and find out!

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Do Activity 6.3 in your Activity Book

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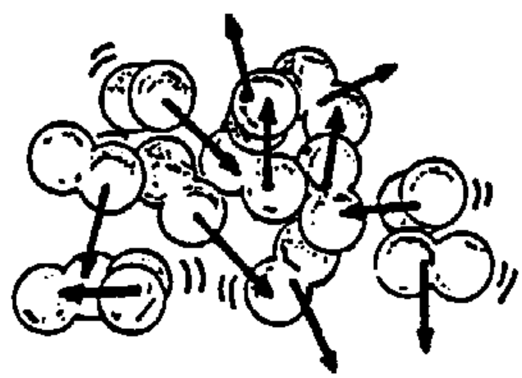
Could you explain why the column of the liquid in the thermometer rose and then fell? You know from Lesson 6.1 that the molecules of liquids move faster when the liquid is heated. That is one way that liquids and solids are alike.

Liquids and solids are also alike in another way. When the molecules move faster, they bump into each other harder and push each other farther apart. So just like solids, liquids expand when they are heated.

Liquids also contract when they are cooled. When the molecules of a liquid slow down, they move closer together. So liquids go through thermal expansion and thermal contraction just as solids do.



Heating makes the molecules of a liquid move faster and push each other farther apart