INTRODUCTION TO LESSON CLUSTER 5

EXPLAINING DISSOLVING

A. Lesson Cluster Goals and Lesson Objectives

Goals

Students should be able to explain dissolving of solids in liquids in terms of molecules.

Lesson Objectives

Students should be able to:

5.1. Explain how sugar dissolves in water.

5.2. Explain why stirring causes solids to dissolve faster than not stirring.

5.3. Demonstrate and understanding that most solutions are complex, that is, have several solids dissolved in water.

B. Key Elements of a Good Description

As already introduces in Lesson Cluster 4, to make a good explanation, students need to answer to questions:

a. What substance is changing and how is it changing?

b. What is happening to molecules of the substance that accounts for the change?

For various phenomena of dissolving in this lesson cluster, the key substances are solids that are dissolving in liquids. It is the solids that are changing, but liquids also have important functions in the change. Thus, students should recognize how solids are changing and how liquids cause this change.

At the molecular level, students should understand two major components involved in dissolving:

a. Molecules of liquids hit the grains of solids.

b. Molecules of solids break away and spread out evenly in liquids.

Unless students integrate all three components in their explanation, their understanding of dissolving is not complete. Furthermore, students should realize that it is the molecular part of the explanation that provides a reason and accounts for the change in substances.

C. Students' Conceptual Learning

Students familiar with dissolving in daily life and, apparently, it seems easy to explain at a macroscopic level (that sugar, for instance, breaks up into pieces too small to be seen). The process of dissolving, however, is complicated at the molecular level. To develop adequate understanding, students should integrate several major components involved in dissolving. Due to this complication of explanation, dissolving may be a difficult task for some students.

Lesson 5.1

When sugar dissolves in water, the amount of sugar is conserved (does not increase or decrease). Some students may not understand conservation of matter. Students may think that, because sugar disappears, it no longer exists. They may mean this when they say that sugar evaporates or dissolves. Students should recognize that even though they cannot see sugar in water, it is still there.

Water has a critical role in dissolving: Water molecules hit the sugar molecules and cause them to break away from sugar crystals. However, many students may think that water has nothing to do with what is happening with sugar. For instance, they may think that sugar crystals in a tea bag get bigger in water (Activity 5.2) get out because the holes in the tea bag get bigger in water, or they may think that the sugar "melts." (Melting is caused by heat and does not require water.)

Some students who remember the conception of empty space between molecules may erroneously think that small holes in the tea bag are actually empty spaces between molecules of the tea bag.

Some students may be confused between sugar molecules and the crystals of sugar. They may think that crystals are actually sugar molecules. The teacher should emphasize that crystals consist of trillions of sugar molecules.

Students may be confused between properties of molecules and observable properties of substances in dissolving. For instance, students may think sugar molecules themselves dissolve in water. Some may also think that after sugar dissolves in water, sugar will go down to the bottom of water and stay there, so it will taste sweeter at the bottom of water than at the top. In fact, sugar molecules are constantly moving and spread out evenly in water.

Lesson 5.2

The speed of dissolving can vary by the method used to speed it up, for instance, by stirring. The teacher needs to note to students that we can make substances dissolve either faster or slower in various ways.

Lesson 5.3

Students who distinguish pure substances from mixtures based on observable properties of substances may have difficulty understanding solutions. Based on color, taste, or other observable properties, some students may think that the water we get from a faucet is a pure substance. Students should recognize that regardless of how a substance appears, the molecules that make the substance determine whether it is pure or a mixture.

D. Conceptual Contrasts

The chart below contrasts common patterns in student thinking with scientific thinking about some of the important issues for this lesson cluster.

Issue	Goal Conceptions	Students' Conceptions
Conservation of matter	Matter is conserved in changes.	Matter not always conserved. The word "dissolve" sometimes used as a synonym for "disappear."
Size of molecules	Molecules are too small to see.	Molecules are visible (e.g., crystals or "wavy lines" of sugar as sugar molecules).
Constant motion	All molecules are constantly moving.	Molecules may sometimes be still (e.g., sugar molecules go down and stay at the bottom of water).
Different kinds of molecules	Molecules of one substance are different from molecules of a different substance.	All molecules are alike.
Pure substance vs. mixture	Pure substances are made of one kind of molecule; mixtures, two or more kinds of molecules.	Distinction based on observable properties of substances, such as color, taste, texture, etc.
Molecular explanation of dissolving	Molecules of solute break away and mix with molecules of solvent.	Focus on observable substances or molecules themselves "dissolve."

LESSON 5.1

HOW DID THE SUGAR GET OUT?

PURPOSE:

To help students develop an explanation of how sugar dissolves in water. To make this explanation, they have to recognize that sugar grains have to break apart into much smaller sugar molecules.

MATERIALS LIST:

For each student or each group of 2-3 students:

magnifying glass	sugar, 5 cc
empty tea bag	plastic cup
water, 150 ml.	

Transparency 9: What happens when sugar dissolves in water?

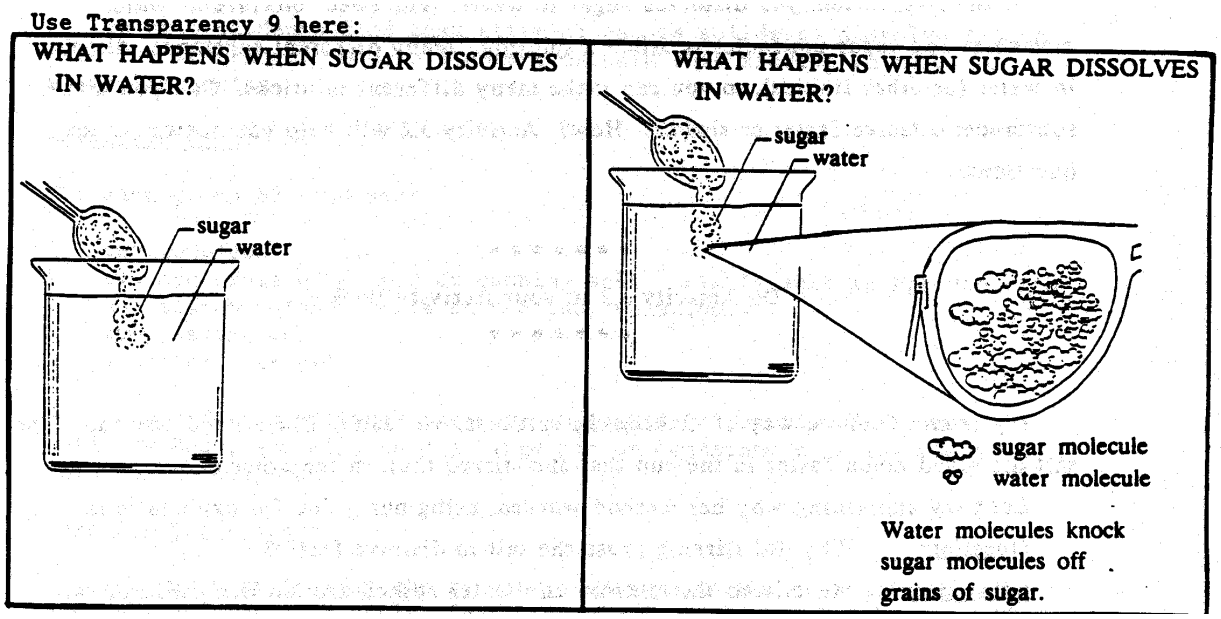
TEACHING SUGGESTIONS:

This lesson begins with a brief introduction and goes right into the activity. Students answer a number of questions as they do the activity. You may want to discuss each question after students have done the activity, or have the class read in the textbook which explains dissolving. The last section of this lesson reviews the explanation and helps students see how the "explanation guide" heuristic applies to this explanation.

Some students do not recognize that water has to go into the tea bag to dissolve the sugar. They may have written in the activity that the sugar gets out because the tea bag holes get bigger in water.

Some students think that sugar crystals are actually molecules. Crystals of sugar are cube-shaped because of the rigid array of (trillions of) molecules in solid sugar.

Use Transparency 9 here:



TRANSPARENCY 9: WHAT HAPPENS WHEN SUGAR DISSOLVES IN WATER?

Bottom Layer

Many students feel that, when sugar dissolves in water, the sugar "disappears" or "melts." Most students will not answer this question in terms of molecules.

Overlay

Students should be challenged to see that just because the sugar is no longer visible does not mean that it is gone forever. On a macroscopic level, the sugar mixes with the water. On the molecular level, water molecules hit the large grains of sugar, knocking off individual molecules. These sugar molecules eventually become evenly dispersed throughout the water. Since we cannot see individual molecules, the sugar seems to have disappeared. We know it is still there, however, because the water tastes sweet.

Remember that the word "substance" is supposed to remind students to ask two questions: What substance is changing? and How is it changing? The word "molecules" is supposed to remind students to write about what is happening to molecules during the change.

It is the molecular part of the explanation that provides a reason and accounts for the change. We want to help students get to the point of explaining the phenomena in this lesson cluster and the following clusters in terms of molecules.

LESSON 5.2

DISSOLVING FAST AND SLOW

PURPOSES:

To help students find that stirring causes solids to dissolve faster than not stirring. To help students explain this finding in terms of molecular motion.

MATERIALS LIST:

For each group of students:
two tumblers
two spoonfuls of Kosher or canning salt (Table salt is sprayed with cornstarch with results in a cloudy solution.)
two plastic cups
coffee stirrer

If you do the optional activity suggested in question 7 of the Activity Book, you will need a large pan or container to allow the salt solution to evaporate.

TEACHING SUGGESTIONS:

You may want to list the student responses to the question "How can you make substances dissolve faster of slower?" on the chalkboard. If the students suggest that heating will make substances dissolve faster, inform them that they will investigate this in Lesson Cluster 6.

After the students do the activity, go over the explanation carefully and discuss the major points with the students.

LESSON 5.3

COMPLEX SOLUTIONS

PURPOSE:

To help students understand that most common solutions are complex; that is, have several solids dissolved in water.

ADVANCE PREPARATION:

Teachers may want to have little cups or bottles of various complex solutions in the room for students to view.

MATERIALS LIST:

Select 3 or 4 items such as:

soda	syrup	liquid dish detergent
mouthwash	kool-aid	hair color dye
catsup	clear shampoo	dish water
honey	apple juice	

Transparency 3: What would ocean water look like?

TEACHING SUGGESTIONS:

Have students collect labels from different complex solutions they may find at home. Discuss why these items are complex solutions. Note: Some items you find in your kitchen or bathroom are not complex solutions, i.e., ammonia (without soap or detergent), bleach (without soap or detergent), hydrogen peroxide, and alcohol. Each of these solutions contains only water and one other compound.

Remember that the word "substance" is supposed to remind students to ask two questions: What substance is changing? and How is it changing? The word "molecules" is supposed to remind students to write about what is happening to molecules during the change.

It is the molecular part of the explanation that provides a reason and accounts for the change. We want to help students get to the point of explaining the phenomena in this lesson cluster and the following clusters in terms of molecules.

Use Transparency 3 here: See Teacher's Guide Lesson 2.2 for a description of Transparency 3.

SUGGESTIONS FOR ADDITIONAL ACTIVITIES:

1. Crystal growing

   An interesting way to extend this lesson cluster is to have students grow two or more different types of crystals. The first step in growing crystals is to prepare a saturated solution. This can be done by dissolving as much of the solid as possible in a hot water solution. Pour this solution in a jar, and cover the jar with cheese cloth to prevent dust from getting into the solution. Allow the solution to cool overnight and crystals should form on the bottom of the jar. Pour the liquid from the crystals into a second jar, take one of the nicest crystals, tie it one a piece of thread, and suspend it in the solution of the second jar. Allow it to stand as the crystals grow.

   If crystals start forming on the bottom or sides of the jar, repeat the procedure just described by pouring the solution into a clean jar and again suspending a seed crystal on a piece of thread.

   There are a number of salts that make interesting crystals. Some are: alum, Rochelle salt, photographer's hypo or sodium thiosulfate, and cupric sulfate. Alum is aluminum sulfate and Rochelle salt is potassium sodium tartarate.

   Growing crystals is tedious and requires a lot of patience. Perhaps you would want to start growing crystals several weeks before you intend to use them.

   Crystals and Crystal Growing, by Alan Holden and Phylis Singer, is a good reference source. It is in the Science Study Series, published by Anchor Books, Doubleday & Co., Inc.

2. Finding complex solutions

   Students bring in solutions from stores and study the labels. (Remember that only clear liquids are true solutions.)

LESSON 5.3

CLUSTER REVIEW

TEACHING SUGGESTIONS:

1. After each child has answered the questions, you may want to write several different answers to each question on the board and compare students' responses.

STUDENT RESPONSES:

1. Students should draw the water molecules in the way they have been drawn previously. The other molecules may be made up by the students: You may want to suggest different shapes for each molecule.

2. Both friends are wrong.

   This question is to help the students contrast dissolving with disappearing and melting. Students should be able to explain what dissolving is; they should show that the sugar still exists.

   (You may want to point out that the sugar has not melted because the sugar or water has not been heated. Hot water is not hot enough to melt sugar either, although sugar dissolves faster in hot water--See Lesson 6.1.)

3. Do not allow the students to just copy what they had written earlier. The explanation should mention both substances (water and salt), and water and salt molecules.

4. You might ask each student to write three statements in their activity book.

Write all student responses on the board. (Even if a response is incorrect). Now have the students group the responses, and discuss any they feel are not correct.

Student responses might include these important points from the lesson cluster:

1. All matter is made of molecules.
2. Molecules can move from one place to another.
3. Grains can break apart into molecules.
4. I can see evidence of molecules moving from one place to another.
5. I can make something dissolve faster by stirring it.
6. When sugar or salt dissolve in H_2O the molecules break away and join with the water.
7. A molecule of sugar in a grain or a molecule of sugar in water is the same.

MATERIALS LIST

CLUSTER 5, LESSONS 5.1-5.3

Lesson 5.1:

For each group:
magnifying glass
sugar
empty tea bag
plastic cup
water
Transparency 9

Lesson 5.2:

For each group:
two tumblers
two spoonfuls of salt (Kosher salt or canning salt)
two plastic cups
coffee stirrer

If you do the optional activity suggested in question 6 or the Activity Book, you will need a large pan or container to allow the salt solution to evaporate.

Lesson 5.3:

Cups of:

soda	syrup	liquid dish detergent
mouthwash	kool-aid	hair color dye
catsup	clear shampoo	dish water
honey	apple juice	Transparency 3