ACTIVITY 1.1
SOLID WATER AND LIQUID WATER

TEACHING SUGGESTIONS:

1. Separate the class into groups of about three students each and distribute the materials. Circulate around the room to monitor the activity and to encourage the students to write answers to the questions.

2. As part of your directions, stress that the students seal the ice cube in the ziplock bags so the water does not leak out. You may want to place a time limit on the activity. The students in each group should decide together how best to melt the ice fast. Caution the students not to roll or pound the ice cube and break the bag.

3. After the students have completed the activity, collect the materials and discuss the activity.

STUDENT RESPONSES:

Calculation time: Many students will find it easier to "count forward" from the starting time to the stopping time than to subtract the times.

1. Students' responses will vary. They might include placing the ice cube bag system between their hands, under their arms, etc.

2. This question is designed to help students focus on the key idea that a change of state does not change the substance: Ice and water are the same substance because ice melts to form only water.

3. This question gets at the major point of the activity: Water and ice are interconvertible, and thus two different states of the same substance.

   Students could change the liquid water back into ice by placing the plastic bag containing the water in a freezer or pouring the water into an ice cube tray and placing it in a freezer.

4. Adequate answers include the idea that when ice melted there was no water lost of gained and thus there would have to be the same amount remaining.

   (Students sometimes say that there would be <u>less</u> ice because some of it evaporates, or that there is <u>more</u> ice because ice weighs more than liquid water, perhaps because it's solid and hard. This is not true. The same amount of ice and water weight the same, as shown in the next question.)

5. Optional: You may want to do the experiment described in this question. If you want to check the weight before and after ice melts, check for leakage (which tends to decrease the weight) and condensation of water vapor in the air on the cold plastic bag (which tends to increase the weight).

   A problem in doing this experiment is that some students believe that the condensation on the outside of the bag is really water leaking from the inside of the bag. Condensation will be discussed in Lesson Cluster 9.

   The students' explanation should include the idea that the weight would have to remain the same since no water was lost or gained as the ice cube melted.

This is a very difficult idea for many students, and not of central importance for this unit. You should not expect all your students to master this idea (that mass is conserved in changes of state) and use it consistently.

DEMONSTRATION 1.2

TEACHING SUGGESTIONS:

If students see water in the tube, they may think that this water is water vapor. To prevent this confusion, set the distillation apparatus up about 10 minutes before class and let it operate several minuets before the students observe it closely. Make sure students understand that there is an invisible gas (water vapor) coming out of the tube and that water is accumulating in the test tube.

STUDENT RESPONSES:

1. Less. As the water boils in the flask, some of it changes to water vapor, moves through the gas tube, and collects in the test tube.

   (There is some confusion about the use of the terms "steam" and "water vapor." Scientists use them both to mean <u>invisible</u> water in the gas state. In common language, though, steam often refers to the visible condensate above boiling water. This is really tiny drops of water--liquid water! Our practice in this unit is to refer to the invisible gas as water vapor and to the visible droplets as "steam"--in quotation marks to indicate the non-scientific usage.)

2. Arrows should show water moving from the boiling water, through the tube, and into the test tube.

3. a. Liquid water to water vapor or gaseous water
   b. Water vapor
   c. Water vapor back into liquid water
   d. Water vapor. (Many students believe that the bubbles are made of air. They are not. The bubbles have only water in the gas state inside them.)

4. No. The bubbles coming up through the water consist of water vapor, not air. Water is changing to water vapor at the bottom of the flask where it is hottest, making the bubbles.

5.
   a. No--water vapor is invisible. But sometimes some water condenses in the tube--changes from water vapor back into liquid water.
   b. No
   c. You cannot see water vapor--water vapor is invisible.

6. Since liquid water can change into water vapor, and water vapor can change back into liquid water, liquid water and water vapor are two different states of the same substance.

QUESTION SET 1.3

THE SMALLEST PIECES OF WATER

1. Molecules
   Atoms (2 hydrogen atoms and 1 oxygen atom).

2.

3. Any illustration, like the one below, that shows the dust particle as <u>much</u> bigger than the water molecules is inappropriate.

4. The arrows should show water molecules moving in all directions, sometimes colliding with each other.

5. No. Water molecules in ice are moving more slowly than water molecules in water, but they continue to move all the time. If the ice cube is put in a colder freezer, the molecules will slow down more, but they are always moving.

   (Students sometimes think that molecules of ice are not moving because ice is so hard. This is not true: ice molecules are constantly vibrating. This is a difficult idea to grasp, but it will come up again in Lesson Cluster 7 on melting and solidifying.)

QUESTION SET 1.4

MOLECULES AND THE THREE STATES OF WATER

1. Ice, liquid water, and water vapor all consist of the same kind of molecules--water molecules.

2. Water molecules in ice are locked in a rigid pattern, vibrate in their places, but do not move past each other.

   Water molecules in liquid water slide and bump past each other.

   Water molecules in water vapor move freely and have much greater spaces between them than either ice or liquid water.

3. No. When water freezes, the molecules themselves do not change. As water is cooled the molecules slow down and move into a rigid array or pattern and vibrate in place.

   (The property of coldness actually indicates that the molecules are moving slowly, not that they themselves are cold. Hardness indicates that the molecules are locked in a rigid array, not that they themselves have become harder.)

4. No. All water is made of water molecules.

   (The molecules are close together, but there is some space between molecules of liquids. Spaces between the molecules are empty. There is nothing in these spaces. This is a difficult idea for some students, especially those who have the naive conception that molecules are like pieces of dust or little germs in air, or bacteria or dirt in water.)

5. No. The bubbles of boiling water are water vapor and water vapor consists of water molecules only.

   (Many students get confused between boiling water and the dissolved air that comes out of water when the water is first heated. When you first start heating a container of water, tiny bubbles form on the inside surface of the container. These are air bubbles from the dissolved air in water. But the bubbles in boiling water are water vapor or steam.)

QUESTION SET 2.1

ARE OTHER SUBSTANCES MADE OF MOLECULES?

1. Encourage students to add many other substances to this list.

SOLID	LIQUID	GAS
Steel	Alcohol	Helium
Sugar	Milk	Carbon dioxide

2. Students may need to be encouraged to use their imagination in drawing pictures of molecules of alcohol and oxygen. Accept any reasonable shapes, but the arrangement of molecules should be similar to any liquid, solid, and gas. (The actual shapes of alcohol and oxygen molecules are shown on pages 14 and 23 of the science book.)

   Alcohol liquid: alcohol molecules are constantly moving, sliding and bumping past each other.

   Ice (solid water): molecules locked in rigid array, vibrate in their places.

   Oxygen gas: Oxygen molecules far apart, bouncing around freely in space.

   You may want to use a student analogy to illustrate the arrangement and movement of molecules in solids, liquids, and gases.

   Solids: Students are in their seats in a classroom. They are moving but they stay in their seats--a rigid pattern.

   Liquids: Students are doing a laboratory experiment moving past each other, but staying in their classroom.

   Gases: Students are changing classes, moving freely and far apart.

3. Both water and water vapor have the same kind of molecules--water molecules. They are different in that water is a liquid and water vapor is a gas. The molecules of water vapor move freely and are very far apart compared to liquid water.

   (Students may wonder whether the molecules of water vapor move faster than the molecules of liquid water. They do, only if the water vapor is hotter than the liquid water. Molecules of a gas at room temperature, like oxygen or water vapor in the air, move at about the same speed as molecules of liquid water at room temperature.)

4. Water vapor and oxygen are both gases and they are both substances made of molecules. They are different because they have different kinds of molecules.

5. Ice and water have the same kind of molecules--water molecules. Glass molecules and the water molecules in ice are different. Therefore ice could not change into glass.

6. Light is not a solid, liquid, or gas, and it is not matter. Only matter is made of molecules. Light is a form of energy.

ACTIVITY 2.2

MAKING MIXTURES

TEACHING SUGGESTIONS:

Because each group of students will prepare six mixtures, you may want to place directions on the chalkboard and assign specific tasks to each group member. This activity works best when small amounts of each mixture is used. For best results, there should be no more than one inch of the mixture in the bottom of each tumbler.

Emphasize that we can see substances but not molecules.

STUDENT RESPONSES:

1. 5cc salt and 25cc pepper: Yes
   5cc salt and 5cc sugar: Responses will vary (differences in crystal shapes are visible with a magnifying glass).
   Pepper water: Yes
   5cc sugar and 150 ml water: No (assuming sugar is dissolved).
   5 ml syrup and 150 ml water: No

2. You could tell the difference between pure substances and mixtures if you could see molecules with a magnifier. But you cannot see molecules with a magnifier.

3. A pure substance is made up of only one kind of molecule. A mixture is made up of two or more different kinds of molecules mixed together.

4. The sugar grains break up into individual molecules.

   The molecules of both the sugar and water are constantly moving. They intermingle so that the molecules of sugar spread throughout the water.

   (Some students think that the sugar disappears and does not exist any longer. One way to tell that the sugar still exists is to taste the water. More on dissolving in Lesson Cluster 5.)

5. The sugar molecules are intermingled throughout the water molecules.

Use Transparency 3 here:

TRANSPARENCY 3: WHAT WOULD OCEAN WATER LOOK LIKE?

BOTTOM LAYER:

Often students make distinctions between mixtures and pure substances based on observable properties only; they believe that if something looks clear, then it is a pure substance. Thus, they will say that ocean water is pure because it looks clear. This would imply that ocean water has only one kind of molecule, even though most students will not answer in terms of molecules.

OVERLAY:

Ocean water, even though it looks clear, has several different kinds of molecules, thus making it a mixture and not a pure substance. Emphasize this difference to your students. Although ocean water is a mixture of a number of different substances, only salt is shown in this transparency, as it is the most familiar to students.

QUESTION SET 2.3

MOLECULES IN STATES OF MATTER

TEACHING SUGGESTIONS:

After the students have complete this question set, you might want to use the transparency "How are molecules arranged and how do they move?" or the poster to discuss the students' answers.

STUDENT RESPONSES:

1. You may have to encourage some students to use their imagination in making up shapes for molecules for substances that they do not know.

   a. Students' choices will vary.

   b. Any shapes are OK, as long as different substances have differently shaped molecules.

   c. Arrangements and motions should be similar to those previously described for molecules of solids, liquids, and gases.

   d. Arrows should show vibration for the molecules of the solid, movement through space for the molecules of the liquid and gas.

2. Your friend was wrong because a speck of dust is huge compared to a molecule. A speck of dust is made of millions of billions of molecules itself. A molecule is so tiny you cannot see it even with a microscope.

3. Yes! Ocean water is a mixture of salt and water, and many other substances.

   Students' drawings should show at least water molecules and salt molecules mixed together. They may represent salt molecules any way they want.

   (There are really no salt "molecules" in ocean water, though. Salt crystals are made of equal numbers of sodium and chlorine atoms, alternatively arranged in a rigid array. The chemical name of salt is sodium chloride, and its chemical formula is NaCl (Na stands for sodium). When salt crystals dissolve in water, the sodium and chlorine atoms move about separately. They are called "ions," because one has a positive electric charge and the other has a negative electric charge.)

ACTIVITY 3.1

IS THE AIR IN A CUP A REAL SUBSTANCE?

TEACHING SUGGESTIONS:

Plastic bag activity:

1. When students collect air in the plastic bags, suggest that they trap air by scooping it through the air, not by blowing into it. Breathing into the bag may leave water vapor, which could be a source of confusion for this activity. Instruct students that once they have trapped air in the bag, to twist the top of the bag tightly so that no air can leak out during the activity.

Cup and hose activity:

2. You will need clear cups or plastic tumblers for this activity. To prevent the transfer of bacteria from one student to another during this activity, you should have both ends of the rubber tubing cleaned with alcohol before letting students begin. Also, allow only one student in a group to suck the air from the cup. You may also attach a straw to the end of the tube and discard it after each student uses it. Note how tape is used to keep the end of the hose near the top of the cup.

STUDENT RESPONSES:

1. The student should say that it is taking up space in the bag and they can feel it when they squeeze the bag.

2. Yes.

3. Students should note that the air can be squeezed into a smaller space. Advise the students not to squeeze too hard, or they'll break the bags.

4. Students should recognize that the water level in the cup goes up when the air is sucked out.

5. The water level goes back down when air is blown into the cup.

6. Students should see that this is a result of air taking up space. When air was taken out of the cup, water had space to go into the cup. When air was pushed into the cup the water was pushed out because air takes up space.

7. The molecules of air in the cup pushed against the molecules of water, keeping the water out of the cup.

QUESTION SET AND DEMONSTRATION 3.2

CLEAN AIR AND SMELLS

TEACHING SUGGESTIONS:

1. During this question set, you will need to release a small amount of perfume.

STUDENT RESPONSES:

1. Nitrogen (N_2), Oxygen (O_2), carbon dioxide (CO_2), and water vapor (H_2O). (Air also contains argon, helium, hydrogen, and other gases.)

2. No. Students should realize that there is no such thing as an "air molecule," but rather that air is made up of different kinds of molecules which are mixed together.

3. Molecules that can be detected by your nose.

4. Some of the molecules of perfume left the container and then mixed in and spread throughout the air until the smell reached your nose. (In addition to molecules of air moving randomly throughout the room, air currents may also help the smell move toward your nose.)

5. Students may use their imaginations to some extent in this drawing, but they should include some ammonia molecules mixed in with the other molecules of air, and should display air by making the molecules far apart from each other.

   A molecule of ammonia--(NH_3)--is pictured on page 24 of the science book. Students should be able to figure out how ammonia molecules mix with the other molecules in air even before they see that picture.

ACTIVITY 3.3

BREATHING OUT AND BREATHING IN

TEACHING SUGGESTIONS:

It is not particularly important that the glass or plastic the students breathe on be cold--just cool enough so when the students breathe on them they will get a fog.

Follow directions in the Science Book Teacher's Guide (Lesson 3.3) for making and testing BTB solution.

STUDENT RESPONSES:

1. Students should see a fog on the piece of glass or plastic.

2. Tiny droplets of water. Students can run their fingers through the fog to see that it is water.

3. The fog came from your breath.

4. The air we breathe out contains a large amount of water vapor.

5. The solution should turn yellow. Students may ask whether the yellow BTB solution can change back to blue BTB. It usually will if left overnight. Try it. The carbon dioxide escapes from the water and BTB solution.

6. The students should respond that there is carbon dioxide in the air we breathe out.

7. The air we breathe out contains more CO_2 and more water vapor than the air we breathe in.

The observation that breath breathed out changes the color of the BTB solutions shows more CO_2 than in normal air, as you saw in the activity. Water vapor from breath condensing on a cool glass shows more H_2O than in normal air. These observations suggest these two components (CO_2 and H_2O) have variable composition in air. The relative amounts of N_2 and O_2 is quite constant throughout the world (78% N_2, 21% O_2, and about 1% other gases). The relative amounts of other gases are approximately: CO_2, 0.03%; H_2O, 0.3%.

Breathing at high altitudes is discussed in Lesson Cluster 5.3.

You might want to use Question Set 3.3: Cluster Review during the next class period. It can be use, if you wish, as an evaluatory tool.

QUESTION SET 3.3

CLUSTER REVIEW

1. Students should list nitrogen, oxygen, carbon dioxide, and water. The formulas are: N_2, O_2, CO_2, and H_2O. Their pictures should correspond to these formulas.

   (There are pictures of these formulas on page 23 of the Science Book.)

2. A speck of dust is trillions of times bigger than a carbon dioxide molecule.

3. When you smell something, the molecules of that substance are intermingling with the air molecules.

4. The smell molecules are constantly moving and so are the molecules of air. This constant movement causes the smell molecules to reach your nose. If the air in the room is not still, the smell molecules are also carried with the air flow.

5. More carbon dioxide, more water vapor, and less oxygen.

DEMONSTRATION 4.1

<u>MOLECULES HITTING EACH OTHER</u>

Directions for doing the demonstration are in the Science Book Teacher's Guide.

1. Students should include these ideas: The air moving out of the hair dryer is a stream of molecules moving mainly in one direction. The molecules hitting the ball from the bottom and sides cause the ball to be lifted and held on the stream of air. The molecules hit the ball hard enough to lift it.

2. The inflated ball does not get flat because the air inside is made of molecules which hit the inside of the ball and push back out on it.

3. a. <u>Yes.</u> Molecules of air are hitting the chimes when air is still; molecules are always moving.

   b. The molecules of still air are moving, but they hit on all sides of the chimes with equal force. When the wind is blowing, more molecules are hitting the chimes on one side than the other.

ACTIVITY 4.2

COMPRESSING AIR AND WATER

TEACHING SUGGESTIONS:

Have the students complete questions 1 and 2, page 18 before you proceed with the activity.

STUDENT RESPONSES:

1. Compared to the water molecules, the air molecules in the student drawings should be very far apart. Both drawings should indicate molecular motion.

2. Students should predict that it would be easier to push air molecules together. The molecules of a gas are very far apart compared to a liquid. The gas molecules can be pushed together but the molecules of a liquid are already close together and cannot be pushed much closer together.

3. Students' drawings should show that molecules of air in the syringe are distributed all over the syringe, not bunched up at one end or the other. They should have a lot of space between them. (Some students think that the molecules are closer together either near the plunger or near the end by the opening. Be sure to point out that the molecules are evenly distributed around the inside of the syringe.)

4. No. The water cannot be compressed because the molecules are very close together and cannot be pushed any closer together.

5. Now the plunger will go in about halfway.

6. You can push in the plunger with air because the molecules are far apart and can be pushed closer together. The molecules of a liquid are already close together so the molecules cannot be pushed closer together. (Some students explain, in a simplistic way, that water is "harder" than air. You should ask them to think about why water is "harder.")

7. You cannot push the plunger all the way in because when you push the molecules closer together, they hit each other and the plunger more often. Therefore, they push out harder on the plunger.

8. The plunger moves back to the original position. This is because the molecules that were forced into a smaller space hit each other and the plunger more frequently. The molecules hitting the plunger push the plunger back to its original position.

QUESTION SET 4.3

THICK AIR AND THIN AIR

1. The molecules in the syringe to the right should be drawn closer together. Both drawings should show about the same number of molecules. Students may draw different types of molecules.

2. The molecules in the scuba tank are much closer together than the molecules in the mountain air. (Students should also remember to use arrows to show that molecules are always in motion.)

3. A gallon of air from a valley. In a valley, molecules of air are closer together, so there would be more in a gallon than on top of a mountain. The higher you go in the atmosphere the fewer molecules you have in a gallon.

4. Air will escape. The air in the scuba tank is compressed and the molecules are pushed close together. They are moving fast and hit each other quite often. When the valve is opened, the molecules of air push each other out of the valve. The air inside the tank expands out of the tank.

QUESTION SET 4.4

EXPLAINING BICYCLE TIRES

STUDENT RESPONSES:

1. The molecules of air are being pushed closer and closer together. The air in the tire is being compressed.

   (Some students might say that it is expanding, because the tire expands a little when it is pumped up. But the air is being compressed. This confusion illustrates why it is important to identify the appropriate substance as part of the explanation.)

2. No. The molecules of air are constantly moving. This causes the molecules of air to spread out evenly throughout the tire.

3. The air is expanding as it escapes. When the valve is opened, the molecules of air rush out, move more freely and farther apart.

4. Should be similar to the statement in the Science Book, Lesson 4.4. A good explanation answers at least two questions:

   a. A question about substances: What substance is changing and how is it changing?

   b. A question about molecules: What is happening to the molecules of the substance?

QUESTION SET 4.4

<u>CLUSTER REVIEW</u>

1. Students can copy the answers to this question from the text.

   a. A question about substances: What substances are changing and how are they changing?

   b. A question about molecules: What is happening to the molecules of the substances?

2. An example of a good explanation: The <u>air</u> (substance) is being <u>compressed</u> as it is pushed into the tire. The pump pushes the <u>molecules</u> of air closer together. The teacher should remind students that a good explanation answers the two questions listed in number 1.

3. An example of a good explanation: The <u>air</u> (substance) escapes through the hole in the tire and <u>expands</u>. The <u>molecules</u> of the air move farther apart when they get out of the tire.

   (Some students will say that the molecules move through the hole in the tire, but they will not say that they move farther apart. The reason they move farther apart is that they were pushed close together when the tire was inflated.)

4. An example of a good explanation: The compressed <u>air</u> (substance) inside the syringe <u>pushes</u> against the plunger and forces it back out. The <u>molecules</u> of the air push by hitting the plunger and bouncing off.

5. An example of a good explanation: Helium (substance) is compressed and put into the tank. The molecules of helium are pushed closer together.

(Helium gas actually consists of individual atoms rather than molecules containing two or more atoms. Most students will not know this, however, and the distinction is not important for this unit. What is important is that there are the same number of molecules--or atoms--of helium in the tank as in the balloon!)

6. An example of a good explanation: Helium (substance) expands as it leaves the tank and goes into the balloon. The helium molecules (or atoms) are moving further apart as the gas moves out of the tank and into the balloon.

ACTIVITY 5.1

WHERE DID THE SUGAR GO?

1. Tea bag drawings should show filaments with gaps between them. Drawings of grains of sugar should show some detail and some size, and not be just dots. If students draw just dots, they may be confusing grains of sugar with sugar molecules.

   a. Yes.

   b. No. Students' drawings might indicate relative size of grains and holes.

   c. Yes. You might point out here that molecules are much smaller than grains. Grains of sugar are made of trillions of molecules.

2. You can drape a tea bag over the side of a cup by wetting the top of the bag and pressing it over the edge.

a. Students usually see wavy lines in the water under the tea bag.

b. The water should taste sweet.

c. The reason you cannot see the sugar is that is has broken into molecules--too small to see. (This question, though, will probably elicit some misconceptions from students, like "you can't see it because it has disappeared," or "because it has melted." You can use this question to help students begin to think about the process of dissolving.)

d. Encourage students to write as much as they can and to explain their ideas clearly. Many will not have complete or even scientific explanations, which is OK at this point, since they are just beginning to develop this explanation. It would be a good idea to discuss three or four different student explanations before reading in the text, and point out differences between them.

e. The sugar would spread evenly throughout the water. The molecules of water and of sugar are constantly mixing. The molecules' motion causes the molecules to intermingle evenly throughout the mixture.

(Some students might suggest that the sugar settles on the bottom. They probably do not understand that molecules are <u>always</u> moving, so they constantly move throughout the water.)

ACTIVITY 5.2

DISSOLVING FAST AND SLOW

TEACHING SUGGESTIONS:

For this activity use Kosher or canning salt because most table salt is sprayed with corn starch (which results in a cloudy mixture).

1. Divide the class into groups. Each group must have 2 cups containing water and salt.

2. Be sure the students understand that they must fill the cups equally.

3. Be sure the students put the same amount of salt in each cup.

4. After the activity is complete, collect materials, clean up and discuss ways students dissolved the salt more rapidly in one cup then in the other.

STUDENT RESPONSES:

1 & 2. Student responses will vary. Some may suggest stirring, or shaking.

3. No, the salt still exists. Taste the liquid which is salty or allow the water to evaporate and salt will remain behind.

4. The student drawing should show water molecules and molecules to represent salt.

5. Stirring moved the water past the grains of salt, and caused more molecules of water to hit the salt grains, so the molecules of salt were broken off from the grains faster.

6. Yes. The magic eyeglasses should show molecules of water, sugar and salt.

7. Place the salt water solution in a pan and allow the water to evaporate. The solid salt will remain in the pan.

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.

<u>Crystals and Crystal Growing</u>, 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.

ACTIVITY 6.1

CANDY IN HOT AND COLD WATER

TEACHING SUGGESTIONS:

Introduce this activity by having the students read the first paragraph and stressing that in a fair test or controlled experiment everything should be the same in the two cups except temperature. Use identical pieces of candy in the two cups. Different candies dissolve at different rates. Differences in speed of dissolving will be more apparent if the candy is broken into small pieces.

STUDENT RESPONSES:

1. Student predictions will vary, but may include:

   a. The candy dissolves in both cups. Wavy lines will be in both cups.

   b. The candy will dissolve faster in the cup with the hot water. There will be more wavy lines in the cup with the hot water.

   c. Hard candy in hot water should dissolve faster than in cold because the molecules of hot water are moving faster and hit the candy more often and harder than in cold. That makes the water molecules knock the molecules of the pieces of candy off faster. (Many students think that the candy "melts" in hot water. You may want to explain that the candy needs a much higher temperature to melt.)

2. Student answers should include the points listed under question number 1 on the previous page.

3. Molecules of water hit molecules of candy and knock them off of the pieces of candy. The separated molecules of candy mix together with the molecules of water.

4. The cup with the hot water. Students may make several suggestions about the difference in the molecules of hot and cold water, but the only difference is that molecules of hot water are moving faster than molecules of cold water. The faster the molecules of water are moving, the more often they knock off candy (sugar) molecules.

ACTIVITY 6.2

HEATING AND COOLING SOLIDS

1. When solids are heated they expand because their molecules move faster, push each other farther apart, and the empty spaces between the molecules become larger.

   When solids are cooled they contract because their molecules move slower, move closer together, and the empty spaces between the molecules become smaller.

   (Some students say that <u>molecules</u> become hot when solids are heated, which is not true--only the <u>substance</u> becomes hot. Students may also say that <u>molecules</u> expand, but molecules only move farther apart--the substance expands. This naive conception is held by "Barry" in question #2 on this page.)

2. Terry. When solids are heated the molecules themselves do not get larger and the number of molecules do not increase. The molecules move faster and push each other farther apart. (Since heat is not a substance, there are no heat molecules.)

3. The hot water heats the jar lid and makes it expand. This causes the lid to expand away from the jar. It does this because the molecules move faster and push each other farther apart when the jar lid is heated.

   (The process actually is a little more complicated than the above explanation implies. The jar is also heated and expands, but not as much as the lid because metal expands more than glass with a given rise in temperature.)

4. In summer the sidewalks get hot and expand compared to the winter. When the sidewalk is heated the molecules move faster, push each other farther apart and the empty spaces between the molecules become larger. Each section of sidewalk is a little larger in the summer than in the winter. The cracks between the sidewalk sections are smaller in the summer than in the winter.

ACTIVITY 6.3

THE THERMOMETER

STUDENT RESPONSES:

1. Most of the colored liquid is in the bulb. (The colored liquid is probably alcohol colored with dye.)

2. The position of the thermometer should not affect the temperature reading.

3. a. When the liquid is heated the molecules move faster, bump into each other harder, and push each other farther apart.

   b. This causes the colored liquid to expand up through the thermometer tube which give a higher temperature reading.

4. No. If you turn the thermometer upside down and heat the bulb, the liquid still expands, but it goes down, not up.

   (The idea that "heat rises" is familiar to students, so they often use it to explain something that "gets higher" when it is warmed. This naive conception may come up again in Lesson 6.4, where warm hands are used to expand air in a bottle and force some of the air out of the bottle's top.)

   In situations where hot <u>substances</u> (not "heat") rise (like ocean currents and weather fronts), it would be more accurate to say "hot liquids and gases are pushed up." Heated fluids (liquids or gases) expand, become less dense than the cooler fluid around them, so that hot fluids are buoyed up by the surrounding cooler fluid. This process is known as convection, and is not included in this unit.)

5. The colored liquid gets smaller or contracts. When the liquid is cooled it contracts because the molecules slow down and move closer together. This gives a lower temperature reading.

   Some students may remember from the Miracle of Water that water is an exception to this general rule between 0 degrees Celsius and 4 degrees Celsius.

After you have finished reading in the Science Book, you may want to have students go back to questions in the Activity Book and change their answers to make them more complete.

ACTIVITY 6.4

THE DANCING DIME

TEACHING SUGGESTIONS:

This activity will work only if the dime forms a tight seal at the top of the bottle. It needs to be wet around the edges to do this.

STUDENT RESPONSES:

1. Air
   Cold

2. The dime jumped or danced.

3. When the air inside the bottle is heated it expands because the molecules of air move faster and hit each other harder. This pushes the molecules farther apart. The expanding air pushes on the dime and forces its way out of the bottle. This makes the dime jump or dance.

   Note: A good optional activity is to place a balloon on a large, cold soda bottle. As it warms up the balloon will inflate. Challenge the students to explain this change by using the kinetic molecular theory.

4. a. The balloon would get larger or expand.

   b. When the air inside the bottle was heated it expanded because the molecules of air moved faster, hit each other harder, and moved farther apart.

   (Some students explain what happens by saying that "heat rises." But the air in the bottle does not move upwards, it only expands and a small amount of air moves out of the opening. Those students who say that "heat rises" will probably be surprised if they tried this activity with the bottle upside down.)

   c. No. The molecules move in all directions, not just up. The molecules throughout the bottle and balloon moved faster, hit each other harder, and moved farther apart.

QUESTION SET 6.4

LESSON CLUSTER REVIEW

STUDENT RESPONSES:

1. a. When substances are heated they expand because their molecules move faster, hit each other more often and push each other farther apart. The empty space between the molecules becomes larger, causing the substances to expand.

   b. When substances are cooled they contract because their molecules slow down, hit each other less often and move closer together. The empty spaces between the molecules become smaller, causing the substances to contract.

2. When you heat the ring it expands and the hole in the ring becomes larger, allowing the ball to go through. The ring expands because when it is heated its molecules move faster, hit each other more often, and push each other farther apart.

3. No. The molecules themselves do not expand or contract. They only move faster or slower.

4. Hot water. The molecules of the hot water are moving faster than the molecules of cold water. The faster the molecules move the more often they will hit the substance and the faster they will knock off molecules of the substance. The hot water will, therefore, dissolve a substance faster than cold water.

QUESTION SET 7.1

MELTING ICE AND FREEZING WATER

TEACHING SUGGESTIONS:

You should remind students to use the elements of a good explanation when they answer the short answer/essay type questions.

STUDENT RESPONSES:

1. a. Melting
   b. Freezing or solidifying
   c. Evaporation or boiling
   d. Condensation or condensing

2. When ice is heated, the molecules begin to move faster and this increased jiggling causes water molecules to break apart from each other and out of their rigid array; so the ice melts into water.

3. When liquid water is cooled, the molecules slow down. When water molecules slow down, the attraction between them causes the molecules to clump together and settle into a rigid pattern. The water has frozen, or turned into ice.

4. Students should mention in their responses that in both melting and expansion, a solid substance is being heated and its molecules are jiggling faster. However, in melting, the molecules jiggle fast enough to break out of their rigid pattern, whereas in thermal expansion, the molecules remain in the rigid pattern but only move farther apart.

ACTIVITY 7.2

MELTING AND SOLIDIFYING KITCHEN SUBSTANCES

TEACHING SUGGESTIONS:

1. You should do this activity as a demonstration since it requires hot water.

2. Have the hot plate set up with a beaker of boiling water. Display the paper clip, and paraffin so the students can see them.

3. Do not put the test tubes directly from boiling water into ice water. The test tubes are likely to break. Cool the test tubes in a test tube rack first.

4. After the students have observed the demonstration, stress that pure substances were not used in this demonstration. The substances were actually mixtures.

STUDENT RESPONSES:

1. No
2. The paper clip
3. Yes
4. Olive oil

5. Students' responses will vary. Possibilities include cheese, butter, creamy peanut butter, ice cream, and frozen juice concentrate.

6. Choice of substance will vary with the student. Students should explain, regardless of the substance, that when something melts, its molecules move faster and break out of their rigid array.

7. Choice of substance will vary with the student. Students should respond that in all solidifying substances, the molecules slow down. When they do this, the attraction between the molecules causes them to clump together and form a rigid pattern or array.

8. Melting is different because when a substance melts, its molecules not only bounce a little farther apart, but they jiggle fast enough to break out of the rigid pattern that they are in as a solid.

QUESTION SET 7.3

MELTING AND SOLIDIFYING KITCHEN SUBSTANCES

TEACHING SUGGESTIONS:

This question set may be used as an evaluation tool. If you choose to use it in this way, make sure to take the Change of State poster down or cover it.

STUDENT RESPONSES;

1. a. melting
   b. freezing or solidifying
   c. evaporation or boiling
   d. condensation or condensing

2. Students should include the idea that when a substance is heated, molecules move fast enough to break out of the rigid pattern or array.

3. Student responses should mention that when a liquid is cooled, the molecules slow down. The attraction between the molecules makes them clump together and settle into a rigid pattern or array.

4. The process of melting gold is very similar to the process of melting ice. In both cases the molecules move fast enough to break out of their rigid pattern. Gold, however, has stronger attractive forces between its molecules, so it melts at a much higher temperature than ice does.

5. This question is similar to the last. Students should state that the freezing process is similar in both cases: Molecules slow down, move closer together, and fit together in a rigid pattern. The difference is that liquid oxygen freezes at a temperature much, much lower than water.

6. a. melting
   b. expansion
   c. dissolving
   d. solidifying

Question Set 8.1: Explaining Evaporation

1. Student responses will vary. They may include puddles after a rainfall, morning dew, water evaporating from lakes, and so on.

2. Although choice of situation will vary, student responses should be consistent with the Science Book's explanation of evaporation. Adequate responses include the following ideas: Liquid water is changing to gaseous water or water vapor. The molecules in the liquid water are sliding past and bumping into each other, and as they do so, some of the molecules gather up enough speed to escape from the liquid water's surface into the air.

3. Dry air. The air has more room for water molecules when the air is dry; therefore, water molecules can escape faster from the towel.

   (This is an adequate explanation for this unit. Actually, if the air is humid, some of the water molecules in the air condense back onto the towel.)

4. Open. If you close the door, the molecules can only escape out from the towel as far as the bathroom door. The air will quickly become humid, and the towel will not be able to dry out any further.

5. (a) The temperature of the water decreases or gets colder because the fastest moving molecules are leaving the water. Water with fast moving molecules is hotter than water with slower moving molecules.

   (b) The faster moving molecules are leaving the water on your head and going into the air, leaving the slower moving water molecules behind. Therefore, your head feels cool.

Question Set 8.2: Where does the water in the air come from?

Student Responses:

1. Your mouth, throat, and lungs. If we trace the water back farther inside your body, it comes from the process of cellular respiration, where food is combined with oxygen to release energy. Water and carbon dioxide are the products of cellular respiration.

2. When you breathe in and out, some of the water molecules on the surface of your lungs, throat, and mouth move fast enough to escape into the air. The air that you breathe out, therefore, is very humid or has a lot of water molecules in it.

3. You can't see the water in the air because water vapor is invisible. The water molecules are too small to see and too far apart in the gas state.

4. Billions of gallons of water evaporate from the oceans everyday and mix with the air.

5. Substances: Liquid water is constantly changing to water vapor at the surface of the ocean. Another way to say this is that water is constantly *evaporating* from the surface of the ocean.

   Molecules: Some water molecules are moving fast enough to escape the liquid water at the surface of the ocean. Since the water molecules move into the air and the air molecules are constantly moving, the air molecules and water molecules intermingle or mix.

6. (a) solidifying
   (b) evaporating
   (c) expanding
   (d) contracting
   (e) evaporating
   (f) melting
   (g) dissolving

Activity 8.3: Alcohol Evaporation Race

Student Responses:

1. Student responses will vary. Students may find it easier to calculate elapsed time by "counting forward" from the starting time to the finishing time.

2. Student responses will vary. They may have thought of blowing on the a;cohol, fanning it, spreading it out, or stirring it.

3. Students should include the following ideas in their responses: Alcohol molecules in liquid alcohol slide around and bump into each other. Some of the molecules are moving fast enough to escape from the surface of the liquid, thus, the liquid changes to gas. The alcohol molecules mix in with the air.

4. Student answers will vary. They may include any of the methods describe above, and they may also mention heating the alcohol. (Burning the alcohol is not an acceptable answer, as burning destroys the molecules. The chemical reaction for this is:

   $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$)

Question Set 8.4

Student Responses:

1. a. evaporated

   b. Some of the molecules of oobleck would have been moving fast enough to escape the surface of the liquid oobleck. Eventually all of the oobleck molecules would have mixed in with the air.

   c. The air should show at least two different molecules that make up air, with oobleck molecules mixed in.

2. The heat from the sun makes the water molecules move faster. The molecules move around and bump into each other until some of the molecules speed up enough to escape the water droplet. This process continues until liquid water changes to water vapor.

3. Student responses should include the following ideas: In evaporation, individual molecules are escaping from the surface of the liquid into the air where their motion becomes freer and more random. In boiling, molecules move faster at the bottom of a heated container. They eventually move fast enough to change to a gas and group together to form bubbles, which rise to the top and escape. Also, water only boils when it is heated; water does not have to be heated to evaporate.

4. a. molecules of the vinegar; vinegar gas

   b. Faster moving molecules escaped from the surface of the vinegar and spread through the air.

   c. The vinegar molecules that escaped from the liquid mixed in with and spread throughout the air, since molecules are always moving.

Demonstration 9.1: Distilling Dirty Water

Teaching Suggestions:

Make sure that all the students can see the apparatus during the demonstration. Keep students alert to the demonstration by asking questions (such as 'What do you see happening here?") as you go along.

l;Student Responses:

1.

a) A colored liquid bubbling in the flask

b) Nothing (Some condensation is possible but not likely if the flask has been boiling for at least 10 minutes.)

c) Clear or uncolored liquids

2 .

a) Molecules of water, dye and salt

b) Water molecules or molecules of water vapor

c) Water molecules in liquid water

3. No, because only the water made it to the test tube; Water is the only

substance boiling. If the dye or salt had been boiling, some of the molecules of dye or salt would have also made it to the test tube.

4. Students should include the following ideas in their responses:

a) All the substances in the flask are being heated, so the molecules are moving faster. The molecules of water that are moving fast enough so that liquid water changes directly to water vapor on the bottom of the flask and forms bubbles which rise to the top of the mixture and escape.

b) Invisible water vapor must be passing through the glass tubing because water vapor is condensing to liquid water in the test tube. Water vapor is invisible because water molecules are too small to see and they are far apart and moving freely through the tube.

c) The water vapor enters the cold test tube and changes back to liquid water. When the water molecules enter the cold test tube, they are moving rapidly, are far apart, and are moving freely. In the cold test tube, the water molecules begin to slow down and cluster together to form liquid water.

Question Set 9.2: Purifying Water Without Boiling

1. a. Cup A
   b. On the underside of the plastic wrap, especially near the weight
   c. Cup A
   d. All through the container
   e. Cup B and underneath the plastic wrap

2. The amount of water is becoming less or decreasing. The water in Cup A is evaporating or changing from a liquid to a gas. As Cup A is heated, more of the water molecules are moving fast enough to escape the surface and mix with the air.

3. Drops of water. As the fast moving molecules in the water vapor come near the cool plastic wrap, they slow down and the attraction between molecules causes them to cluster together to form droplets of water.

4. The salt and food coloring boil at a much higher temperature than water; they do not evaporate from Cup A.

5. Yes, the water molecules are moving rapidly, are very far apart, and too small to see.

Question Set 9.3: Evaporating and Condensing

Student Responses:

1. a. In the dirty salt water, in the air, in the water droplets on the plastic cover, and in the drinking water

   b. In the salt water

   c. In the air

2. If you look at ocean water with magic eyeglasses, you would see water molecules, salt molecules, and a variety of other kinds of molecules. If you look at the drinking water with magic eyeglasses, you would see only water molecules.

3. a. The hot shower water evaporates, and water molecules mix in with the air. (Hot water evaporates faster than cold water. Even in cold water, some of the molecules are moving fast enough to escape the surface of the water. When the water is heated though, more molecules are moving fast enough to escape the surface of the water drops coming from the shower.)

   b. The humid air spreads throughout the bathroom. The water molecules coming from the shower mix with the other gases in the room and move all through the bathroom.

c. Water droplets collect on the cool surfaces of the bathroom, including the walls and bathroom mirror. As the molecules move throughout the air in the bathroom, they hit cooler surfaces, slow down, and form droplets of water.

3. Bathroom fans move the moist humid air out of the bathroom before the water vapor has a chance to condense. The water molecules that would slow down and form droplets of water on mirrors and walls are blown out of the bathroom before they have a chance to hit cold surfaces, slow down, and form droplets of water.

4. Soap does not get on the bathroom mirror because it does not evaporate and condense as readily as water. The molecules of soap are very large and do not move fast enough to escape the surface of the soapy water.

6. a. Water evaporates from the food, the soup, and your mouth.

   b. The water condenses on the plastic wrap, the pot lid, or in the air.

   c. The water molecules spread throughout the air until they reach something cool enough to make them slow down and condense.

Question Set 9.4: The Water Cycle

Student Responses:

1. Your friend should realize that the water on the outside of the glass came from water vapor in the air which condenses on the outside of the cold glass when the molecules of water slow down and come together to form droplets.

   (Some students think that the water on the outside of the glass has just evaporated from the glass, moved around the glass, and condensed on the outside. They often do not realize that there is always some water vapor in the air that can condense on the glass; it will appear even if the glass has a cover over its top.)

2. Water vapor condenses on cold objects such as the glass because the water molecules slow down and cluster together. The water molecules would not slow down near a hot cup of coffee: The hot cup would actually make them move faster.

3. The water evaporates from the oceans in the form of water vapor which condenses to form clouds. The water molecules, when the water is heated by the sun, move faster which increases the number of molecules moving fast enough to escape from the water's surface into the air.

3\. The air around the grass, which contains invisible water vapor, is cooling down. The water molecules begin to slow down. These slower moving molecules cluster together, forming water droplets directly on the grass.

5. No. If only a few pounds of Oobleck evaporated from Mount Neeka-tave, only a few pounds of Oobleck should condense later.

Question Set 9.5: Explaining Precipitation

1. Complete the chart

   a. 2. Spreading--the water vapor mixes and is carried high up.

   b. 1. Evaporation--Water evaporates from oceans, plants, etc.
   3. Cooling and Condensation--Air cools and water vapor condenses into small droplets of water which we call fog.

   c. 2. Spreading--Water vapor mixes with the air. 3. Cooling and condensing--Air cools and water vapor condenses on the grass and other plants on the surface of the earth (dew).

2. Dew is like fog in that water vapor from the air condenses when it comes in contact with a cool object (grass or the mirror).

3. a. Student drawings in the magic eyeglasses should show different kinds of molecules in ocean water such as water, salt, etc.; and only water molecules inside a cloud droplet.

   b. Ocean water contains a number of different substances including salt and water. A cloud droplet contains almost pure water.

   c. Water evaporates and eventually forms clouds, but ocean salt does not evaporate.

Question Set 9.6: Cluster Review

1.

a. condensing

b. expanding

c. boiling

d. melting

e. dissolving

f. evaporating

g. condensing

2. a. water droplets

b. "Steam is formed when fast moving molecules escape from the water surface to form water vapor and then, when cold, the molecules slow down, move closer together, and form tiny water droplets that we call "steam."

3. Set up a solar still so that the water would evaporate away from the poison, condense on the plastic cover, and drop into a cup. this water is pure enough to drink.

4.

a. When water in the soup is boiled, the water molecules moved fast enough to fly apart, so the water changes directly into water vapor or a gas.

b. The humid air from the boiling water spreads throughout the kitchen. When the bubbles of water vapor come to the surface, the water vapor is mixed with the air and spreads throughout the kitchen.

c. The water vapor in the air condenses on cool surfaces in the kitchen, such as the windows. As the water vapor in the air cools, the water molecules slow down and form droplets.

5. The water in the raindrops has come from the oceans, lakes, rivers, and a little from plants and animals.

6. The faster moving molecules escape the surfaces of rivers, lakes and plants, and mix with the air. As the air rises and is cooled, the water molecules slow down and cluster together in large numbers as clouds. Then, when the clouds gather and the air is cooled further, the water molecules slow down, cluster together into larger droplets and fall as rain.

TEACHER'S GUIDE FOR SCORING
CUMULATIVE TEST FOR LESSON CLUSTERS 1-4

1. Students should say that ice and water are made up of the same kind of molecules, but ice and glass are not.

2. Students should say that the molecules that make up air are so small land so far apart (that is, not clumped together as they are in solids and liquids) that air cannot be seen. This is true for most gases.

3. Students should describe both the arrangement and motions of water molecules in the three states:
ice: molecules are close together, in a rigid pattern, vibrating back and forth
liquid water: molecules are also close together, but not in a
pattern, sliding past each other as they constantly move around
water vapor: molecules are very far apart, constantly moving, sometimes colliding with each other.

4. Sixth grade students should be able to say that molecules are the smallest pieces of a substance, or that molecules are the particles or bits that the substance is made up of. Some students say that molecules are very small things in substances. When they say that, it's not clear what they mean.

5. The important part of a correct answer is that individual molecules are too small to be seen. (The situation is analogous to seeing a beach. We can see the beach even when we are much too far away to see individual grains of sand.)

6. a. Students should talk about molecules in their answer, and not just say that air is compressible. The plunger can be pushed part of the way in because the molecules that make up air are far apart and they can be pushed closer together.

b. The plunger can't be pushed in all the way because the air molecules are pushed closer together, they hit back on the plunger more and more often, until it becomes too hard to push them in any farther.(This is a difficult question, and you may want to use it as an "extra credit" question.)

7. The important part of a correct answer is that there are soup molecules in the air if you can smell the soup. (Of course, soup is a mixture of different substances, and not all of them evaporate into the air, nor are all of them smelly. But if you can smell it, then some smelly molecules have left the soup and mixed in with the air.)

8. Students should say that molecules are always moving. That is why some of them that are mixed in with the air eventually get to your nose. Some students say that the air carries the smell (or the molecules) to your nose. A better explanation includes the idea that the molecules of the smelly substance are always moving.

9. a. The polluted water is a mixture.

b. It is a mixture because it is made up of two or more kinds of molecules, water molecules and the molecules that make up the poisonous or otherwise harmful liquids.

c. Drawings should show water molecules and at least one other kind of molecule.

10. Students should talk about water molecules in their answers. The molecules that make up ice, liquid water, and water vapor are the same--they are all water molecules.

11. Air is a mixture. Students' should say that it is a mixture because it is made of more than one kind of molecule. Whether they list the different components of air (nitrogen, oxygen, carbon dioxide, water vapor, and other substances) or not is important.

12. Humid air has more water vapor in it than air that is not so humid. Another acceptable way of saying this is that humid air has more water molecules mixed in with the other molecules.

TEACHER'S GUIDE FOR SCORING
CUMULATIVE TEST FOR LESSON CLUSTERS 5-9

1.

a. The fog is water--liquid water, in very tiny drops. Some students call it moisture; they may or may not know that moisture is water.

b. It is a liquid. Some students call it "water vapor," but it is not a gas at all.

C. Students' answers should include the following points:

1. water vapor in your breath was cooled by the cold glass
2. the water molecules slowed down
3. and they stuck together to form little drops of liquid water.

Some students will mention that the reason they stick together is that there is an attraction between molecules that holds them together if they are moving slowly enough. Explicitly mentioning attraction is desirable, but not necessary, for an explanation of condensation at the sixth grade level.

2. Students should say that the salt dissolved, not melted, and that the molecules of salt are broken off the salt grains and mix in with the water molecules.

3. The correct response is: b. be a little larger. Students should say that when the steel is heated, its molecules move faster and therefore farther apart, making the steel expand. (Substances: the steel expands when it's heated. Molecules: the molecules of the steel move faster and farther apart.)

4. The important parts of the explanation of melting are that (a) the molecules move faster as the ice is warmed and (b) they eventually move fast enough to break out of the rigid pattern they were in as a solid.(Some students may include a statement about the attraction between molecules, but that is not essential for a sixth-grade version of an explanation of melting.)

The drawing for ice should show water molecules close together and in a pattern. Arrows should indicate that the molecules are vibrating back and forth.

The drawing for water should show molecules close together, but in no particular arrangement. Arrows should indicate that the molecules can move past each other.

5. Students should say that the water level goes down, or that the water evaporates.

The explanation of evaporation is that some of the molecules of the water are moving fast enough so that they can break away from the liquid and mix with the air. As more and more of the molecules leave the liquid,, the water level goes down. (Some students may talk about the attraction between molecules, but this idea probably is not essential in a sixth-grade explanation of evaporation.)

6. Candy dissolves faster in hot water than in cold because the molecules of hot water are moving faster, hit the solid candy more often, and break molecules of candy off of the piece of candy more quickly.

7. A good response should say that molecules of the smelly substance are mixed in with the air when you smell something. Students may say that molecules of the substance are reaching your nose when you smell something; this response is acceptable. Some students fail to mention the substance when they explain smells (by saying something like "molecules in the air reach your nose"), but it is not clear what they think molecules are from this type of response.

7. a. liquid to solid
   b. liquid to gas
   c. liquid to gas
   d. gas to liquid

9. a. Students should explain that water from the salt water container evaporates (or turns into water vapor and goes into the air), hits the plastic cover and condenses (or turns back into liquid water), then runs down the plastic cover and collects in the drinking water container. Students may use a drawing to illustrate this.

8. b. Students should include these steps as they trace the movement of a water molecule:

1. The molecule leaves the surface of the salt water, and mixes with the air (evaporation).
2. The molecule moves through the air until it reaches the plastic cover (spreading).
3. The molecule slows down, and eventually sticks together with other water molecules to form drops on the plastic cover (cooling and condensation).
4. The molecule, as part of the drop, moves with the drop down the plastic cover and into the container.

10.

a. small drops of water

b. The water on the outside of the can was in the air in the form of invisible water vapor.

c. <u>Evaporation</u>: water evaporates from oceans, lakes, plants, animals, etc.

   <u>Spreading</u>: water vapor (or water molecules) mix with the air and move around until they come close to the can.

   <u>Cooling and condensation</u>: the can cools off the water vapor and it condenses (or the can slows down the water molecules and they cluster together).