

Activity II.A. Altered States

PURPOSE Examine the three states in which water exists

FORMAT Classroom demonstration and discussion

BACKGROUND *The Great Salt Lake Story*, text page 29 (Utah Museum of Natural History, 1997)

STAGES Students will . . .

1. Consider ways water is encountered in our lives (discussion);
2. Explore water in its three forms (demonstration);
3. Describe the three states of water (discussion);
4. Verify their understanding of the three states of matter (scrapbook).

MATERIALS

- ✓ student paper and pencils
- ✓ board and marker
- ✓ medium (2–4 quart) metal or glass container of ice cubes
- ✓ hammer and hard, unbreakable surface
- ✓ 4 containers of approximately equal volume but of completely different—even bizarre—shapes, one filled with tap water
- ✓ hot plate with a medium (2–4 quart) pot of boiling water and lid
- ✓ Student Scrapbooks

IN ADVANCE Prepare all containers, ice, tap water, hot plate and boiling water.

PRECAUTIONS Be sure that the hot plate and boiling water are nowhere near students or any student traffic area. A microwave oven or hot water directly from a tap can be substituted, but might provide less impact.

DURATION TBA

SEQUENCE

ENGAGE WATER IN OUR LIVES

1. Riddle: Ask the students to name something that all living things need, that is around us and in us all the time, but that most of us hardly ever think about. Responses should eventually include *water*.
2. With no coaching, have the students brainstorm a class list of all the different ways they will have seen or used water that day.

(Many responses are possible, such as: in the sink, in a water fountain, a beverage, from a sprinkler, on the ground, rain, frost on a window, snow, ice cubes, perspiration, saliva, urine, tears, clouds, steam, etc.)
3. Remind everyone that water is everywhere in our lives and is every bit as important as the air we breath. Do the students recall how much

water there is in Great Salt Lake? (5 trillion gallons, on average). Write the number on the board: 5,000,000,000,000.

EXPLORE THE WAYS OF WATER

1. Remind the students that all the things they listed earlier were forms of water. Inform them that you now want their help in coming up with some scientific descriptions of water. State that you are about to give them a demonstration without words and that they are to watch carefully and quietly. As they watch, they should use their observation skills to write down things about water that they are seeing.
2. Show the class the container filled with ice cubes. Shake the ice cubes to provide the sound of hard rattling. Pick up an ice cube and make a “brrr” sound to demonstrate its coldness. Place a cube on a hard surface and strike it carefully with a hammer to demonstrate its *solid* condition.
3. Next, take the container filled with tap water and pour a small amount onto your fingers, rubbing the water between them. Then, pour the water from the first container into one of a completely different shape, and from there into one of another shape, and from there into one shaped even differently. Pour so that everyone can see the water and hear the sound.
4. Finally, direct the students’ attention to the covered pan of boiling water. (If necessary, remove the pot from the hot plate to bring it within better view of the students.) Carefully lift the lid to allow steam to visibly escape. Imagine you are watching water move as steam travels from inside the pot into the air, and up as a *gas* toward the ceiling.

EXPLAIN THE THREE STATES OF WATER

1. Ask the students to refer to their notes and describe the water they observed in the *first* demonstration. Write the descriptions on the board.
2. Ask the students to refer to their notes and describe the water they observed in the *second* demonstration. Write the descriptions on the board.
3. Ask the students to refer to their notes and describe the water they observed in the *third* demonstration. Write the descriptions on the board.
4. Review and discuss the first list of descriptions. Explain that their descriptions were of water in a frozen state, or what is called a *solid*. We use the word, “ice,” to describe water that has become solid. Discuss other examples of solids.
5. Review and discuss the second list. Explain that their descriptions were of water in a wet or fluid state, or what is called a *liquid*. Discuss

other examples of liquids. Remind the students that nearly every liquid in our lives has water in it. (Some exceptions are alcohol, gasoline and mercury.)

6. After discussing the third list, explain that their descriptions included that of a *gas*. When water “disappears” from a boiling pan of water, from a rain puddle, from our perspiration, and even from our breath, it enters a state called *a gas* (not to be confused with gasoline, a liquid). A gas is usually invisible. Discuss other examples of gasses (such as propane, natural gas and the air we breath). Note that although we cannot see it, air has water in it in the form of a gas. Later we will do some experiments that show this.
7. Explain that everything that exists, including ourselves, is either a solid, a liquid or a gas. Scientists call these three ways that things can be found as the *three states of matter*. What does “state” mean when used in this way?
8. Inform the students that water is the only material on earth that naturally occurs in all three states of matter. We can turn wood into gasses when we burn it, we can turn the same gas of our breath—carbon dioxide—into a solid called “dry ice” if we make it cold enough, and rock will even turn into a liquid we call lava if heated enough. But only water can be found all over the earth as a solid, a liquid and a gas, and always changing from one form to another.

ELABORATE UNDERSTANDING THE THREE STATES OF MATTER

To check for understanding, have the students provide their own written definitions for the three states of water, and provide examples of each state for three other familiar materials. (For example, solids might include a desk, a rock, their own bodies, etc. Liquids could include fluids without water, but any liquid is acceptable. Gasses could include propane, natural gas, the air, etc.)

Have each student accompany the descriptions with pictures, and enter this summary in the scrapbook.

Activity II.B. Going Through A Phase

PURPOSE Demonstrate changes between the three states of water as phase changes that occur all the time.

FORMAT In-class or at-home experiments, demonstrations and discussions

BACKGROUND *The Great Salt Lake Story*, text page 29 (Utah Museum of Natural History, 1997)

STAGES Students will . . .

1. Consider familiar phase changes of water (discussion);
2. Work in teams to design and conduct phase change experiments (classroom and at-home sessions);
3. Report results and interpretations of their research (team presentations);
4. Verify their understanding of phase changes in water (scrapbook).

MATERIALS ✓ student paper and pencils
✓ board and marker
✓ various containers, graduated cylinders or other measurement devices
✓ Student Scrapbooks

IN ADVANCE Prepare materials to loan to students.

DURATION TBA

SEQUENCE

ENGAGE INTERSTATE TRAVEL

1. Remind the students about previous activities involving the three states of water. Then, have them consider other things they probably know about water through a brief series of questions, such as the following:
Where does ice come from?
What happens when ice melts?
What is a cloud?
What do clouds sometime do to the ground below?
What do we mean when we say “it’s humid”?
Where does a puddle go when it disappears from the ground?
Where does the water come from that forms on the side of a glass filled with a cold drink?

All answers are acceptable at this point.

2. Instruct the students to hold a hand close to their mouths and force a breath out. What do they feel? If they did this onto a mirror, what would they see? (Moisture, or water from their breath changing from a gas to a liquid.)
3. Suggest to the students that this means, then, that not only is water found in three forms—solid, liquid and gas—but that somewhere it is also always changing from one form to another. Each of the three states of water are also called a *phase*. So, when water changes from one state to another, it can be called a *phase change*.
Phase changes are happening right now, all over the world. Ask the students if they can see or think of another example of a phase change going on right now in the classroom or around the school.
4. Inform the students that they are going to be designing and conducting experiments in phase changes.

EXPLORE PHASE CHANGE EXPERIMENTS

Different teams of students are to design one of the experiments described below, as follows:

1. Preview the entire experimental procedure to the class. Organize the students in teams of two, each assigned one of the four experiments.
2. Have each team meet in class to formulate a draft plan for completing their assignment. Provide them with a worksheet or board checklist to help guide the planning. One team member should be the note-taker during team planning and the other should be ready to present the plan for review.
3. Facilitate the previews and discussions of team plans. To avoid repetition, group reviews that are from teams having been assigned the same research topic: after hearing from one team, ask for

alternatives and suggestions from all other teams that will be conducting the same experiment. Be sure to give all teams opportunity to participate, and try to guide the teams toward consensus. It is conceivable, however, that different teams will decide to research the same problem in different ways.

4. For clarification, review the research plan with each team (or each group of teams). Ask the students if they are uncertain about any procedures and clarify any misunderstandings. Be sure that each team writes up a new step-by-step plan. The plan should also include what visual aid materials they will need to bring to class for their presentation.

Give teams a weekend, or 24 to 48 hours to complete their experiment and compile their report.

Student Research Topics And Guidelines:

Select a written or oral method of describing the following experiments to the students. It is acceptable but not necessary at this time for all students to know all four experimental topics, since they will be exposed to each of them during the presentations that will follow.

The “Research Pathways” section following each of the descriptions below are intended as teacher information, but could be used as prompts to assist students having difficulty with designing their research.

A. *Change water from a liquid state to a solid state.*

What do you have to do with water to change it to a solid? What do you call it when water changes this way? Will there be a difference between the amount of space that water takes up as liquid compared to when it becomes a solid? Design an experiment that accurately measures any differences. Discuss your plan with the rest of the class. After coming up with a final research plan, conduct your experiment and report back to the class. Your report should include what you did, what you used, what you measured, what happened, and why you think it happened.

RESEARCH PATHWAYS: Students will be demonstrating and describing the effects of lowering water temperature to “freezing” as the means to make water solid. This will necessarily require temperatures below 32° F for an extended period. Non-breakable, vertical containers might be precisely marked to compare water level before and after freezing. If the container has truly vertical sides, students might also calculate a fraction to describe the change in space taken up (volume) between the two phases.

B. *Change water from a solid state to a liquid state.*

What do you have to do with water to change it from a solid to a liquid? What do you call it when water changes this way? Compare the amount of space that water took up as a solid with the space it

takes up as a liquid. How will you accurately measure any change? What do you predict will happen? Discuss your plan with the rest of the class. After coming up with a final research plan, conduct your experiment and report back to the class. Your report should include what you did, what you used, what you measured, what happened, and why you think it happened.

RESEARCH PATHWAYS: Students will be demonstrating and describing an increase in water temperature to “thaw” or “melt” as the process by which to transform water from a solid to a liquid. In order to compare the space (volume) needed by water as a solid (ice) to that of a resulting liquid, these students might freeze a measured quantity of water in a vertical measure (such as a graduated cylinder), and precisely record the difference after melting occurs. With a container having truly vertical sides, students might also calculate a fraction to describe the change in space taken up (volume) between the two phases. Because this experiment will likely involve a process similar to experiment A, it will provide an opportunity to compare methods and results of the two groups.

C. *Change water from a liquid state to a gas state.*

What do you call it when water changes from a liquid to a gas? Design an experiment that causes this. Predict what change might take place and decide how to measure this change. Discuss your plan with the rest of the class. After coming up with the final research plan, conduct your experiment and report back to the class. Your report should include what you did, what you used, what you measured, what happened, and why you think it happened.

RESEARCH PATHWAYS: Students will be demonstrating and describing “evaporation” as the process by which to transform water from a liquid to a gas. They might use a heat source such as a microwave oven or other appliance, but would be just as successful using ambient temperatures. It is important that they precisely measure and record quantities before and after evaporation takes place.

D. *Change water from a gas state to a liquid state.*

What do you call it when water changes from a gas to a liquid? How can you demonstrate this change? Is there something you can measure during your experiment? Discuss your plan with the rest of the class. Discuss your plan with the rest of the class. After coming up with a final research plan, conduct your experiment and report back to the class. Your report should include what you did, what you used, what you measured, what happened, and why you think it happened.

RESEARCH PATHWAYS: Students will be demonstrating and describing “condensation” as the process by which to transform water from a gas to a liquid state. Although they have been exposed countless times to this transformation, students might have difficulty with recognizing this concept. As with all four experiments, it is important that the

students arrive at experimental methods on their own. If necessary, you might prompt student thinking by having them consider times that they have seen water “just appear out of thin air” (in the kitchen or bathroom, outdoors, within a closed container or even on the sides of a glass), and use such familiar experiences to generate an approach. These students could use a heat source such as a microwave oven or other appliance, but would be just as successful using ambient temperatures. Depending on the method chosen, a measure of the water condensed by the experiment might be made.

Notes: As an alternative, you may choose to have students conduct these studies in class under your supervision. Both experiments A and B will require the use of a freezer or outdoor conditions below 32° F. None of the experiments require heating appliances for successful completion. For safety, we advise that you exclude the use of any such equipment from the students’ plan, unless they will be carefully supervised by you or another adult.

EXPLAIN OUTCOMES OF STUDENT RESEARCH IN PHASE CHANGES

1. Have the teams present their results according to your presentation guidelines. Group team presentations according to the assigned topic. Set the tone for formal presentations, such as from scientists sharing results with professional colleagues.
2. For each topic, compare and contrast the teams’ methods and outcomes. Help the students explain the meaning of their results, what worked or did not work, and what they might do differently if they were to conduct the study again. Point out any important deficiencies in research practice and process, and encourage perseverance.
3. Help clarify the meaning of each experiment during and as a conclusion to the presentations. Below are some important points to make and new vocabulary to introduce.

Water changing from a liquid to a solid state

Water is one of the few substances that expands measurably upon becoming a solid, or what we sometimes call “freezing.” This can result in some impressive changes, such as uplifted sidewalks or split water pipes. This force is also a factor in transforming rock into soil over time. Have the students provide theories as to why water takes up more space when it becomes a solid. Why does ice float?

Water changing from a solid to a liquid state

Water in liquid form takes up less space than the same amount of water in solid form. When we say “thawing” or “melting,” we are describing water changing from a solid to a liquid state. This happens every spring when snow in the mountains becomes liquid. Where does it go? Much of it flows downhill into streams and rivers. Great Salt Lake gets most of its water this way. When it sinks down through the ground it is called *percolation*.

Water changing from a liquid to a gas state.

Water can seem to “disappear” into the air, especially when the water and air are warm. We call this *evaporation*. Evaporation means water is changing from a liquid state into a gas state. This is happening whenever we dry off in the sun after swimming, when we dry our clothes, or when a puddle disappears. This also happens all the time at Great Salt Lake. On just one summer day, millions of gallons of water evaporate from Great Salt Lake. Where does it go?

Water changing from a gas to a liquid state.

Water is a gas in the air all the time. Warm air can hold more water as a gas than cool air can. When air cools it cannot hold as much water gas as it could before and we usually see something called *condensation*. Why do we see sometimes condensation on our mirrors or windows? What has happened? When we can see things like steam or fog or clouds, these are not water as a gas (remember, a gas is invisible). When water forms visibly in the air it is called *water vapor*—tiny droplets of suspended water in a liquid state. When water condenses into clouds and then falls as rain or snow, it is called *precipitation*.

4. Explain that not only can water exist in the three states, but it is changing between the solid, liquid and gas phases all the time. Review some examples of such phase changes going on in the world right now. Be sure to remind the students that a *change in temperature* is what usually causes water to transform from one phase to another, just as their experiments have shown.
5. Review the terms *freezing, melting, percolation, evaporation, condensation* and *precipitation* by asking students to describe these changes and give examples, or use each word in a sentence.

ELABORATE UNDERSTANDING PHASES CHANGES OF WATER

Have the students write a paragraph and use pictures in their scrapbooks to explain in their own way the above processes and relationships between them. They should use words and show concepts such as *freezing, melting, percolation, evaporation, condensation, and precipitation*, as well as *solid, liquid* and *gas*.

EVALUATE REVIEW STUDENT SCRAPBOOKS

Activity II.C. Disappearing Water

(Based upon *The Great Salt Lake Story*, Utah Museum of Natural History, 1997.)

PURPOSE Describe evaporation and the effects of surface area, wind & heat

FORMAT Classroom demonstrations and discussions

BACKGROUND *The Great Salt Lake Story*, text page 29 and activity #9, “Changing States,” pg. 31 (Utah Museum of Natural History, 1997)

STAGES Students will . . .

1. Review their current understanding of evaporation as it affects Great Salt Lake (discussion);
2. Suggest possible differences in evaporation rates between lakes of various width and depth, and as influenced by temperature and wind (discussion);
3. Consider the experimental design necessary to compare evaporation rates between lakes described above (discussion);
4. Discover differences in evaporation rates between simulated lakes with and without the affects of wind and heat (demonstrations);
5. Graph and interpret data from their observations (discussion);
6. Examine the independent affects of wind and heat on evaporation (demonstration, graphing);
7. Draw conclusions about important variables affecting evaporation from different kinds of lakes (graphing assignment);
8. Verify understanding of evaporation (scrapbook activity).

MATERIALS ✓ 3 containers of nearly the same volume (400 ml recommended):

- jar or bowl with straight sides and a 3–5 in. surface area
- bowl with more gentle sides and a 6–10 in. surface area
- shallow platter or pan with a 12–20 in. surface area

The containers should approximately double in surface area, in progression from smallest to largest. To avoid introducing unwanted variables, they should be of the same color and made of the same material (such as glass or plastic).

- ✓ dark material to place beneath containers (for clear glass only)
- ✓ 3 reflector floodlights with clamp and 150W bulbs
- ✓ mounting stage for clamp lights (optional)
- ✓ oscillating electric fan or large floor fan
- ✓ yardstick, meter stick or tape measure
- ✓ 500 ml graduated cylinder (or measuring cup)
- ✓ a pitcher of water at room temperature
- ✓ a bucket for water disposal (optional)
- ✓ copies of student worksheet II.C.1. (or graph paper) and pencils
- ✓ copies of student worksheet II.C.2. (or graph paper) and pencils
- ✓ Student Scrapbooks

IN ADVANCE Gather materials

Set up a suitable demonstration area with specified equipment

DURATION TBA

SEQUENCE, PART ONE

ENGAGE INTO THIN AIR

1. Remind the students that millions of gallons of water are flowing into Great Salt Lake today and every day of the year, twenty-four hours a day. Even during times when the lake is getting smaller, there are still millions of gallons of water flowing into it. Where is all the water going?

Remind students of what they have learned from their experiments with the three states of water. Remind them, too, that Great Salt Lake is a *terminal lake*, meaning there is no stream flowing out of it. Furthermore, because of solid rock and dense layers of salt at the bottom, hardly any water *percolates* underground.

This brief discussion should lead to the students recalling that water is constantly *evaporating* from the lake. (In fact, an average of 2.6 billion gallons every 24 hours, or more than 108 million gallons per hour!) Review the term, *evaporation*.

EXPLORE DO ALL LAKES EVAPORATE EQUALLY?

1. Describe the following scenario using profile sketches you have made on the board: There are three lakes side by side. Let's say one is a mile across and 100 feet deep. The second is only about half as wide but nearly twice as deep. The third is only about half as deep but nearly twice as wide. They each have exactly the same amount of water.

Is the same amount of water evaporating from each lake? If so, why? If not, which lake loses the most water from evaporation each day, and why? (Leave the lake sketches on the board for later reference.)

2. Describe this second scenario, using a new set of profile sketches: There are three lakes all the same size and with the same amount of water, but in three different places. The first lake is surrounded by forest in a cool mountain climate. The second lake is in a hot, windy desert. The third lake is in a cool climate in an open area with lots of strong winds.

Will the same amount of water evaporate from each lake? If so, why? If not, which lake loses the most water from evaporation each day, and why?

3. After receiving student feedback, ask the students what scientific experiments they could do to test their hypotheses.
4. To add relevance to the experiments, ask the students to suggest which of the lakes in these two examples most resemble Great Salt Lake. (The wider lake and the hot, windy lake, in the first and second scenarios, respectively, most resemble Great Salt Lake.)

Thus, the results of the classroom experiments should also provide clues about how evaporation at Great Salt Lake compares with that at other kinds of lakes.

EXPLAIN EXPERIMENTAL DESIGN FOR EVAPORATION

Involve the students in developing a strategy for experiments to simulate some of those different kinds of lakes in the classroom. To find out which kinds of lakes evaporate the most water, they will need to explore what effect the differences between them have, if any, on evaporation. Factors such as surface area, wind and temperature will need to be involved.

1. Discuss the similarities and differences (*variables*) between the lakes in each of the two scenarios described earlier. Have students confirm that the first scenario describes differences in lake *depth* and *surface* size, but not *amount* (volume). The second scenario describes differences in *temperature* and *wind* (air movement), but not *amount* (volume).

The experiments, therefore, should be designed to test the effects of these variables upon evaporation, using the amount of water (volume) as a constant.

2. Have students gather around the jar, bowl and platter lined up to represent lakes in the demonstration area. Briefly describe the equipment to be used and the procedure to be followed.
3. Discuss with the students the factors that should *not* be different between the lakes for this experiment. For example, you would not want the amount of heat or wind supplied to one lake to differ from that supplied to the others. Nor would the experiment be *valid* if one of the “lakes” was already at a higher or lower temperature than the rest when the study began. Explain that these factors are called *variables*, meaning conditions that vary between the items being tested. An experiment is not valid unless all variables are controlled except the one you wish to test.

Before you begin, have one or more students summarize for the class those variables the experiment *is* about to test.

EXPLORE EVAPORATION DEMONSTRATION ONE: WITH WIND AND HEAT

Employ several student volunteers to assist with the following procedure. For convenience and consistency, instruct them to measure and record data in the same sequence each time, from the most narrow container to the widest.

1. Pour equal amounts of room-temperature water into the three “lakes.” Measure the diameter of the water surface of each “lake.” Each student should record the volume and surface measurements.
2. Position the flood lights close to each container so that light shines on each. Turn the lights on. All three containers should be receiving the same amount of “heat.”

3. Place the fan so that all three containers receive the same amount of “wind.” Turn the fan on.
4. After five minutes, turn off the “heat” and “wind.” Re-measure the volume of water in each container one at a time by carefully pouring, without spilling, into the graduated cylinder. After each measure, carefully return the water to its container. Record the results.
5. Turn on the fan and lights and repeat the above sequence twice, for a total test time of fifteen minutes.

Note: During each of the three five-minute test periods, you might wish to occupy the wait time by distributing and reviewing Worksheet II.C.1. (or graph paper with instructions for preparing axes and labels), and to document the steps being taken for the experiment.

EVAPORATION DEMONSTRATION TWO: WITH NO WIND OR HEAT

Repeat the experiment as above, but without “wind” and “heat.” Record the amounts of water left in the containers during this test sequence, again totaling fifteen minutes.

EXPLAIN SURFACE AREA, HEAT AND WIND, AND EVAPORATION RATE

1. Direct the students in preparing graphs showing the results under the two test conditions, *with heat and wind* and *without heat and wind*. Titles such as these should be added to their worksheets.
2. Discuss the results. Ask the students if they see any pattern to their graphed data, and possible reasons for the outcomes.

Which “lake” had the greatest total evaporation? Why?
(The platter, because it had the greatest surface area.)

What difference was there in evaporation rates when the experiment was repeated without the “heat” and “wind”? Why?
(Evaporation rate is increased by higher temperatures and moving air.)

NOTE You can make the seemingly small quantities of these experiments more meaningful and dramatic by helping the students apply a scale relative to Great Salt Lake. Calculate how many gallons each milliliter represents in the demonstrations by dividing the total quantity into 5 trillion (the number of gallons of water in Great Salt Lake, on average).

For example, $5,000,000,000,000 \div 400 \text{ ml} = 12,500,000,000$.

Thus, converted to the scale of Great Salt Lake, each milliliter of water evaporated from a “lake” starting with a volume of 400 ml is equivalent to 12.5 billion gallons! This insight can make the differences between the three “lakes” quite impressive.

ELABORATE WHAT HAVE WE LEARNED SO FAR?

Review the three-lake scenarios sketched and discussed earlier. Discuss with the students which of the original questions about lakes and evaporation have now been answered.

The students should now realize that of the lakes in the first scenario, the lake that is wide and shallow would have the greatest amount of evaporation. They should also know that of the lakes in the second scenario, the one in the cool mountain climate with little wind would lose the least amount through evaporation.

However, we do not necessarily know which of the other two lakes in the second scenario wins the evaporation prize. To know this, an experiment would have to be conducted that considers the difference in evaporation between the lake subjected to wind and the one subjected to both wind and heat. This way, the possibility that it is wind alone that causes the increased evaporation and that heat makes no difference can be confirmed or eliminated. The following sequence describes such an experiment.

SEQUENCE, PART TWO

ENGAGE THE REST OF THE STORY

1. Ask the students to review what discoveries they recall having made so far about factors that influence the rate and amount of evaporation from lakes such as Great Salt Lake.
(Surface area, and heat combined with moving air.)
2. Ask if they recall the piece of information that is still missing from their experimentation. (They still have not determined what separate effects either heat or moving air might have on lake evaporation.)

EXPLORE EVAPORATION DEMONSTRATION THREE: WITH WIND BUT NO HEAT

Conduct the three-lake experiment as before, but with only “wind.” Record all volume data during this test sequence, again totaling fifteen minutes.

(If there is time and interest, you could conduct a fourth experiment, with heat but not wind. This would provide still another data series to compare. However, since we are most interested in verifying the influence of both heat and wind on evaporation, but not necessarily quantifying differences between the two, it is sufficient to confirm that heat and wind each have an independent effect on the rate of evaporation.)

EXPLAIN INDEPENDENT EFFECTS OF WIND AND HEAT ON EVAPORATION

1. Direct the students in preparing a new graph to compare results between the three “lakes” under the test conditions of *wind with no heat*.
2. Discuss the results. Ask the students if they see any pattern to their graphed data, and possible reasons for the outcomes.
Which “lake” had the greatest total evaporation? Why?
(The platter again, because it had the greatest surface area.)
3. Now compare all three graphs that have been made. Ask the students to summarize the evidence they now have about the various effects upon evaporation. The summaries should confirm the following:
 - a. Water with a greater surface area will lose more water to evaporation than other lakes of the same volume and temperature.
 - b. Increased surface area, heat, or moving air will each increase the evaporation of water.
 - c. Evaporation rate is increased both by increased temperature and by moving air.
 - d. A larger surface area, combined with increased heat and moving air will cause the greatest evaporation.

(Note: In the interest of accuracy, you should be cautious when summarizing these conclusions by distinguishing *rate* of evaporation from

amount of evaporation, whether or not you choose to actually engage students in such a discussion. A greater surface area causes water to evaporate at a *rate* no different than any other water under the same conditions of temperature and wind. That is, water will escape through evaporation at a given rate per square inch of surface regardless of how much surface exists. However, a larger surface area will exhibit a greater *amount* of total evaporation, because it has more total square inches evaporating at one time.)

ELABORATE EVAPORATION INSPIRATION

1. Assign each student to one of the three “lakes” with the following instructions involving graphing and graph interpretation. Worksheet II.C.2. is supplied for this purpose.
 - a. Make a graph of one of the container “lakes” to show how that one lake was affected in each of the three experiments. The graph for this lake should include the effects of heat and wind from experiment 1, effects with no heat and wind from experiment 2, and effects of wind alone from experiment 3.
 - b. Using your finished graph, describe three things that it shows you about lakes and evaporation.
2. Review the assignment with the students. Go over several examples of student graphs for each of the three lake types. Discuss student interpretations, and note various examples of style and accuracy demonstrated by students. Examine differences between these individual lake graphs and the earlier graphs that compared the evaporation of all three “lakes” at once.

EVALUATE SCRAPBOOKS ASSIGNMENT

Instruct the students to use their scrapbooks to demonstrate what they have learned about evaporation as follows:

1. Organize all notes, graphs and other materials prepared during class discoveries about evaporation.
2. Draw a picture of Great Salt Lake. Label it with some words that describe the kind of lake it is. Then, write a story about the kind of lake Great Salt Lake is and its features that cause water to evaporate as much as it does.

Activity II.D. What A Difference “Na” Makes

PURPOSE Investigate water chemistry of Great Salt Lake
Describe salinity and its effects on evaporation

FORMAT In-class demonstration and discussion

BACKGROUND *The Great Salt Lake Story*, text page 29 and 31 (Utah Museum of Natural History, 1997)

STAGES Students will . . .

1. Examine reasons for Great Salt Lake’s salinity (map activity);
2. Explore evidence and reasons for variation in salinity between different regions of Great Salt Lake (discussion, activity);
3. Consider the effects of salt on evaporation rate (demonstration);
4. Interpret the results of an evaporation experiment (graphing);
5. Verify their understanding of factors that both affect evaporation in Great Salt Lake and cause parts of Great Salt Lake to differ in salinity (scrapbook).

MATERIALS ✓ Part One: classroom map of Utah

MATERIALS ✓ student maps of Great Salt Lake
Part Two ✓ classroom map of Great Salt Lake

MATERIALS ✓ copies of student worksheet II.D (or graph paper) and pencils
Part Three ✓ 2 identical shallow platters or pans with a 12–20 in. surface area (such as used in the previous activity)
✓ Approximately 100 g (3–4 oz.) table salt
✓ water at room temperature
✓ 500 ml graduated cylinder or measuring cup
✓ 2 reflector floodlights with clamps and 150W bulbs
✓ mounting stage for clamp lights (optional)
✓ oscillating electric fan or large floor fan
✓ Student Scrapbooks

IN ADVANCE Gather materials.
For Part Two, dissolve 125 g (3–4 oz.) table salt in 500 ml water and set up a suitable demonstration area with specified equipment.

DURATION TBA

SEQUENCE, PART ONE**ENGAGE THE SALT OF GREAT SALT LAKE**

1. Remind the students that almost everyone knows that Great Salt Lake is salty, but what does that mean? What do we mean when we describe the lake as “salty?” (Responses might include the sense of taste, or simply that salts are dissolved in the water.)
2. Suggest to the students that since we’ve learned so much about water, it is time to think more about the water in Great Salt Lake.

[It is possible that your students have already learned the causes of salinity in Great Salt Lake from an earlier discussion, such as during the presentation of “The Lake Affect.” If so, you should merely use this opportunity for a brief review, and move directly to Part Two below.]

EXPLORE WHY THE SALT?

1. Ask a student to locate Utah Lake (or substitute another locally familiar freshwater lake) on the classroom map of Utah. Then have the student remind the class where Great Salt Lake is located by identifying it on the map.
2. Ask the other students whether water in Utah Lake (or the substitute lake) is fresh or salty. Be sure all students understand that this lake contains fresh water.
3. Ask the students to consider *why* Great Salt Lake is salty. Where does the salt come from? Point out that there are many other ponds and lakes in Utah, and most of them are not salty at all. What is different between Great Salt Lake and other lakes that explains the salt? Consider and discuss various responses.
4. Ask a student to identify on the map where most of the water in Utah Lake (or the substitute) comes from. (It is from the lake’s primary tributary, such as the Provo River flowing into Utah Lake.) Next, instruct the student to trace the flow of water from several miles upstream back down into the lake.
5. Ask the class to describe at least three ways that water can then leave Utah Lake (or the substitute). Answers should include *evaporation*, *percolation*, and an *outlet* stream, such as the Jordan River flowing north out of Utah Lake. (Removal for agriculture or other uses might also be included.)
6. Next, ask the students where Great Salt Lake gets its water. Answers should include *precipitation* directly into the lake, and stream flow, mostly from the three major rivers. Instruct a student to locate these three rivers on the map. Ask other students to give the names of these three rivers (The Bear, Weber and Jordan Rivers).
7. Ask whether someone can identify where water flows out of Great Salt Lake. (It is not possible, because Great Salt Lake has not outlet.)

8. What might this difference between Great Salt Lake and most other lakes tell us about the cause of Great Salt Lakes saltiness? Accept and briefly discuss several explanations from students.

EXPLAIN EASY IN, NO WAY OUT

1. Inform the students that when water contains one or more kinds of salt, we say that it is *saline*. When we talk about water's saltiness, we refer to its *salinity*.
2. Explain that as water from rain or melting snow percolates into the ground or flows across the land it is picking up and dissolving minute particles of chemicals from the rocks and soil. Many of these chemicals are different kinds of "salts." Our drinking water contains many of these chemicals, but they are in such small amounts we usually cannot taste them.

Rivers flowing into Great Salt Lake have been bringing small amounts of dissolved chemicals to the lake in this way for thousands and thousands of years. Because Great Salt Lake is a *terminal lake*—it has no outlet stream—the chemicals can never get out again. While, as the students have already learned, the lake's water is constantly leaving by evaporation, all chemicals in the water must stay behind, accumulating day by day.

Lakes such as Utah Lake can't build up chemicals in their water like Great Salt Lake because they have an outlet. Chemicals are always leaving the lake about as fast as they come in.

ELABORATE UNDERSTANDING THE CAUSES OF SALINITY

Confirm student understanding of lake salinity by conducting a discussion of, or having students write responses to, the following:

1. How can what we have learned about salinity help to explain why the oceans are salty?

[Oceans are the "end of the line" for all rivers flowing into them. Just as chemicals carried by water into Great Salt Lake are left behind as water continues to evaporate, so the chemicals brought into the oceans from all parts of the world have no place to go.

Oceans remain less saline than Great Salt Lake, however, because of their huge size and volume, and because many chemicals are being taken up by lifeforms within the vast ocean system.]

2. How could you prove by experiment that chemicals brought into Great Salt Lake cannot escape through evaporation the way water can?

[An experiment could be described in which chemicals are added to water and the water is caused to evaporate, leaving the chemicals behind.]

SEQUENCE, PART TWO

ENGAGE HOW SALTY IS GREAT SALT LAKE?

1. Ask the students if, in addition to now knowing *why* Great Salt Lake is salty, do they know *how salty* it is? Ask if any students recall this information from the earlier presentation of “The Lake Affect.” All responses are acceptable at this point.
2. Ask the students whether they would consider Great Salt Lake as being *uniform* in its salinity (the same all over) or *diversified* (having different amounts throughout). All responses are acceptable at this point.

EXPLORE A DIVERSITY OF SALT

1. Remind the students that Great Salt Lake has species of plants and animals living there that do just fine with salt in their soil, water or food, and some even *specialize* in salty living. Ask if students recall from the presentation or already know about any of these species. (Some examples are: certain species of bacteria and algae, pickleweed, saltgrass, brine shrimp, brine flies, and eared grebes.)
2. Remind the students that some other plants and animals at Great Salt Lake don’t mind *some* salt. Ask if students recall from the presentation or already know some examples of these species. (This group might include other species of bacteria and algae, inkweed, iodine bush, greasewood, shadscale, alkali dropseed, four-winged saltbush, certain insects, some fish, phalaropes, gulls, white pelican, burrowing owl, badger, coyote, fox, and meadow vole.)
3. Then, remind the students that there are still other species that don’t get along with salt much at all, but still make a good living at Great Salt Lake. Ask if students can name any of these species. (Some of these are: freshwater algae, cattails, mosquitoes, dragonflies, leopard frogs, turtles, snakes, yellow-headed blackbird, great blue heron, northern harrier, bald eagles, muskrat, and mink.)
4. How can this be? How can a place called Great Salt Lake provide homes for all these kinds of plants and animals?
5. Explain to the students that they are going to use their Great Salt Lake maps to add some of this information. Instruct the students to take out their personal maps of Great Salt Lake. Have the classroom map available as well.

EXPLAIN LAKE SALINITIES

1. Instruct the students to look at their maps. Discuss the variety of clues the maps give about which areas in Great Salt Lake Ecosystem are most saline, which parts are less saline, and which parts are likely to contain little or no salt.

2. As needed, clarify that places farther away and higher than the lake shores become less and less saline. Rivers carry fresh water into the lake, mixing with the salt water and making it *diluted*, or less saline. As pointed out in “The Lake Affect” presentation, almost all water flowing into Great Salt Lake remains in Bear River Bay, Farmington Bay and Gilbert Bay. The railroad causeway severely restricts freshwater from entering Gunnison Bay, so it is the most saline part of the lake.
3. Ask the students how we usually describe salinity (how salty the water is). Discuss percentage as the way to talk about salinity. Provide the students with salinity data for the major lake regions.

Bear River Bay: 3–6% (This part of the lake is the least saline)

Farmington Bay: 3–6%

Gilbert Bay: 8–10% (although it has been as high as 15%)

Gunnison Bay: 25–27%

Have the students write the percentages on the appropriate parts of their map.

4. Ask the students to suggest why the salinity of the lake changes over time.

Explain as needed that the amount of fresh water flowing into the lake varies from year to year, and from season to season within a year. It might be worth noting that before the railroad causeway was completed in 1959, Gunnison Bay and Gilbert Bay mixed freely and averaged 18–20%.)

Find out what trend Great Salt Lake is now in and report it to the class.

WRAP UP ADD INFORMATION TO THE CLASSROOM MURAL

SEQUENCE, PART THREE**ENGAGE WHAT ABOUT THAT SALT?**

1. Review with the students their discoveries made so far about factors that influence evaporation. Discuss these factors in terms of Great Salt Lake. Inform the students that there is still something else about Great Salt Lake that has not been considered, and that it is a factor that might also influence the rate of evaporation. Ask the students to speculate what that factor might be.
(Hints: It is something that makes the lake famous. It is part of the lake's very name.)

2. Suggest to the students that chemicals dissolved in water might make a difference in evaporation. Salt is a chemical, and there is surely a lot of that in Great Salt Lake. Thinking about the kinds of research we all did earlier, what kind of experiment can we perform to find out whether salt affects evaporation?

(The students should see that an experimental procedure similar to the last activity would be a useful way to perform this new test.)

EXPLORE HOW DOES SALT AFFECT EVAPORATION RATE?

1. Have the students gather around the two platters representing lakes in the demonstration area. Before beginning the experiment, re-emphasize the importance of controlling variables. Ask students to restate the controls needed in this experiment to make it valid.
(This review should affirm that salinity is the variable to be tested. Volume, surface area, and temperature are three variables that should not exist in this experiment.)

2. Explain that you have prepared two equal volumes of water, one of fresh water and one containing about as much salt as Gilbert Bay in Great Salt Lake.

3. Employ several student volunteers to assist with the following procedure:
 - a. Pour room-temperature tap water into the first "lake." Pour the premixed room temperature salt water into the second "lake."
 - b. Position the flood lights close to and above each container. Turn the lights on. Both containers should be receiving the same amount of "heat."
 - c. Place the fan close to the containers so that each container will receive the same amount of "wind." Turn the fan on.
 - d. After five minutes, turn off the "heat" and "wind." Re-measure the volume of water in each container one at a time by carefully pouring, without spilling, into the graduated cylinder. After each measure, carefully return the water to its container. Record the results.

- e. Turn on the fan and lights and repeat the above sequence twice, for a total test time of fifteen minutes.

Note: During each of the three five-minute test periods, you might wish to occupy the wait time by distributing Worksheet II.D. (or graph paper with instructions for preparing axes and labels), and to document the steps taken for the experiment.

EXPLAIN SALINITY AND EVAPORATION RATE

1. Guide the students in preparing graphs showing the results.
2. Discuss the results. Ask the students what pattern they see to their graphed data, and possible reasons for the outcomes.

Which “lake” had the least total evaporation? Why?

(The one with salt water, evidently because salt water evaporates at a slower rate than fresh water.)

3. Ask the students to consider what other factors might have caused the difference.

(As long other variables were controlled— surface area/identical containers, amounts of added wind and heat, initial temperature and volume—the only variable remaining was the one being tested: salinity.)

Explain to the students that careful researchers always analyze what might have gone wrong with an experiment, and not just “what worked.” Ask the students, for example: what would have been the problem if this experiment was conducted with containers of two different sizes or even different colors? Could any conclusions be drawn?

ELABORATE SCRAPBOOK ASSIGNMENT

Referring to their maps, have each student provide written answers to the following questions:

1. What are four factors that affect evaporation at Great Salt Lake? (surface area, temperature, wind, salinity)
2. Which sections of Great Salt Lake evaporate the greatest amount in a day? Why? (Bear River Bay and Farmington Bay, because they have the lowest salinity.)
3. Which section of Great Salt Lake usually evaporates the least amount in an hour? Why? (Gunnison Bay, because it has the highest salinity.)

EVALUATE PERIODIC REVIEW OF STUDENT SCRAPBOOKS

Activity II.E. All Mixed Up

(Adapted from *The Great Salt Lake Story*, Utah Museum of Natural History, 1997)

PURPOSE Determine the relationship between temperature and solubility

FORMAT Classroom lab with groups of four

BACKGROUND *The Great Salt Lake Story*, text page 29 and 33; and Activity #10, "Solutions, Solutions," pg. 33 (Utah Museum of Natural History, 1997)

STAGES Students will . . .

1. Consider the variety of familiar liquids containing water (discussion);
2. Observe differences between the way two solids mix in water (demonstration);
3. Learn important terms pertaining to mixtures involving water
4. Explore factors that affect experimental design and accuracy
5. Explore the affects of temperature on solubility (team experiments);
6. Graph and interpret data from temperature-solubility experiments (discussion);
7. Verify understanding of water mixtures and related terminology (scrapbook assignment).

MATERIALS ✓ 2 clear cups containing equal amounts of water, room temperature
Part One ✓ teaspoon
 ✓ table salt
 ✓ flour
 ✓ spoon or stir stick

MATERIALS For each group:
Part Two ✓ paper and pencil
 ✓ copies of worksheet II.E. (or graph paper)
 ✓ 1 clear plastic cup (8 oz. or larger)
 ✓ measuring cup
 ✓ teaspoon
 ✓ Epsom salts (or magnesium sulfate)
 ✓ spoon or stir stick
 ✓ hot water, room temperature water, or cold water
 ✓ thermometer
 ✓ Student Scrapbooks

IN ADVANCE Gather and prepare materials for each experiment

DURATION TBA

SEQUENCE, PART ONE**ENGAGE A SUPER SOLVENT**

1. Create a list with the students of what they had to drink in the past twenty-four hours. Review the list and have students suggest what was contained in the various beverages. Make particular note of how many beverages contain water as a main ingredient.
2. Have the students consider the many other liquids in our lives with water in them (shampoo, dish soap, most thermometers, window cleaner, hand lotion, eye drops, mouthwash, etc.) Why is it that water is a main ingredient for so many liquids?
(At times, cost may be a factor, but the primary reason is because water is such an effective solvent—many solids and other liquids tend to dissolve readily in it.)
3. Inform the students that they are about to discover what happens when we mix some different solids in water.

EXPLORE SOLUTIONS, SOLUTIONS

Perform the following experiment in a demonstration area set up so that all students can see the procedure. Select two students to assist you.

1. Have the students observe carefully while someone adds 1/2 teaspoon table salt (sodium chloride) to water at room temperature in a clear cup. Have someone else stir the mixture until the salt has dissolved. (The solution should look like clear water, as before.)
2. Then, have the students observe carefully while someone adds 1/2 teaspoon flour to another cup containing the same amount of water at room temperature. Have someone else stir the mixture briskly for the same amount of time the salt had been stirred..
3. Let both cups stand undisturbed for five to ten minutes. To build suspense and avoid distraction, cover the two cups with a cloth or inverted box.

During this time, ask students to review what they observed with the first cup. Where did the salt “go.” What did they observe about the second mixture? How did what happened in the two cups differ?

4. After sufficient time has passed, remove the cover and ask the students to observe the cups again. Have them describe their observations.

EXPLAIN SOME IMPORTANT VOCABULARY

1. Help to summarize the student observations.
2. Introduce and discuss the terms *dissolve*, *solution* and *suspension*, *soluble* and *insoluble*, *solubility*, *saturation* and *super-saturation*, and *precipitate*.. Summarize the meanings for each term and provide examples.

3. Ask the students to suggest other materials that are and are not soluble in water. The first list will likely be much longer. If time permits, allow students to test some materials about which they are uncertain.

SEQUENCE, PART TWO

ENGAGE HOW MUCH CAN A LAKE TAKE?

Remind the students that they already know that a lot of salt is dissolved in Great Salt Lake, and how it got there. But can a lake even as big as Great Salt Lake keep dissolving salt forever? Does water ever reach a point where it cannot dissolve any more salt? Does dissolved salt ever “un-dissolve” and come back out of the water? Tell the students that these are the kinds of things about which they will be discovering answers.

EXPLORE WHAT AFFECTS SOLUBILITY?

1. Inquire of the students what *variables* might affect how much of a substance will dissolve in water. Can any students describe past experiences to answer this question? What variable shall we test?
(Variables might include: the actual substance being dissolved, the amount of stirring, other ingredients in the water, the amount of water, and water temperature. Some have likely had such experience with differences between how readily hot and cold water dissolve cocoa, sugar and other substances.)
2. Suggest to the students that since temperature is a variable they can measure, and since it has surely been an important factor in other research they have done, perhaps that is the variable they should explore now with some *solubility* experiments.

EXPLAIN A PLAN TO STUDY THE AFFECT OF TEMPERATURE ON SOLUBILITY

1. Explain that designing an experiment is sometimes made easier by answering two guiding questions: “What do we want to find out?” and “What do we need to do in order to find out?”
2. Discuss the first guiding question, “What do we want to find out?” (A response similar to “How temperature affects solubility” should evolve from this discussion.)
3. Discuss the second guiding question, “What do we need to do in order to find out?” (A response similar to “Find out how much salt can be dissolved in water at a different temperatures” should evolve from this discussion.)
4. Confirm with students their understanding of the variable being tested. (water temperature)
5. Confirm with students factors that should not vary. (water volume and measuring accuracy)

6. Explain that the material you are providing to be dissolved is something that comes from Great Salt Lake—Epsom salts (magnesium sulfate).

EXPLORE CONDUCTING THE SOLUBILITY EXPERIMENT

1. Divide the class into 6 (or 9) teams and introduce them to the materials to be used and the general procedure. Inform them of the volume of liquid that will be used, and urge caution to avoid spilling, which would alter the volume and impact the experiment. Two (or three) teams will be given hot water, two (or three) will have room temperature water, and two (or three) will have cold water.
2. Remind the students that to keep their research valid, they must use precise measurements, take careful notes, and work skillfully.
3. Teams should divide roles by having one person measure and add salt, another stir, and one record all information.
4. Deliver the water to all teams. Remind those with hot or cold water to work efficiently and not make more than about twenty brisk stirs (about five seconds), or else their water might soon change to room temperature.
5. Supervise the teams during the following procedure:
 - a. Each team should add salt to their water $1/2$ teaspoon at a time and stir briskly about twenty rotations (5–10 seconds) to dissolve the material. If, *after waiting at least thirty seconds*, there remain more than a few grains of un-dissolved salt, one or two additional series of twenty brisk stirs may be completed, but no more. The record-keeper must be sure to keep track of the number of half-teaspoon measures that are added.
 - b. As soon as a team finds more than a few grains of salt remaining at the bottom of the cup after three rounds of stirring, they have reached *saturation* and should immediately measure the temperature of their saturated solution. The record-keeper should note this temperature on the sheet.
 - c. Each team member should copy onto his or her own data sheet the measurements for the volume of water, quantity of salt added, and saturation temperature.
6. As teams complete their experiments, instruct them to prepare for reporting their results to the class.

EXPLAIN RESULTS OF THE SOLUBILITY EXPERIMENT

1. Ask each team to report their results. As the reports are given, students of other teams should add the new data to their own data sheets.
2. Instruct the students to graph the class data using Workshop II.E., comparing water temperature with the amount of salt dissolved. Assist the students with completing their graphs as necessary.

ELABORATE INTERPRETING RESULTS

1. To verify understanding, direct the students to answer the following questions on a page to be entered in their scrapbooks:
 - a. By examining your graph, what can you now say about the relationship of the temperature of water to the solubility of salt? (The warmer a certain amount of water is, the more salt that can be dissolved in it.)
 - b. How would using less water at a certain temperature affect the amount of salt that can be dissolved? (Less salt can be dissolved in less water at a given temperature; less water would become saturated sooner.)
 - c. What would happen if your team added more water to your solution? (More salt could be dissolved in a larger volume of water, if the temperature remained the same.)
 - d. What would happen if we let all of our experimental solutions sit in the room for several days? Hint: think about what would happen to the water, and what would happen to the salt dissolved in the water. (Answers will vary. The water would evaporate. Less water would mean that less salt could stay dissolved and some would precipitate back out as a solid. The amount that precipitates out would depend on the original water temperature and how much salt had been dissolved in the water.)
2. Review and discuss with student their responses to the above questions. Clarify any misunderstandings.

EVALUATE STUDENT SCRAPBOOKS

Instruct the students to choose one of the following projects to include in their scrapbook:

1. Write a story about the water in Great Salt Lake. Your story should use all of the new words you have learned: *dissolve, solution, soluble, insoluble, suspension, saturation, supersaturated, precipitate*.
2. Describe the experiments done in class by writing a newspaper article using new words you have learned: *dissolve, solution, soluble, insoluble, suspension, saturation, supersaturated, precipitate*.