

Water is Essential!

Lesson plan for grades 6-10

Length of lesson: 2-3, 40-50 minutes class

Adapted by: William Oakley, Environmental Science Institute, April 12, 2012

Authored by: Mars Gamma Ray Spectrometer NASA

SOURCES AND RESOURCES:

- Mars Gamma Ray Spectrometer NASA website
http://grs.lpl.arizona.edu/lessons/buried_water.html
- USGS website for water
<http://ga.water.usgs.gov/edu/waterproperties.html>

POTENTIAL CONCEPTS TEKS ADDRESSED THROUGH THIS LESSON:

§112.18. Chemistry, Grade 6: 1A,2ABCDE, 3A, 4AB

§112.19. Chemistry, Grade 7: 1A,2ABCDE, 3A, 4AB, 9A

§112.20. Chemistry, Grade 8: 1A,2ABCDE, 3A, 4AB

§112.32. Aquatic Science, Grade 10: 2A, 3A

PERFORMANCE OBJECTIVES:

- Students characterize the solubility of three solutes (salt, sugar, and cornstarch) in three solvents (water, vegetable oil, and rubbing alcohol).
- Students compare the abundance of three solvents (water, crude oil, and alcohol) found at and near the surface of Earth.
- Students discuss relative ease of evaporation of water, oil and alcohol.
- Through the above explorations, students draw conclusions regarding possible reasons why liquid water is important for living systems on Earth.

MATERIALS (per group of four):

- “Why Follow the Water?” [Student Guide](#) (1 per student)
- “Why Follow the Water?” [Student Guide Answer Key](#)
- Pens
- Butcher paper
- Small, clear plastic cups (6 per group)
- Graduated cylinders
- Coffee stirrers (or Popsicle sticks to stir solutions, 3 per group)
- Permanent markers
- Small spoons (3 per group)
- Paper towels
- Water

- Isopropyl alcohol (rubbing alcohol)
- Vegetable oil (Canola, or other light-colored oil)
- Sugar
- Kosher salt
- Cornstarch

BACKGROUND:

Water is one of the fundamental foundations of life, without it life as we know it would cease to exist. Wars have been fought for water rights, and clean drinking water is a primary concern of many third world nations that some villages need to walk 50 miles just to get to the nearest source of water. However, many people don't actually know why water is so important to life. This lab is designed to give students an opportunity to look at a few of water's unique characteristics.

PREPARATION:

Students will need to have their pencils ready before the Engage. No worksheets should be handed out until the appropriate time to prevent students from being distracted or trying to work too far ahead of everyone else unless you are comfortable with that. Worksheets should be ready to distribute when needed.

ENGAGE:

Divide the classroom into groups of 3 or 4 (at the discretion of the teacher) and have students discuss in their groups for 10-15 minutes to discuss the following question: "Why is water important?" Groups should write down their answers on butcher paper (or something similar) and be prepared to share with the class some of their ideas. The paper should be kept for reflection during the end of the lab

EXPLORE: Part 1- Pre-Lab Work

(Note that part 1 is intended as a demonstration and thought experiment, but the teacher is more than welcome to modify the lesson to let all groups participate in this part of the lesson)

- Pass out the Worksheet packet and remind the class about how liquids turn into a gas when they reach a certain temperature, a process called evaporation. One of the unique characteristics of water is how it evaporates compared to other liquids. Give the students a few minutes to do the pre-lab questions for evaporation. To demonstrate this property, pour 30 mL of water into one plastic cup, 30 mL of Isopropyl Alcohol and 30 mL of vegetable oil all into plastic cups. Label the cups with a marker. The class will wait a day to give the liquids time to evaporate and then later discuss what has actually happened.
- Solubility is the second property investigated in this lab, so it would be wise to go over the basics of the concept with the class if the subject has not been taught already. The following terms should be familiar to the students by the end of the first day:

Solubility: The amount of a substance (called the solute) that can be dissolved in a given amount of liquid (known as the solvent).

Dissolve : The act of taking one substance and combining it with another substance so that they mix to make a uniform solution of the two – when a substance disappears into a liquid.

Solute: A substance that is dissolved in another substance.

Solvent: Substances (usually liquid) capable of dissolving or dispersing one or more other substances.

Soluble : Capable of being dissolved in a solvent.

Partially soluble: When only part of a solute dissolves leaving the other part non-dissolved and usually still visible.

Insoluble : The inability of a substance to be dissolved in another substance.

Ask students to discuss what they already know about solubility. Below are some sample questions:

- Can solids change into liquids? *(Yes, by melting or dissolving in a liquid.)*
- Does sugar dissolve in anything? *(Yes, water. In this case, the sugar is called the solute and the water is called the solvent.)*
- What is a solute? *(Something that dissolves in a liquid.)*
- What is a solvent? *(A liquid in which something dissolves.)*
- Are there liquids in which sugar does not dissolve? *(Yes, oil.)*
- How do you know when something has dissolved in a solvent? *(You can't see any more solid on the bottom of the cup of liquid.)*

The remainder of the day should be spent discussing the procedures of the solubility lab, that way the next day can be spent completely on the lab. Make sure the students write down the procedures (listed in the next section) in their worksheet packet so they remember how they are supposed to perform the lab.

Day 2- Solubility Exercise

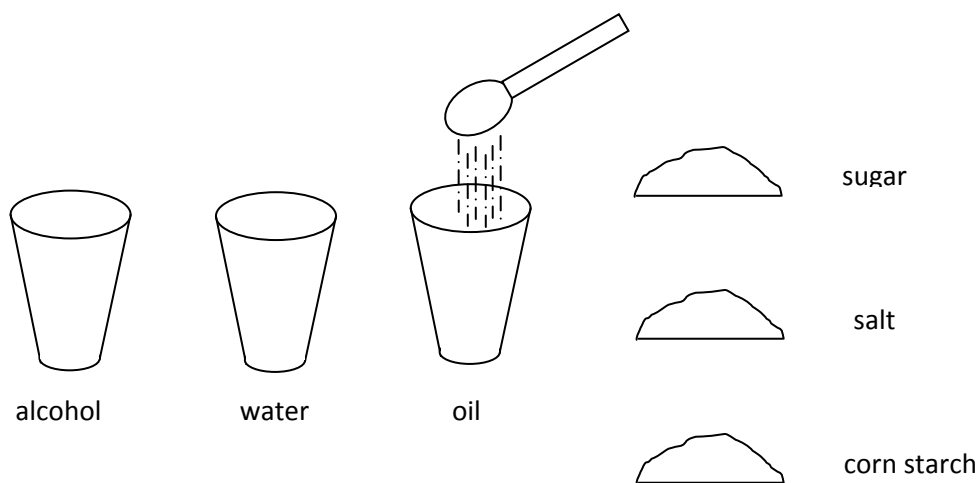
Pass out cups of the sugar, salt, and cornstarch as students review their lab procedure from the previous day. This will help students get a better idea of what these solutes look like and think about strategies for adding solutes to the three cups of solvents. Spoons should be used for one type of solute only in order to avoid contamination of the cups of solute. The teacher should pour the solvent into student testing cups after students have determined their lab procedure and decided how much solvent they will need. Remind students to use avoid using excessive amounts of solvent to conduct the experiment; rather, have them use a moderate amount of solvent (30-50 ml) with smaller amounts of solute. Explain that students will need to use a new cup of solvent for each solute test, even if the used solvent cup looks uncontaminated. Set up one or several liquid waste buckets in the classroom for students to quickly and cleanly dispose of their solvents in between experiments.

Have students complete the Solubility Lab Worksheet (see Materials list above). Show students the solvents and explain that they need to observe and compare the behavior all three solvents with all three of the solids in order to determine which solvents are better than others. Explain that a solvent that dissolves a large amount of solute is defined as a “good solvent” and one that does not dissolve as much solute is a “poor solvent.”

Students will use the worksheet to help them design their experiment. They should write a clear purpose, materials list, and procedure with their groups. Student groups should get their plan approved (with careful attention to the detail of the procedures) before they start the lab. Students should be notified that they will be required to present and explain their findings to the class.

Students may need help with the idea that the quantities of solvent must be the same for all trials. Students should note if they think a solute is partially soluble, meaning that only some of the solute dissolved, since this may help students rank their solvents. If students are stuck, suggest that they add a spoonful of one solid to each solvent and see what happens. They can keep adding another spoonful to each solvent until only one solvent is able to dissolve the solid completely. (For example, if students add one spoonful of sugar to the oil, alcohol, and water, the oil will not dissolve any of the sugar, the alcohol may dissolve some, and the water may dissolve all. If this is the case, students should infer that oil is not a very good solvent for sugar, alcohol does fairly well, and water works the best.) Discuss the idea of a data table to help students keep their data organized.

The diagram below provides a cartoon sketch of the materials of a possible lab setup.



EXPLAIN :

Turn the classes’ attention back to the original evaporation experiment. By now, the alcohol should have evaporated the most, the water somewhat and the oil very little. Based upon these observations alone, have

the groups discuss for 5 minutes which of the three liquids would be the most useful to life based solely on their evaporation properties and justify their answers.

Alcohol is not a good liquid because it evaporates far too quickly; the liquid form is unstable. If the oceans of the world were all made of alcohol, they would quickly evaporate and leave everybody high and dry. On the flip side, the oil has a much harder time to evaporate, meaning that it is hard for the Earth to replenish itself through a cycle. This would make the recycling process take much longer which could easily destabilize the climate. Water, however, is stable enough in its liquid form that a portion of it can remain in liquid state despite the sun shining on it, and yet a large portion evaporates, and is transported from one place to another to continue the recycling process.

The most effective way to illustrate this phase is to assign each group to “present” their findings to the rest of the class. Give each group a few minutes to prepare. If there are more than 3 groups, you can either combine groups for presentations or choose random students to pick it. (This is at the discretion of the teacher). The students should discuss with the class what they found out between the 3 liquids and the 3 different solids used during the lab. The following questions may be used to probe more discussion:

- Which of the liquids dissolved the most? Which of the solids was the easiest dissolved?
- Should a liquid be soluble for it to be essential for life? Why?
- Which of the three would you recommend based on this lab alone?

After the class is done presenting, explain to the class that cells need nutrients like sugar and salt in order to survive, and that water’s ability to dissolve these nutrients allows it to easily carry the nutrients through the body to where it needs to go.

ELABORATE: (Note, depending on time, this may need to be done on another day)

1. The rest of the worksheet has an abundance section. Let the students work together in groups to complete the section of the worksheet and finally complete the conclusion. Have the students present their findings to the class
2. There are some extensions linked on the website listed on the first website if the teacher wishes to spend more time on this subject.

EVALUATE: Because the lab is worksheet based, the evaluation will be determined by how the students answered the questions. In the lab the teacher should use the separate answer key as a baseline for the answers to the questions. Additional things the teacher should be on the look out for include: the consequences of volatile substances that evaporate too quickly, the consequences of substances that don’t evaporate enough and the consequences of a liquid that can’t dissolve substances.

WHY FOLLOW THE WATER?

Pre-Lab Questions (*Answer Key*)

A key NASA strategy to look for current or past life on Mars involves “following the water” – looking for places where water currently or once existed on the planet. In this activity, we will consider some of reasons why liquid water is important for life on Earth and may be important for life on Mars. In particular, we will consider the properties of ease of evaporation, solubility, and abundance.

Ease of Evaporation

Even though a liquid may not boil at room temperature, it can still evaporate depending upon atmospheric conditions. If a liquid evaporates over the course of a few hours when set on a counter top, it is easy to evaporate. If a liquid can remain on a countertop for several days without evaporating, it is difficult to evaporate.

- 1) If you place a full cup of water out on a table in your classroom, will it start to boil? Why or why not?

Water is stable to boiling at room temperature because the temperature is below the boiling temperature of the water at pressures found in the classroom.

- 2) If you leave a full cup of water out on the table overnight, would you expect the level of the water to increase, decrease, or stay the same by the next day? Explain your reasoning.

Unless the atmosphere is at 100% relative humidity, some water can still evaporate away from the cup into the atmosphere. The water is not stable to evaporation. We would expect that some of the water will have evaporated into the air, reducing the amount of water in the cup. Students should not expect the cup to be completely empty because water does not evaporate quickly enough. A discussion about the differences in relative humidity of the air and how it would affect how much water would evaporate is relevant here if students understand what humidity is.

- 3) Now imagine that you leave three cups out on a table overnight. One is filled with water, the second with rubbing alcohol, and the third with vegetable oil. They are all filled with exactly the same amount of liquid. How would you expect the levels of each liquid to change by the next day? Which will evaporate the most? Explain your reasoning.

This question requires students to hypothesize about the relative evaporation rates of three liquids. Answers will vary, and all answers are acceptable as long as students explain their reasoning.

Solubility

The *solubility* of a liquid describes how easy it is for another substance to dissolve in the liquid. If you dissolve a solid in a liquid, the solid is called the *solute* and the liquid is called the *solvent*. Following this pre-lab, you will design and conduct an experiment to test the solubility of three solvents (water, vegetable oil, and rubbing alcohol) using three solutes (salt, sugar, and cornstarch).

- 1) Two students dissolve a spoonful of salt into a container of water. Which substance is the solvent and which is the solute?

A solvent is a liquid that can dissolve things, and a solute is the substance that is dissolved in the solvent. In this case, the salt is the solute and the water is the solvent.

- 2) Chocolate powder is soluble in milk. What does soluble mean?

Soluble means that something will dissolve in the solvent listed. In this example, the chocolate powder will dissolve in the milk. There will be no more chocolate powder on the bottom of the glass once it has mixed.

- 3) Two students are preparing to do a solubility experiment. They carefully measure equal amounts of three solvents (water, oil, and rubbing alcohol) into different containers. They are now discussing ideas for testing the solubility of sugar in these liquids.

Student 1: I think we should put ten spoonfuls of sugar into each cup. If the sugar is soluble, the solvent should be able to dissolve all of it. After we stir up the liquid, we'll see if the sugar has disappeared.

Student 2: What if the solvent can dissolve one spoonful but not ten? If we dump too much sugar in at once, we won't know if the solvent could have dissolved a smaller amount. I think we should add a spoonful of the sugar at a time.

Do you agree or disagree with either or both of these students? Explain your reasoning.

If students follow the suggestion of Student 1, they may have difficulty determining if at least some of the sugar could dissolve in each liquid. Using the method suggested by Student 2, students will be able to see more easily if a small amount of solid dissolves. It is also important to note that both students suggested correctly that they should add the same amount of solute to each solvent in order to perform the experiment.

WHY FOLLOW THE WATER?

Solubility Lab (*Possible Procedure*)

Lab Objective: The purpose of this lab is to determine the relative solubility of the following solvents: water, rubbing alcohol, vegetable oil. You will have the following solutes to conduct this experiment: sugar, salt, and cornstarch.

Materials: Below is a list of materials for the lab. In the Procedure Section below, describe how you will use these materials to complete the lab objective.

Solvents: water, rubbing alcohol, vegetable oil
Solutes: sugar, cornstarch, salt
Other materials: empty cups for solvents (3), spoons (3), stirrers (3), markers (1)

Procedure: (How will you do your experiment? Be sure to include step-by-step instructions, including the amounts of each substance you are using.)

1. Obtain containers of solute and containers for solvents.
2. Label each of the 3 empty cups with the name of one of the solvents. Into one of the cups measure the amount of water students want to use and draw a line on the cup at the surface of the liquid. Then pour the water into another cup and mark the water level. Then pour the water into the third cup and mark the level again. This method will ensure that the volumes of the three solvents will be the same. (The volume of the solvents is not critical. A volume of 30 – 50 ml of solvent with good results.)
3. Add rubbing alcohol to the marked line in the cup labeled "ALCOHOL," add water to the marked line in the cup labeled "WATER," and add oil to the marked line in the cup labeled "OIL." Now there are three cups containing the same volumes of three different solvents.
4. Add a spoonful of sugar to each cup, stir with a coffee stirrer, and note if the solid dissolves in any of the solvents. If the sugar dissolves completely in two or more solvents, add an additional spoonful of solute to each solvent and stir. Keep adding a spoonful at a time until there is only one solvent which is still able to dissolve the sugar completely. This last solvent is not yet "saturated" with the solute and you could conceivably continue to add more.
5. Note the number of "doses" of sugar added to the solution before the solvent was saturated since it will be helpful in ranking the solvents if students know which solvents dissolved more of each solute. A suggested data table is below.

Solvent	Solute	# of spoonfuls	Observations (soluble, insoluble, partially soluble)
Water	Sugar	Answers will vary.	Soluble
Oil	Sugar	Answers will vary.	Insoluble
Alcohol	Sugar	Answers will vary.	Partially Soluble
Water	Salt	Answers will vary.	Soluble
Oil	Salt	Answers will vary.	Insoluble
Alcohol	Salt	Answers will vary.	Partially Soluble
Water	Cornstarch	Answers will vary.	Insoluble
Oil	Cornstarch	Answers will vary.	Soluble
Alcohol	Cornstarch	Answers will vary.	Insoluble

6. After all observations using sugar as the solute are recorded, pour the solvents into a waste bucket (or down the sink).
7. Redo Steps #3-#6 for salt
8. Redo Steps #3-#6 for cornstarch.
9. Analyze the results and rank the solvents in terms of their ability to dissolve the solutes in the experiment.

Observations and Results: (What did you find out? Rank the solvents from best solvent to worst solvent.)

Water dissolved sugar and salt, alcohol dissolved some sugar and some salt, and oil dissolved cornstarch. Water is the best solvent for these three solutes tested. Best solvent to worst solvent: Water, Alcohol, Oil. Since this is a qualitative experiment, students may have ranked their solvents differently. Discuss reasons for the differences in results (different quantities of solvent, differences in observations, experimental error, differences in criteria for measuring good solvents, etc.) Students should have reasons for ranking the solvents the way they do. For example, students may say the oil looks like it dissolved the cornstarch but it is possible that it could be a suspension of particles, and therefore oil is the worst solvent. Students may say that the alcohol is the worst solvent because it took a lot longer than to dissolve solutes than the other solvents.

WHY FOLLOW THE WATER? Post-Lab Questions (Answer Key)

Ease of Evaporation

- 1) Based on your discussion about ease of evaporation, rank water, oil, and alcohol from the easiest to evaporate to the hardest to evaporate.

Rubbing alcohol is the easiest to evaporate, water is next, and vegetable oil is the hardest to evaporate.

- 2) Based upon the results regarding evaporation ALONE, which liquid would you expect to be the most useful for life? Explain your reasoning.

Based ONLY on the fact that vegetable oil is more stable to evaporation than water or rubbing alcohol, students might guess that vegetable oil is the most important liquid for life. This experiment introduces the concept that we can measure and compare properties of various substances.

Solubility Experiment

- 3) With the three solutes tested in the solubility lab, which liquid was the worst solvent (water, rubbing alcohol, or vegetable oil)? Explain your reasoning.

Students will find that the vegetable oil was a worse solvent than water and rubbing alcohol for the solutes tested.

- 4) Sugars, salts, and other solutes need to be able to move into, out of, and inside cells in order to carry out the basic functions of life. If a cell composed of mostly the liquid you listed in Question 3, would the cell still be able to transport solutes easily around the cell? Explain your reasoning.

If a cell were composed of mostly oil, sugars and salts would not be easily dissolved and would therefore not be able to move around inside the cell as easily as with a cell filled with water. The sugars and salts also would not be able to react with other molecules because they would remain in their less active, solid state.

- 5) Based upon the results of the solubility experiment, rank the three liquids from highest solubility to lowest solubility.

Students should find that water has the highest solubility, rubbing alcohol is next, and vegetable oil has the lowest solubility. Some students may have difficulty distinguishing between the solubility of rubbing alcohol and water.

- 6) Based upon the results of the solubility experiment ALONE, which liquid would you expect to be the most useful for life? Explain your reasoning.

Water is important to living things because it can be used to dissolve solids such as sugars and salts. Chemical reactions can occur more easily when these molecules are dissolved in a solvent such as water. Water can serve as a good solvent for dissolving and transporting these molecules necessary for life.

Abundance at the Surface of the Earth and Other Properties

A final characteristic we will consider is the abundance or amount of liquid present at or near the surface of the Earth. The table below lists the abundances of rubbing alcohol, crude oil, and water at or near the surface of the Earth in units of cubic miles. Crude oil and vegetable oil have similar solubility and evaporation properties, but there is much more crude oil present at or near the surface of the Earth than vegetable oil.

Solvent	Abundance (in cubic miles)
Rubbing Alcohol	Trace amounts
Crude Oil	42
Water	330,000,000 (330 million)

- 7) What do you notice about the abundance of water near the surface of the Earth compared to other two liquids?

There is way more water at the surface of the earth than there is crude oil or alcohol. Given that the amount of vegetable oil is significantly lower than crude oil, we still conclude that water is much more abundant than the two liquids testing in the solubility and evaporation labs.

- 8) Based upon abundance ALONE, which liquid would you expect to be the most useful for life? Justify your answer.

Because water is so much more abundant than the other two liquids, students will guess that water is the most important liquid for life.

- 9) In this activity, we have tested only three liquids (water, vegetable oil, and rubbing alcohol) for three properties (solubility, evaporation, and abundance). List some other liquids we could test if we had more time and resources. What are some additional properties that could be investigated?

Due to limited time and resources along with safety concerns, we only tested three solutes in three solvents. There may be other solvents that are effective at dissolving solids and we could have also tested many additional solutes. While the lab shows that water is a "good" solvent, it does not prove that it is the "best" solvent for all materials. Other possible liquids include ammonia, vinegar, and hydrogen peroxide. Other properties to test for include specific heat, density, boiling point, melting point, and polarity.

Conclusions

10) Now consider all three liquid characteristics we have investigated. Complete the following table based upon the results of our three investigations. In each column, rank the solvents from high (1) to low (3) in terms of their solubility, ease of evaporation, and abundance at or near the surface of the Earth.

Solvent	Solubility	Ease of Evaporation	Abundance
Water	Higher than oil (1 or 2)	2	1
Oil	Lower than water (2 or 3)	1	2
Rubbing Alcohol	Answers will vary (1, 2, or 3)	3	3

11) Based upon all three properties considered TOGETHER, decide which liquid (water, oil, rubbing alcohol) is probably most important for life on Earth. Explain your reasoning.

Based upon the table, water is the most suitable solvent for life on Earth. While oil is more stable to evaporation, there is simply more water present at or near the surface of our planet and water also is a better solvent. While rubbing alcohol is a reasonable solvent, it is very unstable to evaporation and has very low abundance.

12) NASA scientists looking for evidence of life on Mars think it is important to “follow the water.” Why do you think scientists link the presence of water on other planets to possible life there?

Finding signs of liquid water on other planets is exciting because scientists know that water is an important solvent to life forms on Earth. Since scientists know that water is important to life as we know it, they can guess that if there is water-based life on another planet, it should be located where there is liquid water. With water available, there is a possibility that water-based life could have been present. On Mars, the best possibility for finding evidence of water-based life is to look where there is or was liquid water.

OVERALL ASSESSMENT

Ask students to write a response to the following questions:

- Why is water important to life on Earth?
- Why should NASA “follow the water” on Mars?

In their responses, students should demonstrate their knowledge of the solvent nature of water and the abundance and evaporation of water on Earth. Students should be able to use the information they have learned about water to describe why water is important to life on Earth. They should also discuss why scientists plan to look for evidence of life where liquid water exists on other planets. Use the following rubric for grading.

	Exceeds Standards	Meets Standards	Approaches Standards	Falls Far Below Standards
Solvent Content	Solvent lab conclusions reported and extended to include predictions about other solvents, conclusions justified, many details and evidence used to relate results to the importance of water. (4)	Solvent lab conclusions reported, conclusions justified, results related to the importance of water using several details and evidence. (3)	Solvent lab conclusions reported, one of the following incomplete or missing: -conclusions justified -results related to the importance of water using several details and evidence. (2)	Two or more of the following missing or incomplete: -solubility lab conclusions reported -conclusions justified -results related to the importance of water using several details and evidence. (1)
Evaporation Content	Evaporation lab conclusions reported and extended to include predictions about other liquids, conclusions justified, many details and evidence used to relate results to the importance of water. (4)	Evaporation lab conclusions reported, conclusions justified, results related to the importance of water using several details and evidence. (3)	Evaporation lab conclusions reported, one of the following incomplete or missing: -conclusions justified -results related to the importance of water using several details and evidence. (2)	Two or more of the following missing or incomplete: -evaporation lab conclusions reported -conclusions justified -results related to the importance of water using several details and evidence. (1)
Plant Productivity Content	Plant productivity connections reported and extended to include predictions about unlisted biomes, conclusions justified, many details and evidence used to relate results to the importance of water. (4)	Plant productivity connections reported, conclusions justified, results related to the importance of water using several details and evidence. (3)	Plant productivity connections reported, one of the following incomplete or missing: -conclusions justified -results related to the importance of water using several details and evidence. (2)	Two or more of the following missing or incomplete: -plant productivity connections reported -conclusions justified -results related to the importance of water using several details and evidence. (1)
“Follow the water” Defense	Detailed description of NASA’s “follow the water” goal, many reasons and details explaining why NASA should follow the water. (4)	Detailed description of NASA’s “follow the water” goal, several reasons and details explaining why NASA should follow the water. (3)	Incomplete or missing one of the following: -description of NASA’s “follow the water” goal -reasons and details explaining why NASA should follow the water. (2)	Incomplete or missing both: -description of NASA’s “follow the water” goal -reasons and details explaining why NASA should follow the water. (1)
Writing		Paper is well organized, detailed, clear, and free of spelling/grammar mistakes. (3)	Missing one of the following traits: -well organized -detailed -clear -free of spelling/grammar mistakes (2)	Missing two or more of the following traits: -well organized -detailed -clear -free of spelling/grammar mistakes (1)



Why Follow the Water? Student Guide



Pre-Lab Questions

Source: “Why Follow the Water?” Mars Gamma Ray Spectrometer NASA website
http://grs.jpl.arizona.edu/lessons/buried_water.html

A key NASA strategy to look for current or past life on Mars involves “following the water” – looking for places where water currently or once existed on the planet. In this activity, we will consider some of reasons why liquid water is important for life on Earth and may be important for life on Mars. In particular, we will consider the properties of ease of evaporation, solubility, and abundance.

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- 1) If you place a full cup of water out on a table in your classroom, will it start to boil? Why or why not?
 - 2) If you leave a full cup of water out on the table overnight, would you expect the level of the water to increase, decrease, or stay the same by the next day? Explain your reasoning.
 - 3) Now imagine that you leave three cups out on a table overnight. One is filled with water, the second with rubbing alcohol, and the third with vegetable oil. They are all filled with exactly the same amount of liquid. How would you expect the levels of each liquid to change by the next day? Which will evaporate the most? Explain your reasoning.



Why Follow the Water? Student Guide



Solubility

The *solubility* of a liquid describes how easy it is for another substance to dissolve in the liquid. If you dissolve a solid in a liquid, the solid is called the *solute* and the liquid is called the *solvent*. Following this pre-lab, you will design and conduct an experiment to test the solubility of three solvents (water, vegetable oil, and rubbing alcohol) using three solutes (salt, sugar, and cornstarch).

- 1) Two students dissolve a spoonful of salt into a container of water. Which substance is the solvent and which is the solute?

- 2) Chocolate powder is soluble in milk. What does soluble mean?

- 3) Two students are preparing to do a solubility experiment. They carefully measure equal amounts of three solvents (water, oil, and rubbing alcohol) into different containers. They are now discussing ideas for testing the solubility of sugar in these liquids.

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Do you agree or disagree with either or both of these students? Explain your reasoning.





Why Follow the Water? Student Guide



WHY FOLLOW THE WATER? Solubility Lab

Lab Objective: The purpose of this lab is to determine the relative solubility of the following solvents: water, rubbing alcohol, vegetable oil. You will have the following solutes to conduct this experiment: sugar, salt, and cornstarch.

Materials: Below is a list of materials for the lab. In the Procedure Section below, describe how you will use these materials to complete the lab objective.

Solvents: water, rubbing alcohol, vegetable oil

Solutes: sugar, cornstarch, salt

Other materials: empty cups for solvents (3), spoons (3), stirrers (3), markers (1)

Procedure: (How will you do your experiment? Be sure to include step-by-step instructions, including the amounts of each substance you are using.)

Observations and Results: (What did you find out? Rank the solvents from best solvent to worst solvent.)





Why Follow the Water? Student Guide



WHY FOLLOW THE WATER? Post-Lab Questions

Ease of Evaporation

- 1) Based on your discussion about ease of evaporation, rank water, oil, and alcohol from the easiest to evaporate to the hardest to evaporate.
- 2) Based upon the results regarding evaporation ALONE, which liquid would you expect to be the most useful for life? Explain your reasoning.

Solubility Experiment

- 3) With the three solutes tested in the solubility lab, which liquid was the worst solvent (water, rubbing alcohol, or vegetable oil)? Explain your reasoning.
- 4) Sugars, salts, and other solutes need to be able to move into, out of, and inside cells in order to carry out the basic functions of life. If a cell composed of mostly the liquid you listed in Question 3, would the cell still be able to transport solutes easily around the cell? Explain your reasoning.
- 5) Based upon the results of the solubility experiment, rank the three liquids from highest solubility to lowest solubility.
- 6) Based upon the results of the solubility experiment ALONE, which liquid would you expect to be the most useful for life? Explain your reasoning.





Why Follow the Water? Student Guide



Abundance at the Surface of the Earth and Other Properties

A final characteristic we will consider is the abundance or amount of liquid present at or near the surface of the Earth. The table below lists the abundances of rubbing alcohol, crude oil, and water at or near the surface of the Earth in units of cubic miles. Crude oil and vegetable oil have similar solubility and evaporation properties, but there is much more crude oil present at or near the surface of the Earth than vegetable oil.

Solvent	Abundance (in cubic miles)
Rubbing Alcohol	Trace amounts
Crude Oil	42
Water	330,000,000 (330 million)

- 7) What do you notice about the abundance of water near the surface of the Earth compared to other two liquids?

- 8) Based upon abundance ALONE, which liquid would you expect to be the most useful for life? Justify your answer.

- 9) In this activity, we have tested only three liquids (water, vegetable oil, and rubbing alcohol) for three properties (solubility, evaporation, and abundance). List some other liquids we could test if we had more time and resources. What are some additional properties that could be investigated?





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Conclusions

10) Now consider all three liquid characteristics we have investigated. Complete the following table based upon the results of our three investigations. In each column, rank the solvents from high (1) to low (3) in terms of their solubility, ease of evaporation, and abundance at or near the surface of the Earth.

Solvent	Solubility	Ease of Evaporation	Abundance
Water			
Oil			
Rubbing Alcohol			

11) Based upon all three properties considered TOGETHER, decide which liquid (water, oil, rubbing alcohol) is probably most important for life on Earth. Explain your reasoning.

12) NASA scientists looking for evidence of life on Mars think it is important to “follow the water.” Why do you think scientists link the presence of water on other planets to possible life there?

