CONTENTS

Pre-testing of Science Explorations

All the inquiries and experiments in this module have been trial tested. However, it is important for teachers to conduct their own trial test prior to using each investigation in the classroom to become familiar with the equipment and procedures.

Equipment and Supplies

The authors designed activities that use the least expensive, readily obtainable equipment and supplies. A list follows.

Learning Experience 1	• Chart paper for each group of 4-5 students, and teacher • Markers • Masking tape • Large map of the Earth • A cup of water for each student
Learning Experience 2	**Activity One** • Masking tape, about 4 rolls • Aluminum foil • Whistle or other noise maker to get students' attention **Activity Two** **For pairs of students:** • Permanent, fine tipped marker to write on plastic • Cup filled part way with water • Medicine dropper • 3 pieces of clear plastic tubing (available at hardware store or pet shop), 8 cm each • Small piece of modeling clay (enough to plug one end of tubing) • Small ruler, preferably metric • Access to a freezer **Activity Three** • Open container partially filled with ice cubes in water (can use glass or plastic, any size) • Closed container partially filled with warm water (e.g., screw-capped jar, capped plastic bottle, cup covered with plastic wrap) • Potted leafy plant enclosed in clear plastic. (Prepared the night before class) • Hot plate and pyrex beaker or pot of water, or crock pot filled part way with water • Index cards marked: Station 1, Station 2, Station 3, Station 4 • Large sheets of chart paper, markers, and masking tape • Reference books or magazines that show scenes of: snow-capped mountains, coastal plain, ocean, river valley, underground cave, polar region

Learning Experience 3	Per group or 3 (or 4): • 2 pennies • Cup partly filled with water – labeled • Cut partly filled with rubbing alcohol -- labeled • 2 droppers • 2 pieces of glass capillary tubing (If high school doesn't have this, contact a nearby clinical lab.) • Plastic fork • 4 paper clips • Handout One • Pair of magnets
Learning Experience 4	• 2 transparent cups filled with water • Food coloring • Sugar • Masking tape Per group of 3-4 students (set up a supply table): • Table salt • Sugar • 2 transparent cups • Supply of water • Supply of rubbing alcohol • 2 Stirrers • Marker that writes on plastic • ¼-teaspoon measurers • Optional: scales or a balance • Large sheet of chart paper, markers
Learning Experience 5	• Access to information on water conservation and water pollution • Chart paper • Markers • Masking tape

Additional Advice to Teachers

The National Science Education Standards asserts few students are able to understand the abstract concept of atomic and molecular particles until high school. Certainly students at the elementary grades level should not be expected to comprehend the molecular nature of matter.

Since the intent of this module is to introduce students to physical properties of water in preparation for deeper understanding to be developed in the secondary module, *The Mysteries of Water II,* the instructional emphasis and subsequent learning should remain focused on acquisition of concrete concepts.

Scientific Inquiry

Scientific inquiry refers to "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" [National Science Education Standards (NSES), National Research Council, 1995, p. 23]. Scientific inquiry reflects how scientists come to understand the natural world, and it is at the heart of how students should learn. From a very early age, children interact with their environments, ask questions, and seek ways to answer those questions. Understanding science content is significantly enhanced when ideas are anchored to inquiry-based experiences. In the process of learning the strategies of scientific inquiry, students learn to conduct investigations and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions (NSES).

Prerequisite Science Knowledge

This module assumes that students have been introduced to, and have a familiarity with the following terms:

- <u>Matter</u>: any substance that takes up space and has mass. All matter is made of up various combinations of about 100 different elements. Hydrogen and oxygen are examples of elements.
- <u>Mass</u>: the *amount* of matter that makes up an object.
- <u>Elements</u>: combine in a multitude of ways to make up all of the living and nonliving things that we encounter. The example in this module: hydrogen and oxygen are elements that combine to form water.
- <u>Atom</u>: the smallest unit of an element that maintains the characteristics of that element.
- <u>Molecule</u>: the smallest unit of a compound that maintains the characteristics of that compound. Water is an example of a molecule.
- <u>Volume</u>: the measure of how much space a given quantity of matter takes up.

Stage 1–Desired Results

Massachusetts Curriculum Frameworks

Physical Science
Grades 3-5:

-Recognize that magnets have poles that repel and attract each other.
-Compare and contrast solids, liquids, and gases based on the basic properties of each of these states of matter.
-Describe how water can be changed from one state to another by adding or taking away heat.

Grades 6-8:

-Differentiate between an atom (the smallest unit of an element that maintains the characteristics of that element) and a molecule (the smallest unit of a compound that maintains the characteristics of that compound).
-Give basic examples of elements and compounds.
-Differentiate between physical changes and chemical changes.

National Science Standards

Content, Physical Sciences

Grade 4:

Electricity and magnetism are related effects that have many useful applications in everyday life.
As a basis for understanding this concept, students know:
e. electrically charged objects attract or repel each other.
f. magnets have two poles, labeled north and south, and like poles repel each other while unlike poles attract each other.

Grade 5:

Elements and their combinations account for all the varied types of matter in the world.
As a basis for understanding this concept, students know:
a. during chemical reactions, the atoms in the reactants rearrange to form products with different properties.
b. all matter is made of atoms, which may combine to form molecules.
d. each element is made of one kind of atom. These elements are organized in the Periodic Table by their chemical properties.
f. differences in chemical and physical properties of substances are used to separate mixtures and identify compounds.
g. properties of solid, liquid, and gaseous substances, such as sugar ($C_6H_{12}O_6$), water (H_2O) helium (He), oxygen (O_2), nitrogen (N_2),and carbon dioxide (CO_2).
h. living organisms and most materials are composed of just a few elements.
i. common properties of salts, such as sodium chloride (NaCl).

Investigation and Experimentation

Grade 4:

6. Scientific progress is made by asking meaningful questions and conducting careful investigations.

As a basis for understanding this concept, and to address the content the other three strands, students should develop their own questions and perform investigations. Students will:

a. differentiate observation from inference (interpretation), and know that scientists' explanations come partly from what they observe and partly from how they interpret their observations.

b. measure and estimate weight, length, or volume of objects.

c. formulate predictions and justify predictions based on cause and effect relationships.

d. conduct multiple trials to test a prediction and draw conclusions about the relationships between results and predictions.

e. construct and interpret graphs from measurements.

f. follow a set of written instructions for a scientific investigation.

Grade 5:

6. Scientific progress is made by asking meaningful questions and conducting careful investigations.

As a basis for understanding this concept, and to address the content the other three strands, students should develop their own questions and perform investigations. Students will:

b. develop a testable question.

c. plan and conduct a simple investigation based on a student-developed question, and write instructions others can follow to carry out the procedure.

d. identify the dependent and controlled variables in an investigation.

e. identify a single independent variable in a scientific investigation and explain what will be learned by collecting data on this variable.

f. select appropriate tools (e.g., thermometers, meter sticks, balances, and graduated cylinders) and make quantitative observations.

g. record data using appropriate graphic representation (including charts, graphs, and labeled diagrams), and make inferences based on those data.

h. draw conclusions based on scientific evidence and indicate whether further information is needed to support a specific conclusion.

i. write a report of an investigation that includes tests conducted, data collected or evidence examined, and conclusions drawn.

Enduring Understandings	Essential Questions
Students understand that: 1. Water has unique physical properties. 2. Because of these properties, water plays an essential role in supporting life. 3. The amount of water on earth is essential fixed and water moves through a cycle. 4. Humans have a responsibility to conserve water resources and improve water quality.	a. What makes water unique? b. What is the relationship between the unique properties of water and life on earth? c. What is an individual's responsibility to the local and global water resource?

Content: Students will be able to	Skills: Students will
• Describe at least six physical properties of water, including: - It exists in three forms on this planet: liquid, solid, gas; - In it's solid state, ice, water is lighter (less dense) than in the liquid state and thus ice floats on top of liquid water; - It's colorless, tasteless, odorless; - It is a good solvent; - Water molecules stick together (cohesion), forming surface tension and water droplets. • Explain that a molecule is the smallest particle of a compound that still has all the characteristics of that compound; water is an example of a molecule. • Demonstrate or illustrate the effect of heat on water molecules by showing that as heat energy increases, the water molecules vibrate faster. • Explain through writing or illustration that the amount of water on Earth remains the same, cycling over and over; driven by heat energy to evaporate and become water vapor, then condensing as it cools to become a liquid again. • Describe how at least three physical properties of water provide essential support for living systems. • Elaborate with examples on why it's important for every individual to conserve water resources and improve water quality. • Provide at least ten practices that everyone can follow to help conserve and maintain the quality of our water resources.	▪ Plan and conduct a controlled experiment. ▪ Interpret data, draw conclusions. ▪ Plot a line and a bar graph. ▪ Apply scientific knowledge to real world situations. ▪ Accurately measure volume of a liquid. ▪ Accurately measure temperature. ▪ Accurately measure length.

Assessment Evidence
Performance Tasks (Students may work alone or in small groups, but each student is responsible for demonstrating the requisite content knowledge and science skills listed above.) a. Design and conduct an experiment that explores a property of water. b. Demonstrate knowledge of what physical properties make water unique, how these properties support life, and how individuals can contribute to conserving water resources and improving water quality. Students will choose their own type of performance, such as an oral report, a feature article for the local newspaper, mural, one-act play, video or other appropriate demonstration of their knowledge.
Other evidence • Logs of class experiments and other scientific inquiries • Teacher-made tests of content knowledge and ability to apply knowledge • Participation in class activities

Student Self-Assessment: How will students reflect upon and assess their own learning?

- Reflective writing about class activities and student's performance assessments
- Discussion with peers

Learning Plan

Learning Experiences Page

Learning Experience One

What Do You Know about Water?

Overview

Guiding Questions: Why would I want to study water? What do I already know about water?

There are two purposes to this learning experience: 1) To pique students' interest in an inquiry into the scientific nature of water, the impact of water on human activity, and the impact of human activity on water; and 2) for the teacher to determine the extent of students' scientific knowledge about the properties of water.

Evaluation

Students write a description of the characteristics of the substance water. (This is a pre-assessment.)

Materials

- Chart paper for each group of 4-5 students, and teacher
- Markers
- Masking tape
- Large map of the Earth political or topographical
- A cup of water for each student

Activity One: Why Should I Care to Learn about Water?

- Before class post chart paper on the walls with these headings: Where does water occur on Earth? How do humans use water? What human foods contain water (including natural and prepared foods)? How do plants use water? Why should we all be well informed about water?
- Explain to students that they are beginning a new unit, and that you are starting with activities that will give them an overview of the unit and also help you understand what they already know about the content. Tell them that they will be working in groups. Be sure to remind students about the rules of group work (taking turns, talking quietly, etc.).
- Carousel Activity: Assign students to each chart paper, so that students are evenly divided among the five charts. Provide a marker to each group. Students assign a recorder. Explain that groups will have about two minutes at each chart to list as many responses as they can. When told to move, all groups will shift to the chart on their right. Stop after every group has visited each chart. Invite students to read the entries on each chart and add anything else that comes to mind.

- Work with the class to write a summary statement on each chart. For example, regarding the responses to the question, "Where does water occur on Earth?" students might conclude that water appears on earth in many different ways and covers a large portion of the earth.
- Students interview a partner on the question: "What are your thoughts about the role of water on this planet?" Students can report out by doing a "Think, Pair, Share" as you ask them to report what their partner's thoughts were about the question.
- The class discusses students' reflections.

Activity Two: What do I Know About Water?

- Provide each student with a potable glass of water (let students know they can drink the water). Ask students to use all their senses to study the water and write everything they know about water. Observe students' efforts, offering clues as necessary, such as: What does it look like? How does it behave? What is it made up of? In what ways is water important to life? Assure students that the purpose of this exercise is to assess what they already know; that you will therefore collect each student's work at the end of class, but will not grade it. Their work will be returned to them near the end of this unit of study so they can determine how much they have learned.
- Students then work in groups, using all of their combined information to design an advertisement for water on chart paper. Discuss the purposes of advertisements first, and have students offer examples.
- Each group presents it's advertisement to the class.
- Tell students that in this unit of study, they will be focusing on the physical properties of water that make water so necessary for living things. Define and discuss the term, physical properties, as <u>scientists</u> use it:

  The physical properties of water are those characteristics that we can <u>observe</u> or that we can <u>measure</u> without changing water into a different substance.

  Explain that 'physical properties we can observe' means those that we can detect with our senses of smell, sight, hearing, touch, and taste.

  <u>Some physical properties we can observe</u>: odor, appearance, texture, color and taste.

  <u>Some physical properties we can measure</u>: the temperature at which water melts (melting point), boiling point, density, solubility (note: density and solubility are not taught in this unit), and electrical charge.

- Students identify from the information in the advertisements all the descriptions they find that refer to the physical properties of water. List these and keep them posted.

- Ask students if they think they see any incorrect information. Post the advertisements and tell students they will have an opportunity to correct any misinformation during this investigation into the properties of water and why these properties are both special and important to life.
- Assignment: Students collect newspaper and magazine articles and advertisements, and notes they take from news heard on the radio or television that include anything at all about water—use of water, problems related to water, water in weather, and so forth. At the beginning of each class, invite students to report on what they have found. Use the students' articles and notes to build a collage on the wall or poster paper. Students should write their names on the materials they contribute to the collage. After two to three days of adding material to the collage, ask students to create a title.

Learning Experience Two

The Strange States of Water

Overview

Guiding Questions: What are the ways that the states of water are unique? How do these unique attributes affect life?

Students learn, or are reminded of physical science terms that will be used throughout the module: matter, element, atom and molecule. The definitions used at these grade levels are simple. The three states of matter are then investigated in three activities, applying what the students learn to how these properties of water support life on Earth. The investigations and discoveries by the students build the necessary information for the students to 'invent' the water cycle in the third activity. Investigations explore: the characteristics of states of matter (solid, liquid, gas) with particular reference to water, how heat affects the transition of water from one state to another, and finally the water cycle as an expression in nature of water continuously changing from one state to another.

Prerequisite knowledge

The directions assume students know the following terms. They can be introduced as necessary if students do not already know them.

- *Matter* can exist in different *states* or phases:
  - Below freezing it is a solid—water would exist either as *ice* or snowflakes.
  - Between freezing and boiling, it is a liquid.
  - Above the boiling point it is a *gas*. Water in its gaseous state is called *steam or water vapor*.
- When matter changes state from a:
  - solid to a liquid, the process is called *melting*.
  - liquid to gas, the process is called *evaporation*.
  - gas to a liquid, the process is called *condensation*.
  - gas directly to a solid, the process is called *deposition*—e.g., *frost formation*.
  - solid directly to a gas, the process is called *sublimation*—e.g., snow evaporating.

Evaluation

Each student:

- describes the effect of heat on molecules, using the terminology of states of matter.
- designs an experiment to test the effect of temperature on water volume
- diagrams and correctly labels the water cycle.
- gives at least three examples of how water, while existing in a state or as it changes state, supports life.

Materials

Activity One

- Masking tape, about 4 rolls
- Aluminum foil
- Whistle or other noise maker to get students' attention

Activity Two

For pairs of students:

- Handout One: Experimental Design
- Permanent, fine tipped marker to write on plastic
- Cup filled part way with water
- Medicine dropper
- 3 pieces of clear plastic tubing (available at hardware store or pet shop), 8 cm each
- Small piece of modeling clay (enough to plug one end of tubing)
- Small ruler, preferably metric
- Access to a freezer

Activity Three

- Open container partially filled with ice cubes in water (can use glass or plastic, any size)
- Closed container partially filled with warm water (e.g., screw-capped jar, capped plastic bottle, cup tightly covered with plastic wrap)
- Potted leafy plant enclosed in clear plastic. (Prepared the night before class)
- Hot plate and pyrex beaker or pot of water, or crock pot filled part way with water
- Index cards marked: Station 1, Station 2, Station 3, Station 4
- Large sheets of chart paper, markers, and masking tape
- Reference books or magazines that show scenes of: snow-capped mountains, coastal plain, ocean, river valley, underground cave, polar region

Activity One: How does Heat Affect Molecules (Matter)?

Set up the classroom for this activity by moving the furniture to open a space large enough for all the students to stand with about two feet between each other. Seating should be available.

- When students arrive, ask them to find a place to sit just long enough to introduce the activity. Explain that for the next few days they will be investigating some of the more interesting properties of water—properties that enable life to exist on earth.
- First review the terms matter, atom and molecule, which will be used throughout this unit of study. Explain that scientists have their own vocabulary. In order to discuss scientific information, we need to understand this vocabulary, much the way we would need to know German if we wanted to have a conversation with

someone from Germany. Students may be able to provide definitions that are understandable. Encourage simplicity. Use a dictionary when necessary. The following definitions are sufficient:

<u>Matter</u>: Anything that takes us space and has mass.

<u>Element</u>: Any material that can't be changed into another substance under normal circumstances (that is, through chemical reactions). Elements are the building blocks of all the matter in the universe. In all, there are just over 100 (some say 117, others say 118) elements that have been identified. Some examples are gases such as oxygen, hydrogen (the building blocks of water), and chlorine; and metals such as lead, iron, aluminum, and copper.

<u>Atom</u>: The smallest particle of an element.

<u>Molecule</u>: Made up of two or more atoms that have chemically combined to form a new substance. Three common examples are:

> **Water (made of 2 atoms of hydrogen and 1 atom of oxygen)**
> **Table salt (made of one atom each of sodium and chlorine)**
> **Sugar (made of atoms of hydrogen, carbon, and oxygen).**

- Demonstrate the concept of an atom by holding up a piece of aluminum foil. Remind students that aluminum is an element. Tear off a piece and hold this up. It's smaller, but it is still aluminum. Tear this piece. It is still aluminum. As you continue to tear into smaller and smaller pieces, confirm with students that you are still holding a piece of the element aluminum. When you have a piece as small as you can hold, ask what would happen if you could keep tearing into smaller pieces, so small you couldn't see them anymore, even with a microscope. Eventually, you would be holding a single atom of aluminum. You cannot tear it apart any further. You have torn the aluminum down to its smallest particle—an atom of aluminum.
- Instruct students to stand in the center of the space as close as possible to each other without touching. Ask them to imagine that they each are an atom of aluminum, and together they are a small sheet of aluminum. They are in the *solid* state, which is the state that we experience aluminum on earth under natural circumstances. Ask for two volunteers to step out of the group long enough to help you define the perimeter of the group by taping masking tape to the floor.
- Tell students it's very important for them not to talk during this demonstration unless they raise their hand to answer or ask a question. (Continue to reinforce throughout the activity).
- <u>The solid state</u>. Move close to the encircled students and explain that you will represent heat energy, such as a very hot fire, by clapping. The faster you clap the more heat the aluminum will receive. Clap very slowly and tell students to sway

very slightly to the beat of the clapping, without moving their feet. Explain that atoms in all solids are always moving, or vibrating, just a little (exception unnecessary to explain to students: molecules are no longer in motion if the molecules reach a state of no heat at all, which doesn't occur naturally on earth).

- The liquid state. Now tell them that you are going to increase the speed of your clapping just enough for the aluminum to *melt* and become a *liquid*. Ask them to sway a little more, following the beat of your clapping; ask them to now move their feet very slightly from side to side as they sway. They should still remain close to each other but avoid touching each other. Stop for a moment and ask students what they notice. They may be taking up just a little more space than before (check the perimeter now that was previously defined by the masking tape), but not necessarily. Remind them that they are now *liquid* aluminum—very hot. Ask them if, now that they are in the liquid state, they could form another shape. Remind them that they have melted. Challenge the students to stay close to each other without touching but to move to the beat of the clapping so that instead of swaying in one place they actually flow. This mimics what a real liquid would do. Remind them to stay the same distance apart. Clap at the same rate, as they move (flow).
- Stop clapping (students should stop moving as well). Ask them what limited the shapes they could take. Certainly the number of students, or atoms, determined how far the liquid aluminum could flow, but they could form many shapes.
- Now tell them that you are going to apply more heat, but first, you're going to put them in an open container. Ask for three or four volunteers to help you quickly rearrange the masking tape to contain the liquid, but leaving one opening that is wide enough for no more than 2-3 of the students to be able to move through at a time.
- The gaseous state. Tell the students that when you clap faster, the heat will be great enough for the aluminum to *evaporate* and become a *gas*. The rule of standing close to each other no longer applies and the students can move around to keep in step with the beat of the clapping, but never touch another atom. The other rule is that students must stay inside the masking tape, noting that there is just one opening to their container where they could leave. Caution students to be careful not to bump into each other or to talk. Clap faster while students move. Students near the opening should soon realize they can move out, leaving room for the other students to move apart until more and more of them have escaped the container. Stop clapping and ask the students to stop moving.
- Ask students to describe what has happened. Prompt students to use the scientific terminology to describe that the aluminum *atoms evaporated* and the *gaseous atoms* spread out of the container, moving further and further apart.
- Ask students to sit down so that you can debrief the activity with them.
    - What was the major difference between the piece of aluminum as a solid and as a liquid?
    - How was the liquid aluminum changed when it evaporated?
    - What did you think was realistic about the demonstration of what happens when a solid is heated?
    - What did you think was not very realistic?
    - What would have been different if you had each represented a *molecule* of water? (Students might know that solid water takes up more space than

liquid. If no one makes this observation, do not provide an answer. The next activity measures the expansion of water when it freezes.)

- Apply the concept of states of matter to water: Ask students what the 'melting point' (the temperature at which ice melts) of ice is and the 'boiling point' (the temperature at which water evaporates) of water. Note that these temperatures are all normal Earth temperatures. Tell students that water may be the only chemical substance on the planet Earth that exists in nature as a solid, liquid, and gas. Ask if they can think of any other substances that do this. If students mention soft drinks, remind them that these drinks are mostly water and it's the water that is freezing, melting and evaporating. Most chemicals are found in only one state on Earth, while water exists in three states: as ice or snow, as a liquid, and as water vapor or steam. This is quite remarkable! Ask students to talk with a partner about this unusual attribute of water. Students can report out by doing a "Think, Pair, Share" as you ask them to report what their partner's thoughts were about the question.

Activity Two: How does Freezing Affect the Volume of Water?

Students' experimental designs may vary to some extent, but in general they will all place water into a piece of plastic tubing, mark the level of the water, freeze the water, and measure the depth of the ice. Freezing such a small volume of water takes only about 10 minutes. Some students may want to compare the height of the frozen water starting with two or three different amounts of water.

- Tell students that water has more unusual physical properties than the fact that it exists in all three states on Earth. Ask students to describe what is unusual about what happens to water when it freezes and becomes ice. (Prompt: what can happen if you freeze a bottle or can of soda?) It is all right if students don't know that water expands when it freezes, since the following experiment will demonstrate that property. If students do mention that water expands when it freezes, tell them that in this experiment they will study this special property of water.
- Introduce an experiment to compare the volume of water in its liquid state to its frozen state. Tell students that they will work with a partner to design an experiment to answer the question: How does freezing affect the volume of water? If students have already observed that water expands when it freezes, ask them if they know how much it expands? If they had 10 milliliters of liquid water, how many more millimeters would that sample be after it had frozen? This experiment will provide students with precise data on just how much a given volume of water expands when it freezes.
- Distribute the materials: plastic tubing, marker, water, dropper, clay, ruler.
- Students work with their partners to design an experiment, using Handout One as a guide.
- Ask students to read their designs. Ask students to offer suggestions to each other as necessary to ensure that only one variable is being measured: the volume of the water as the temperature changes. The temperature is the only change that can occur throughout the experiment. Everything else must remain the same. *If students don't yet know the term variable, explain that the experiment must be fair.*

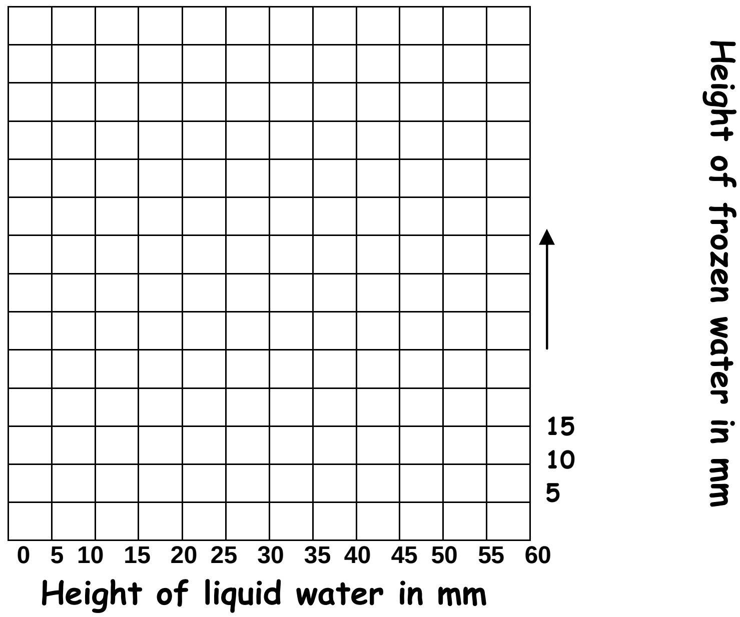
To be fair, the only thing that they change during the experiment is the temperature of the water. If in their design they are changing more than the temperature, then it is not a fair experiment.

- Explain to students that they will compare their results to other groups and therefore measuring accurately is very important. Students should seek help from other students if they are not confident in using the ruler. Also, if the ruler allows for both metric and English measurements, ask students to use the metric. Help students make a chart to record their data. An example follows:

Number of drops of water used	**Height of liquid water in tubing in millimeters**	**Height of solid water (ice) in tubing in millimeters**

- Allow time for student teams to prepare their experiment and set the tubes in a freezer. You can continue to Activity Three while students are waiting for their samples to freeze.
- After students have collected their data, create a class chart.
- Ask students if there is another way to look at the data. Would a graph be easier to read than the chart? An example of a graph follows. This graph would show the relationship of the volume (actually measured in height) of water to ice.

A graph comparing how much space in a hollow tube a given volume of water takes up as a liquid and a solid



- Talk with students about whether they can accurately compare their data from all the teams. Before they decide, ask them what questions they want answered by the other teams. Prompt students to consider accuracy of measurement, and whether the readings were ever rounded up or down. Also, did the modeling clay take up space inside the tubing; of so did the students measure from the bottom of the tubing or the top of the clay inside the tubing? If students determine that there are reasons why they cannot compare their data, ask for volunteer teams that used more than one sample to plot their data on your graph. Students may also repeat the experiment, this time agreeing as a class on all the protocols. Explain that scientists have to be very specific about how they conduct an experiment, because they or other scientists may want to repeat or modify it.
- Discuss students' observations about the data.
    - What did you learn from the experiment about what happens when water changes from liquid to solid?
    - How does this explain why frozen water (ice) floats on liquid water? *It's not necessary for students to fully understand the concept of density to get the basic concept that the same amount of molecules present in liquid water was spread out over more space, so ice would be lighter than liquid water. Normally, the solid state of a substance takes up the same or less space than the liquid.*
    - What are some examples of how living things benefit from the fact that ice floats on liquid water? (e.g., aquatic animals surviving winter, protected by a layer of ice above them, rather than being crushed as the water freezes and sinks; polar bears being able to walk on ice floes, diving into the water to capture prey, and returning safely to a solid surface.

- Place students in small groups. Students will brainstorm examples of how this property of water—ice being less dense than liquid water and thus floating on it—is important to some living things. This may require prompting, possibly with visuals.

Activity Three: How the States of Water Create the Water Cycle in Nature

Part A: Breaking the cycle down into its component parts

- Before class, prepare the containers of ice water and warm water, bringing the water on the hot plate to a simmer.
- Arrange and label four stations: Station 1: simmering water; Station 2: water in closed container; Station 3: ice water; Station 4: plant. to demonstrate: evaporation, condensation and transpiration (covered plant)
- Divide students into four groups, assigning each group to one of the stations. Assign a recorder and reporter. Instruct students not to touch anything, and to keep at a safe distance when they are near the simmering water on the hot plate.
- The recorder will write everything the students observe about the water at each station. Instruct students to write only their <u>observations</u>, i.e., what they <u>see</u>.
- When it's time to change stations, ask students to move clockwise to the next station.
- Meanwhile, prepare a carousel. Post four pieces of chart paper. Headings will include the station number plus description, e.g., Station 1: simmering water, Station 2: water in closed container, Station 3: ice water, Station 4: covered plant.
- When groups have documented their observations at all four stations, ask the groups to each stand by a chart. Groups record their observations onto the chart paper. Students then move clockwise from chart to chart, adding any observations that were not already posted by the previous group. When they have an observation that is already recorded, they can place a check mark beside it.
- Based on these observations, students work in pairs to describe what they thought was occurring at each station with regard to the water, using scientific terminology. You may want to post terms from which students can select: e.g., liquid water, ice, water vapor, steam, gas, solid, melt, freeze, evaporate, evaporation, condense, condensation, transpiration, sublimation, deposition.
- Ask four triads to each write on one of the charts what they thought was occurring and the reasoning behind their decision. Discuss as a class. Students will probably describe the plant as demonstrating evaporation of liquid water from the plant into water vapor which then cooled and condensed on the inside walls of the plastic covering. Introduce the term *transpiration* to describe the process of water evaporating from the leaves of plants. You may want to also explain that plant leaves have small openings from which water is released. Water evaporates from the surface.
- Write on the board under the heading, 'Terms used in describing changes of state of water': Melt, freeze, evaporate (or evaporation), transpiration, condense (or condensation), precipitate (or precipitation), sublimate (or sublimation), and deposition. Ask students to provide a description of each term. It is likely that students won't know the last two terms. Give an example for each:

Sublimation: snow and ice (solid) evaporating directly into water vapor (gas)

Deposition: water vapor (gas) condensing directly into frost (solid) (Hint for remembering: The root of the word is 'deposit.')

- Students work in eight small groups. Each group is assigned one of the terms they just defined: Melt, freeze, evaporate (or evaporation), transpiration, condense (or condensation), precipitate (or precipitation), sublimate (or sublimation), and deposition
- Groups create a labeled drawing on a large piece of chart paper to represent as many examples as they can think of where water undergoes that process in nature.
- Groups post and explain their illustrations to the rest of the class. Invite students to add more examples to the charts.
- Ask students where the heat energy comes from for the process of evaporation (the sun, which should be included in the drawings).
- Write terms on the board that you think students may have difficulty recalling or spelling, such as:

atmosphere	**precipitation**	**evaporation**
sublimation	**deposition**	**condensation**

- Students interview a partner on the question: When you look at these charts, what thoughts come to mind about water? Invite students to share some of the comments with the class.
- Write on the board:

The total amount of water on planet Earth never changes.

No water is ever lost.

Almost no water enters from space.*

About 96.5% of the water on Earth is in the oceans.

*Teacher's Note: Many scientists accept that small quantities of water are continuously being introduced to our planet via comets in the form of cosmic rain. Some scientists even believe that the bulk of the water on the planet may have arrived in the form of cosmic rain. An undetectable amount of water enters from outer space each year, but is so miniscule that it only has an impact on the water cycle in terms of hundreds of millions of years not decades or centuries.

- Assignment: Ask students to think about the information on the board. Ask students to imagine that they are a molecule of water on planet Earth. They are very old, billions of years old. Instruct students to write a narrative about some highlights of their travels on Earth over these billions of years. Provide Handout Two as a guide.

Part B: Combining the parts of the water cycle to create the whole picture

- Students work in triads, taking turns to tell their stories. Listeners ask questions about anything they didn't understand or about what they want to know more.
- Each student completes this sentence: On planet Earth, water is . . .
- Discuss some of the responses.
- Ask students if they know what scientists call the process they have been describing—the movement of water on the planet—how it evaporates, falls back to earth—moving in, through and out of living things. Write on the board:

Water Cycle

- Ask students why it is called a cycle. Where else is the word *cycle* used—and what does it mean in those other uses (such as, bicycle or cycling). Given what they know about the changes of state of water, and what they know about the word, 'cycle,' ask how they would define the term, water cycle. Ask each student to write a definition of water cycle. Post students' ideas, prompting to be sure the following are included: a process that goes on all the time, describes where water is located, includes all the ways that water moves on the planet, is driven by the heat energy of the sun.
- Tell students they are going to create a mural for the wall that represents the water cycle. (Refer to Notes to Teachers for a diagram and description of the water cycle.) Place students into six groups. Provide each group with a large sheet of chart paper and several colors of markers. Charts should be positioned horizontally (wider than they are high). Assign each group to draw one of the following scenes, including the atmosphere above. Each drawing should be a side view so you can see the land or water environment and the atmosphere above it. Have references (books, magazines) available with appropriate scenes if you think students will need help visualizing their assigned scene.

Chart 1: ocean
Chart 2: coastal plain or wetland area
Chart 3: snow-capped mountains
Chart 4: river valley, with the river opening into a lake
Chart 5: polar region
Chart 6: underground cave

- Ask each group to use arrows and words to show the parts of the water cycle that would be happening in the scene they have drawn.

- Students tape their scenes side-by-side, except for the cave scene which is taped underneath one of the other five scenes.
- The members of each group take turns pointing out to the class the parts of the water cycle occurring in their scene. The listeners can be invited to add details.
- Debrief:
  - Which scene represents the largest source of water for the water cycle? Tell students that the ocean actually provides about 90% of all the water that evaporates into the atmosphere.
  - Have they included in their scene the primary source of heat energy for evaporation and sublimation? (sun) Should they, if they haven't? Why or why not? (not in the cave)
  - What would happen to water organisms that live in cold climates if water behaved like all other substances when it turned to a solid and sank instead of floating?
  - What part do all the plants on earth play in the water cycle? Tell students that plants provide about 10% of the water that evaporates into the atmosphere. (Thus, plants and the oceans are the main sources of atmospheric water)
  - Why is the water cycle a necessary process for the survival of humans?
- Remind students that the water cycle, which is so necessary for ensuring that water is available everywhere on earth, is made possible because water appears naturally on Earth in three states: solid, liquid and gas. Amazingly, it is the only substance on Earth that does. Briefly explain and discuss some of the ways the water cycle is so important for living things.
  - Water in the oceans and the atmosphere absorbs a lot of heat without changing state. It also gives off that heat slowly. This has a moderating effect on weather.
  - Water currents affect temperature. Look at the location of England on a world map. Compare the longitude with other areas at the same longitude that have much colder climates. It's the Gulf Stream that flows up the east coast of North America and then, in a circular pattern, flows east where it warms England before cycling south again where it warms and repeats the pattern.
  - Polar ice is a home for polar bears, who feed in the cold waters, then climb back onto the ice. Without the polar ice, the bears would not be able to survive.
  - Ice on the surface of large bodies of water allows aquatic organisms to survive the winter, protected under the ice.
  - The cycling of water moves water from its huge reservoir in the oceans to the land by evaporating into the atmosphere, where the water vapor is carried by currents in the air, cooling and condensing, and then falling to earth over land masses.

LE 2 Handout One

Experimental Design and Data Collection

Question to investigate: How does freezing affect the volume of water?

What is your hypothesis (What do you think the answer to your question is?)

How will you compare the volume of liquid water to the volume of water after it freezes?
Write the steps you will take:

1. ____

2. ____

3. ____

4. ____

5. ____

(continue as necessary)

Make a chart to record your data:

LE 2 Handout Two

An Imaginary Tale

Imagine: You are a molecule of water. Like every other water molecule, you have been on Earth since the beginnings of this planet.

Remember the definitions of **atom: The smallest particle of an element,** and **water molecule: Made up of two or more atoms that have chemically combined to form a new substance. Water is made of 2 atoms of hydrogen and 1 atom of oxygen**

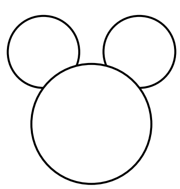
Write a short story about the highlights of your life.

1. Include a title for your story.

2. Here are some questions to get you started:

* Where are some places that you have you been? How did you get there?
* What have you done in each of those places?
* What were the most memorable places you traveled to?
* What was your favorite place? What were you doing there?
* Describe your involvement in what humans would call a natural disaster.
* How did you help to save a life?
* When were you frightened about your surroundings?
* Did you even do anything you were sorry about later?
* What were some of the most important things you've done?
* Is there a person, plant or animal you were in that was special?

3. You might want to include some illustrations of your adventures. Here is a commonly used cartoon drawing of a water molecule. Some people say it resembles the head of Mickey Mouse. The two small circles represent hydrogen atoms and the large circle is an oxygen atom.



4. Here are some scientific terms for your story:
   Melt, melted
   Freeze, frozen
   Evaporate, evaporated (or Evaporation)
   Transpiration
   Condense, condensed (or Condensation)
   Precipitate, precipitated (or Precipitation)
   Sublimation, sublimated
   Deposition

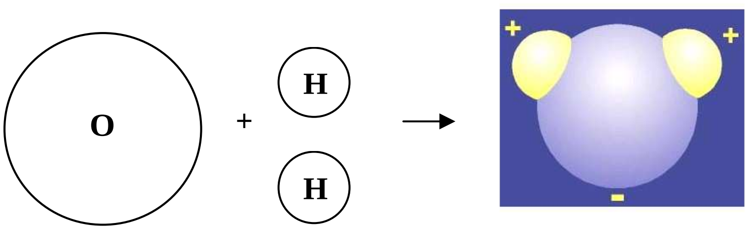
Notes to Teacher

Background information on water
Note: This is more technical than what students need to know.

Water covers over 70% of the earth's surface. Water is so common and abundant that we often take it for granted and don't realize that water is one of the most unusual and unique substances in the solar system and possibly in the entire universe.

What are the physical properties that make water so unique? To understand these special properties, it is first necessary to understand the chemical structure of the water molecule. Water is a very simple molecule made of two atoms of hydrogen and one atom of oxygen. Hydrogen and oxygen are two of the lightest atoms on the Periodic Table of Elements. When these atoms chemically combine to form water, unusual properties occur. A molecule of water is formed when two atoms of hydrogen, which is highly explosive and the very lightest of all elements, combine with one very light and very reactive oxygen atom. The single electrons from each hydrogen atom form a bond with electrons from the oxygen atom to complete the outer electron orbits for each atom to produce the new water molecule. The electron pairs are closer to the oxygen molecule. This produces a negatively charged pole (-) at the oxygen end. The hydrogen atoms at the other end of the water molecule carry a positive charge (+). The result is a highly charged *bi-polar* molecule of water.

1 oxygen atom and **2 hydrogen** atoms
combine to form 1 water molecule



Each bi-polar water molecule now acts like a magnet to attract or repel other charged polar substances. The opposite charged ends of each molecule attract opposite charged poles from other molecules to form weak bonds called Hydrogen Bonds. All these molecules will stick to each other like a pile of magnets. When water molecules stick to each other, this is called *cohesion*. The property of cohesion enables water to be pushed and pulled in a variety of ways, similar to magnets. When this cohesion of water molecules happens at the surface of the water, it is called *surface tension*. The cohesive force between water molecules may be strong enough to keep objects that may be denser than the water (e.g. pins, paper clips, many bugs, and the like) from breaking the surface tension of the water and thus, the objects sit on the surface of water as if it were a trampoline. The phenomenon also explains the formation of water droplets.

Because water is such a strongly charged polar molecule, the positive (+) and negative (-) polar ends of water molecules attract many other electrically charged molecules to form new Hydrogen Bonds. The new Hydrogen Bonds keep these substances uniformly mixed with the water molecules. This mixture is called a *solution*. Many types of salts are charged polar molecules and will readily dissolve in water to form a solution. That is why water is called the universal solvent. Each and every drop of open ocean sea water is a highly charged ionic soup with each drop containing over 60 elements from the Periodic Table. This unique property of water is also why water is so important to all living things on earth. Every nutrient, enzyme, and other chemicals necessary for life processes are all able to dissolve in water, where life-supporting chemical reactions occur. Water is also the means by which chemicals are transported throughout the organism.

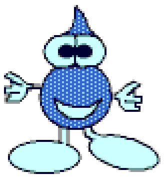
In a similar manner, water molecules are attracted to the molecules of solid substances, such as glass, and even the vascular structures in plants and in animals. This attractive force is called adhesion, because the water is attracted, in this case, to other substances. Adhesion explains capillary action, including for example, the movement of water even against gravity through narrow tubing (e.g., the tubing used to collect a small sample of blood from the tip of the finger), up a plant from the roots to the leaves of a tree, and through the capillaries in animals.

Water is also unique in that its solid form, ice, is less dense than its liquid form. Ordinarily, in a water molecule, the angle that holds the two hydrogen atoms to the oxygen atom is 105 degrees. When water freezes, the angle expands to 109 degrees. This increase of separation of 4 degrees between each hydrogen molecule as the water freezes and changes from the liquid phase to the solid phase increases the amount of space each water molecule takes up. In addition, the lower temperature slows molecular motion in the liquid water. As water turns to a solid, many new multiple Hydrogen Bonds develop between the hydrogen atoms to fix the ice in a crystalline matrix. This further slows the motion of molecules and reduces the fluid nature of liquid water. The result is an increase in the space the ice takes up. The ice volume increases but the mass remains the same. This change makes the expanded ice molecules less dense than the same number of water molecules, so the ice floats. The expansion of each freezing water molecule by 4 degrees and the formation of many new Hydrogen Bonds as it expands into the crystalline state of ice, produces a very powerful force. Expanding ice molecules can crack metal water pipes, rupture automobile engine blocks, split rocks in half, and change the face of mountains and continents. It was the force caused by the formation of ice that broke the ‘face’ off the "Old Man in the Mountain," New Hampshire's state symbol, a huge boulder in the White Mountains of the Northeast that resembled a facial profile.

Water, which we may take for granted, is in fact an extraordinary substance. Every time we add ice to a glass of water and watch the ice float, it is a scientific marvel. If water were not unique and ice didn't float, then conditions on our planet Earth would be greatly altered. If the ice on the earth sank deep into the *aphotic abyss*, the portions of oceans and lakes that are not exposed to sunlight, these bodies of water would freeze from the bottom up and the earth would be completely changed. Also consider that the oceans’ waters serve as a heat buffer, moderating temperatures, particularly coastal lands. Water vapor in the atmosphere performs a similar buffering function.

Water Cycle
The following diagram and narrative can be found, with hot links to more information, at http://ga.water.usgs.gov/edu/watercyclesummary.html

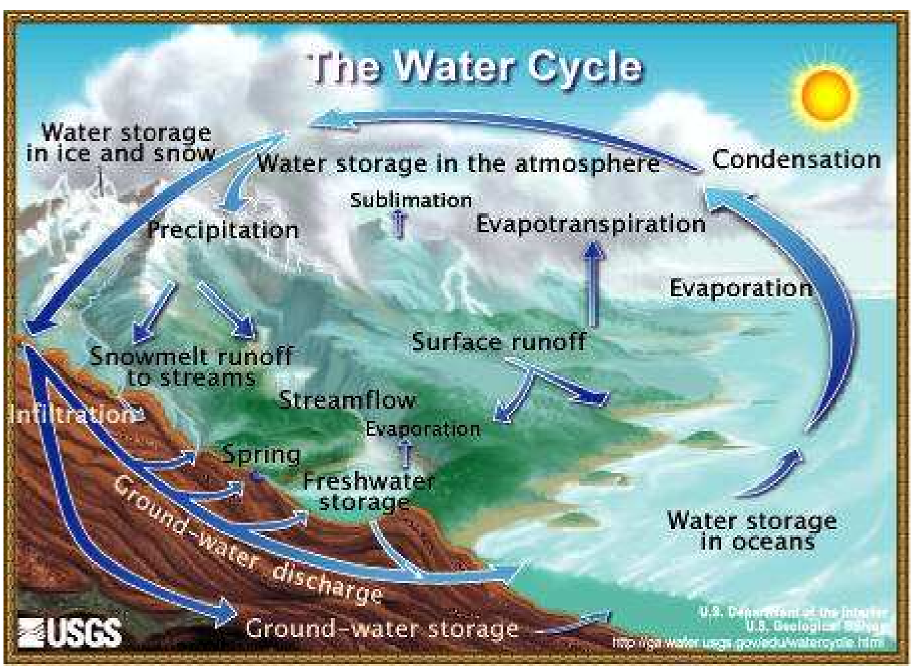
What is the water cycle?



What is the water cycle? I can easily answer that—it is "me" all over! The water cycle describes the existence and movement of water on, in, and above the Earth. Earth's water is always in movement and is always changing states, from liquid to vapor to ice and back again. The water cycle has been working for billions of years and all life on Earth depends on it continuing to work; the Earth would be a pretty stale place to live without it.

Where does all the Earth's water come from? Primordial Earth was an incandescent globe made of magma, but all magmas contain water. Water set free by magma began to cool down the Earth's atmosphere, until it could stay on the surface as a liquid. Volcanic activity kept and still keeps introducing water in the atmosphere, thus increasing the surface- and ground-water volume of the Earth.

A quick summary of the water cycle



Here is a quick summary of the water cycle. The water cycle has no starting point. But, we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it *evaporates* as *vapor* into the air. Ice and snow can *sublimate* directly into water vapor. Rising air currents take the vapor up into the atmosphere, along with water from *evapotranspiration*, which is water *transpired* from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to *condense* into clouds. Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as *precipitation*. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and ground-water seepage, accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers, though. Much of it soaks into the ground as *infiltration*. Some water infiltrates deep into the ground and replenishes *aquifers* (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as ground-water discharge, and some ground water finds openings in the land surface and emerges as freshwater springs. Over time, though, all of this water keeps moving, some to reenter the ocean, where the water cycle "ends" ... oops - I mean, where it "begins."

Learning Experience Three

The Attractive Nature of the Water Molecule

Overview

Guiding Question: What property of water helps it move from the roots of a tree to the leaves against the force of gravity, helps blood circulate through the tiniest vessels in our body, and allows some insects and small aquatic organisms to stay on the surface of a body of water rather than sink?

Students work in groups to explore the 'sticky' nature of water. They observe how water beads on a surface, how water rises in a capillary tube, and how an object that normally sinks in water can be made to float. Students compare the behavior of magnets to that of water molecules in order to explain the 'sticky' behavior of water as the result of water molecules having an attractive force both to themselves and to other substances that have an electrical charge.

Note: In the secondary module students create models to more fully explore and understand the nature of this charge. At this grade level, it's sufficient for students to observe that water tends to be 'sticky' and that this accounts for a number of phenomena that support life.

Evaluation

Students describe the properties of cohesion and adhesion and explain at least two ways that these properties help support life.

Materials

Per group or 3 (or 4):

- 2 pennies
- Cup partly filled with water – labeled
- Cut partly filled with rubbing alcohol -- labeled
- 2 droppers
- 2 pieces of glass capillary tubing (If high school doesn't have this, ask a clinical lab.)
- Plastic fork
- 4 paper clips
- Handout One
- Pair of magnets (optional learning extension)

Activity: Exploring the Properties of Cohesion and Adhesion

- Place students in small groups. Distribute the materials, including Handout One. There are three explorations; instruct students to take turns being the reader and being the person who does the exploration. Every student should draw what he sees. Circulate among the groups, listening to students' discussion, asking questions (refer to handout) if necessary to sharpen students' observations.

- As a class, talk about the students' observations:
  - o Compare the way the water behaved to the way the alcohol behaved. What was the same? What was different?
  - o Where have you seen this behavior of water (e.g., insects walking on water, water drops beading on a plant leaf or blade of grass). *Be sure students do not confuse the floating of the paper clip with the floating of a ship—there is a different principle operating. Students may want to investigate buoyancy.*
- Provide the terms to explain this 'sticky' behavior of water:

Cohesion: The attraction of water molecules to <u>each other</u>, causing them to 'stick' together. This forms a 'skin' on the surface of water, which takes some force to break through. This 'skin' is called:

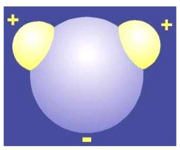
Surface tension

Examples: water forms drops and beads, some insects can walk on the surface of water.

Adhesion: The attraction of water molecules to some other materials, causing the water to stick to these materials.

Optional extension:

- o Explain to students that water molecules have a different electric charge at each end. Draw a water molecule on the board:



- o Tell students the (+) or positive charge is attracted to the (-) negative charge of another water molecule, or even a molecule of a different material, such as glass. Keep the explanation simple.
- o Distribute the bar magnets to each group. Ask students to observe and describe what happens when two magnets are brought close to each other. Tell students that the positive and negative electric charges on a water molecule are similar to the north and south poles of a magnet.
- o Given that explanation, each student will write a description of why water molecules stick to each other, a process called cohesion, and stick to some other materials, a process called adhesion.

- Provide examples in nature of how cohesion and adhesion support life (it might be helpful to provide images):

- Cohesion: Some small organisms are able to live right on the surface of bodies of water (their niche, if students know this term). Others, like water striders, move from place to place by walking on the surface of water.
- Cohesion and adhesion working together:
  - These two properties of water allow plants to grow very tall. Water moves upward in plants that have tubing (called xylem), which is similar to the tubing used in the exploration. The movement of water upward from the roots through the xylem actually defies the force of gravity. Think about how high above the ground water moves in a giant sequoia tree! Actually, there is a third property of water that contributes to this upward flow of water in a plant. The evaporation of water from small openings in the leaves of trees. This process, called transpiration, was observed in a previous activity. As the water evaporates, it helps ‘pull’ the water up the xylem.
  - Adhesion and cohesion of water molecules allow blood (which is primarily water) to flow through tiny capillaries to reach all the cells in our body.

LE 3 Handout One

Comparing the Behavior of Two Liquids

Three Explorations

1. Place the 2 pennies flat on the table where everyone in your group can see them. Add drops of alcohol to one penny. Add drops of water to the other penny. Draw what you see. Label the penny, water, and alcohol.

<u>Test this</u>: How many drops of water will the penny hold before spilling over. How many drops of alcohol?

---

2. Hold one glass tube straight up and down. Touch the glass tube to the surface of the water. Repeat with the alcohol. Draw what you see. Label the water and alcohol.

---

3. Drop a paper clip in the cup of water. Drop a paper clip in the cup of alcohol. Place a paper clip on the fork and lower the paper clip slowly into the water. Do the same with the alcohol.

Describe what happens.

<u>Group Discussion</u>

Talk about how the water behaved compared to the way the alcohol behaved. What was the same? What was different?

Learning Experience Four

Water as the Universal Solvent

Overview

Guiding Question: Why is water called the universal solvent?

Students learn the term, universal solvent. They then design and conduct an experiment to compare the solvent capacity of water to that of alcohol. The teacher provides examples of how water's capacity to dissolve most substances is important to living things. At the conclusion of this Learning Experience, students work alone and then in groups to summarize what they have learned about the physical properties of water and why these are so important to living things.

Evaluation

- Each student explains the results of the experiment.
- Each student provides at least three examples of how the physical properties of water make life possible on Earth.

Materials

For the class:

- 2 transparent cups filled with water
- Food coloring
- Sugar
- Masking tape

Per group of 3-4 students (set up a supply table):

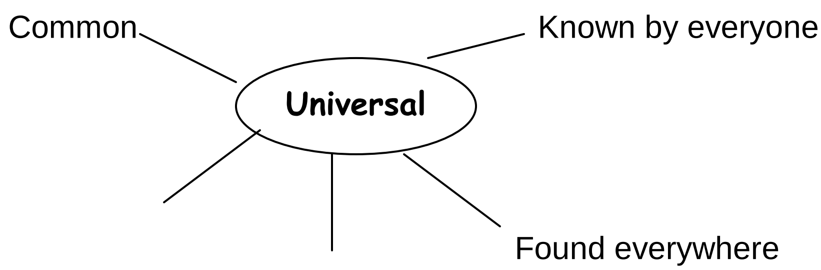
- Table salt
- Sugar
- 2 transparent cups
- Supply of water
- Supply of rubbing alcohol
- 2 Stirrers
- Marker that writes on plastic
- 2 ¼-teaspoon measurers
- Optional: scales or a balance
- Large sheet of chart paper, markers

Activity One: Investigating the Solvency Property of Water

- Introduce this property of water by writing on the board:

Scientists describe water as the universal solvent.

- Ask students if they know what this means. What words are new? Use word mapping to explore definitions for universal. Look at the root of the word for clues.



Solvent may be a less familiar term. Ask if students can describe what the word *dissolve* means. Students refer to a dictionary to find a scientific definition. Ask students to compare the words solvent and dissolve to discover that both words have the same root. Students use the dictionary to define the prefix in the word dissolve and look for familiar words that begin with the same prefix.

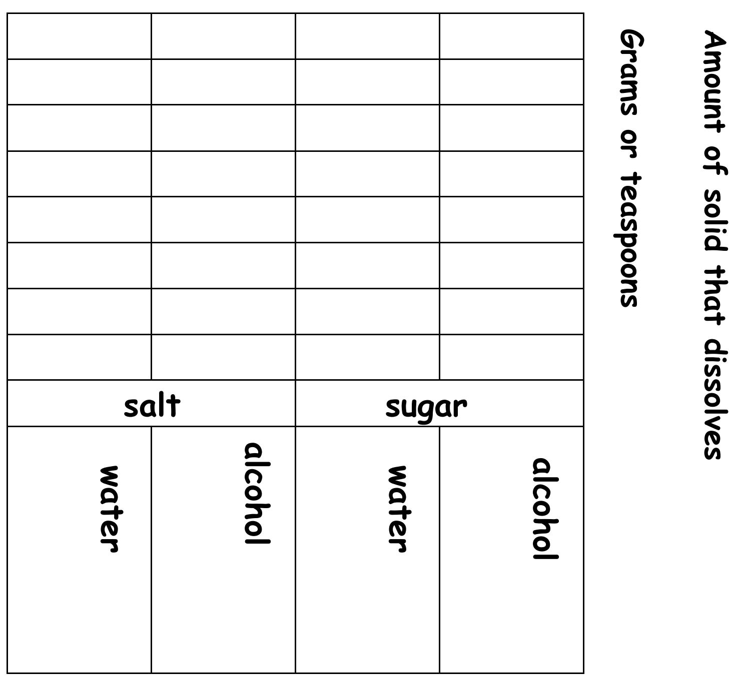
- Explain that in scientific language, a *solvent* is a substance in which other substances will break up and become evenly distributed. This is called *dissolving*. Demonstrate by asking students what will happen if some sugar is added to a cup of water. Have a student conduct the test for the class. Students will see that the substance being dissolved is no longer visible. Ask students if substances always disappear completely when they dissolve. What will happen if a drop of food coloring is added to water? Have a student do the test. Ask the students how they know the food coloring was dissolved. Students will see that the color is still visible and the food coloring becomes evenly distributed throughout the cup of water.
- Tell students that they will be designing an experiment to investigate the solvent property of water. They will test two common substances, table salt (sodium chloride) and the simple sugar commonly used at home to sweeten foods and drinks (glucose). In order to compare water's capability as a solvent, they will also test alcohol. They will be using household alcohol, which is a solution of isopropyl alcohol and water, usually 91% alcohol and 9% water, so it's mostly alcohol. Note that this is an example of a liquid dissolved in another liquid.
- Tell students that they will work in small groups. They should assign tasks and also take turns with each task. Tasks are:
  - Gathering the materials, disposing of wastes after the experiment, and returning materials to the supply table
  - Recording the data
  - Performing the test—measuring the solids, stirring
  - Everyone is responsible for observing the results and agreeing on what data to record.

- Place students in groups. Distribute Handout One. Groups design their experiment.
- Ask students to read their designs. Invite students to offer suggestions to each other as necessary to ensure that only one variable is being measured: the amount of the test solid (sugar, salt) that is added to both liquids. Everything else must remain the same: the amount of liquid (water, alcohol), temperature of the liquids (most likely both will be at room temperature). Remind students that measuring accurately is very important. Discuss options on how to measure the solid in small enough amounts so that they will know the amount the liquid was just able to dissolve. Ask, what would be wrong with: not measuring the amount added, not adding a little at a time? If balances are available, some students may choose to weigh the solids, while other students may decide to measure the volume of the solid using the teaspoon or other tool that will measure small amounts.
- Help students make a chart to record their data. An example follows:

Solvent being tested:	**Maximum amount of sugar that dissolves**	**Maximum amount of salt that dissolves**
Alcohol		
Water		

- Students conduct their experiment.
- After students have collected their data, create a class chart.
- Ask students if there is another way to look at the data. Would a graph be easier to read than the chart? An example of a bar graph follows.

A graph comparing how much solid will dissolve in a given amount of alcohol and water



- Groups create a graph on the chart paper.
- Discuss students' observations about the data.
  - What did you learn from the experiment about the solvent property of water and alcohol?
  - [If results varied among groups] What might account for the different results among the groups?
  - Would the temperature of the liquid affect the results? How would the results be different if the liquids were hot? Why? (refer to Learning Experience 2)
- Discuss with students ways that it is important to living things that water is an excellent solvent. Refer to 'Notes to Teachers' for examples. Invite students to think of ways. Write all the ways on the board or chart paper. You may also want to discuss the negative consequences in relation to pollutants.

Summary Activity for Learning Experiences One - Four

- As a summary of the first four Learning Experiences, students write a response to this question: Astronomers look for life on other planets. The clues they look for are: water and a temperature range similar to that on earth. Why are these two features the most important clues?
- In small groups, students synthesize their ideas. Each group present its reasoning to the class.

LE 4 Handout One

Experimental Design and Data Collection

Question to investigate: How does water compare to alcohol in its capacity to dissolve salt and sugar?

What is your hypothesis (What do you think the answer to your question is?)

How will you compare the amount of salt and sugar the water is able to dissolve to the amount that alcohol is able to dissolve?
Write the steps you will take:

1. ____

2. ____

3. ____

4. ____

5. ____

(continue as necessary)

Make a chart to record your data:

Notes to Teacher

Water as the ‘universal solvent’

Water has the unique property of being able to dissolve so many other substances that water is described by scientists as the "universal solvent." This property has both positive and negative consequences.

On the positive side, water has a critical role in all living things. It carries oxygen and nutrients to living cells and carries carbon dioxide and wastes away. All the chemical reactions necessary for life are carried out in water because all life-sustaining chemicals dissolve in water. Nutrients dissolved in water enter plants through the roots.

For humans, water’s solvency is used in many ways. Water is used alone, or with many different kinds of chemicals dissolved in it, for cleaning nearly everything we use. Many medicines are dissolved in water. Patients who cannot eat are kept alive by dissolving nutrients in water and feeding intravenously. Fluoride, which protects teeth from cavities, is dissolved in our drinking water by most water treatment plants. The various drinks we enjoy contain flavorings, sweetener and other ingredients dissolved in water.

On the negative side, because water is such a great solvent, it also dissolves dangerous chemicals (including medicines, cleaning solutions, industrial waste). These pollutants that humans put into the environment enter waterways, making water unfit for all living things to use, including humans.

Learning Experience Five

How Can We All Help Conserve Water?

Overview

Guiding Question: What can we do to conserve water and prevent water pollution?

This final Learning Experience focuses on stewardship. The first activity engages students in formulating a strong argument why clean water and water conservation are so important for survival of both humans and all other living things on Earth. In the second activity students gather strategies for everyday practices that conserve and don't pollute water. The final activity involves students in actively promoting these practices both personally and within their community.

Evaluation

- Students prepare a personal list of practices they will commit to for conserving water and keeping it clean.
- Students submit documentation on one action taken to inform and encourage others to conserve water and keep it clean, and a reflection on the impact of that action.

Materials

- Access to information on water conservation and water pollution
- Chart paper
- Markers
- Masking tape

Activity One: Creating the Argument for Water Conservation and Clean Water

- Introduce this activity by discussing the collage of water information that the students have been creating since the beginning of this unit of study. What conclusions do they draw from this collection?
- Inform students that only about 1% of all the water on Earth is safe for drinking! Ask students to talk with a partner about why they think this is the case. Create a class list of reasons.
- Discuss what students have been learning about water throughout this unit of study. Be sure students know that:
    - Water is a resource that is absolutely essential for all life.
    - Although it may seem like there is a huge amount of water on Earth, a large proportion of that water is either in the oceans, or in a place that makes it unavailable, such as being already inside living things, contained in deep, underground rivers, in the atmosphere, and so forth.
    - All the water there will ever be is already on this Earth.

- Ask each student to list all the reasons why it is important for each person not to waste water, and not to pollute water.
- In small groups, students prepare a combined list of reasons on chart paper. Each group tapes its chart to a wall and presents its reasons to the class.
- Create a class list of reasons. Keep these visible for the next activity.

Activity Two: What Can Each of Us do to Conserve Water and Help Keep It Clean?

- Ask each student to write at least one concern he or she has about water. Create a class list of these concerns. Prompt students to consider concerns about both the quantity of available water both to plants and to animals, and concerns about the quality of the water—both for consumption and for the health of aquatic organisms.
- Ask students to make a list of chemicals that are known pollutants. Then ask them to think about how those chemicals are introduced into the environment and the water supply. (This may require prompting).
- Ask each student to write at least three things her or she can do to not waste water and at least three things the student or students' family and neighbors could do to keep from polluting water.
- As a class, produce a list of these practices.
- Give students time in class, or assign as homework, the task of adding to that list by consulting references, hardcopy, Internet or experts. Refer to 'Notes to Teachers' for examples of practices. The local utilities company and health department are likely to have literature.
- Add the results of this research to the original class list.
- Students make a personal list of new ways they will commit to saving water and keeping it clean.

Activity Three: Being a Water Activist

- Ask students what else they can do to help conserve water and keep it clean, besides working on their own personal water-use practices. Prompt students, if necessary, to consider educating and encouraging others in the community.
- Each student writes one way that he can spread the word.
- Brainstorm a class list.
- Each student works alone or with others to select and execute one strategy, such as writing a newspaper article, speaking to another class, talking at a church gathering, putting on a skit for a kindergarten class, talking with the county or town manager about publicizing in the community.
- Students write a reflective paragraph on this experience and report the results to the class.
- As a final exercise, ask students to compare what they knew at the beginning of this unit of study (what they wrote in Learning Experience One) to what they now know. Discuss some of the new things students have learned, particularly those things that were most interesting or most important to them. Has their behavior changed in any ways as a result of this study? How? Why?

Notes to Teachers

Practices for conserving water and keeping it clean:

- Reuse water whenever possible.
- Collect rain water for watering plants.
- Don't landscape with plants that are not native to your region and require extra watering to survive.
- Don't pour chemicals that may be harmful down the drain.
- When you shower, turn off the water while you're soaping. Take a short shower.
- Use biologically safe cleaners, soaps, shampoos. Check on the Internet for recommended products. Avoid anything with the ingredient sodium lauryl sulfate, a sudsing agent that is a pollutant.
- If you don't have a water conserving toilet, put something like a brick or a plastic jug filled with water in the tank to take up some space and reduce the amount of water that is used with each flush.
- Conserve water when brushing your teeth or washing your hands by turning off the faucet.
- Repair dripping and leaking faucets and toilets. A leaky faucet can waste gallons of water in a month.
- Don't use the toilet to dispose of used facial tissues. Throw tissues into a waste basket.
- Don't use a dishwasher or washing machine unless it is completely full.
- Use water-saver fixtures in the shower.
- Be aware of ways to reduce water use when house cleaning or washing the car.