Water is Life

Water has properties that make it essential to life, and while water recycles and cleans itself, there are limited quantities which must be conserved.

Chapter 1

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Discuss their ideas about water and its uses.
2. Know the difference between elements and compounds.
3. Recognize water as an abiotic part of the ecosystem.
4. Know that matter has physical and chemical properties.
5. Recognize that chemical formulas are used to identify substances and subscripts allow us to determine the number of atoms of each element.
6. Make a model of water distribution on Earth and the amount of water useable by humans.
7. Describe abiotic parts of an ecosystem and how organisms depend on abiotic factors such as water.
8. Describe interactions of biotic and abiotic parts of the ecosystem.
9. Use models to help them understand abstract ideas.
10. Explain, on the molecular level, what makes water a polar molecule and how that affects water's properties.
11. Plan and carry out a comparative investigation of the surface tension of various liquids.
12. Discuss surface tension in the aquatic environment.
13. Investigate their own use of water and devise ways to cut usage to conserve our water supply.
14. Identify the constants, and the dependent and independent variables in the water conservation experiment.
15. Read Chapter 1: Water Is Life to reinforce concepts and vocabulary and find new information.
16. Go online to various websites and search for water quality information.
17. Use technology and methods for testing water for pollution and determining water quality including water chemistry test kits and equipment.

18. Identify sources of water samples in their water quality tests.
19. Use safe practices and conservation of resources in the lab.
20. Collect data and record information in tables.
21. Draw conclusions based on data.
22. Make connections between testing of water quality and careers.
23. Identify ways human activity can affect aquatic environments.
24. Identify sources of water samples in their water quality tests.
25. Use safe practices and conservation of resources in the lab.
26. Collect data and record information in tables.
27. Draw conclusions based on data.
28. Make connections between testing of water quality and careers.
29. Identify ways human activity can affect aquatic environments.
30. Demonstrate the use of course apparatus, equipment, techniques, and procedures.
31. Collect baseline quantitative data, including pH, salinity, temperature, mineral content, nitrogen compounds, phosphates and turbidity from an aquatic environment.
32. Identify water quantity and quality in a local watershed.
33. Identify how human activities impact aquatic environments.
34. Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic ecosystem.
35. Analyze the cumulative impact of human population growth on an aquatic system.
36. Identify the impact of various laws and policies such as the Clean Water Act on aquatic systems.
37. Compare and describe how adaptations allow an organism to exist within an aquatic environment.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, B, C, D, E; 6.3 A, B, C; 6.4 A, B; 6.5 A, C; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A, B, C; 7.4 A, B; 7.6 A; 7.11 B; 7.12 A; 7.13 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 A, B, C; 8.4 A, B; 8.5 D; 8.11 B; 8.14 A

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 B; 7 C; 12 A, B, E; 10 B; 12 C

Environmental Science: 1 A, B; 2 E, F, G, K; 3 E; 4 D, E; 5 B; 9 A, B, C, E, K

Materials

For every activity students will need their science journals.

Lesson 1.1

Chart paper and markers

Lesson 1.2

Inflatable globe

For Each Group

5-gallon aquarium or bucket filled with water

2-cup measure

Clear bowl

½ cup measure

Eyedropper

1 lb box of salt

Ice cubes

Food coloring

Clear jar

Microscope slide

Paper towels

Lesson 1.3

For each pair of students:

Six 2½-inch blue circles and twelve 1-inch gray circles

Wax paper

Eyedroppers

Toothpicks

1 vial of blue food colored water

For each group of 4 students:

Glass of colored water

Celery, white carnations, white daisies, or other white flower

2 glass microscope slides

Petri dish

Tape

Lesson 1.4

For each pair of students:

Plastic 200 ml graduated cylinder

Bowls of water

Clear containers in several shapes

3-5 ice cubes

6 large blue circles and 12 small grey circles from the last activity

For the Class:

Teakettle

Hot plate

Clear plastic container with a lid for the teacher to catch steam

Safety goggles

Lesson 1.5

For each pair of students

Vials of various liquids such as alcohol, vinegar, oil, soapy water

Water

Eyedroppers

Pennies

Paper towels

Beaker

25 milliliters of distilled water

Pipette

New pennies

Old pennies

1 quarter

Tiny amount of dish soap

Cup of water

Regular paper clip

Large paper clip

Optional:

Native aquarium (10 gallon aquarium or a smaller aquarium for each group, nets, seines, plastic gallon jugs, collected organisms)

Lesson 1.6

For each pair of students:

Safety goggles

Clear plastic cups

Graduated cylinders

Scale

Water

Salt

Blue and gray circles from previous lesson

Small green circles and large white circles to make models of salt molecules

Blue and yellow food coloring

Corn syrup

Bottle of warm club soda

Bottle of cold club soda

Paper towels

Old newspapers

Lesson 1.7

1 *Water Use Record* sheet for each student

1 *Bar Graph Template* sheet for each student

Pens or pencils

Colored pencils

Lesson 1.8

Student Guide, Chapter 1

Science journals

Pens and pencils

Lesson 1.9

Safety goggles—one per student

At least three water samples for each group pre-labeled A, B, C. Sample sources may be tap water, rainwater, pond water, creek water, etc.

Water quality test kits, meters or other equipment which may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, phosphate kit, etc.

Water Chemistry Investigation sheet for each student

Secchi disc, stop watch, tennis ball or piece of wood, macro-invertebrate identification chart such as the *Bug Picking* chart on the Texas Parks and Wildlife website.

Safety Precautions

Students and teachers wear safety goggles.

Use caution when handling glass.

Only the teacher should handle the teapot and collect steam.

Go over safety guidelines for field investigations.

Vocabulary

- Abiotic
- Adhesion
- Aquatic organisms
- Aquatic resource
- Biotic
- Charge
- Clean Water Act
- Cohesion
- Compound
- Conductivity
- Decompose
- Dissolve/dissolving
- Dissolved oxygen
- Element
- Gaseous
- Hydrosphere
- Ion
- Inorganic
- Liquid
- Molecule
- Molecular
- Natural resource
- Nitrates
- Organic
- pH
- Polar
- Polarity
- Reservoirs
- Solid
- Solubility
- Solute
- Solvent
- States
- Surface tension
- TPWD–Texas Parks and Wildlife Department

- TCEQ–Texas Commission on Environmental Quality
- NRCS–Natural Resource Conservation Service

Teacher Resources

American Chemical Society teacher resources and lesson plans

http://www.middleschoolchemistry.com/

Other websites

http://www.tpwd.state.tx.us/landwater/water/conservation/fwresources/biotic.phtml

http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_lf_k0700_1117a.pdf

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_lf_k0700_1118a.pdf

http://www.tceq.gov

http://www.nrcs.gov

Enrichments

Project WET

- Adventures in Density
- Choices and Preferences, Water Index
- Common Water
- Drop in the Bucket
- Every Drop Counts
- H_2Olympics
- Hangin' Together
- Is There Water on Zork?
- Water Meter
- What's the Solution?

Project WILD Aquatic

- How Wet Is Our Planet?
- Something's Fishy Here!
- What's in the Water?

Guest Speakers:

- Water resource professional to talk about careers and clean water issues
- Texas Stream Team volunteer water quality monitor

Lesson 1.1: What Do I Know About Water?

Objectives

1. Students will discuss their ideas about water and its uses.

TEKS

6.3 A; 7.3 A; 8.3 A

Aquatic Science: 3 A

Environmental Science: 3 A

Estimated Time

1 Class period

Materials Needed

Chart paper and markers

Special Instructions

Write questions on the board.

Procedure

Eliciting Students' Knowledge About Water

Have each group of 4 students work together to write the answers to the questions on chart paper and discuss their ideas about water. Allow 10 to 15 minutes for groups to discuss and record their answers.

Ask each group to share and discuss their ideas with the class.

Questions:

- **How much of the Earth do you think is covered with water?**
- **Why is water important?**
- **How do you use water?**
- **How much water do you use each day?**
- **How do you know if water is good quality?**
- **Would you drink water from a local farm pond or creek? Why or Why not?**
- **Would you drink water from a local river? Why or Why not?**
- **Would you drink water from the ocean? Why or why not?**

Explain to the class that this chapter will help them understand the value, importance, and properties of water as well as some ways to determine whether water is clean or not.

Lesson 1.2: Water Distribution and Scarcity

Essential Concept

While nearly ¾ of the Earth is covered with water, only a very small amount of that water is available for human use.

Objectives

1. Students will make notes of water distribution on Earth and the amount of water useable by humans.
2. Students can describe abiotic parts of an ecosystem and how organisms depend on abiotic factors such as water.
3. Students will describe interactions of biotic and abiotic parts of the ecosystem.

TEKS

6.3 B; 6.12 E; 7.3 B; 8.3 B; 8.11 B

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 class period

Materials Needed

Inflatable globe

<u>For Each Group</u>

5-gallon aquarium or bucket filled with water

2-cup measure

Clear bowl

½ cup measure

Eyedropper

1 lb box of salt

Ice cubes

Food coloring

Clear jar

Microscope slide

Paper towels

Procedure

1. Surface Water

Ask students to use an inflatable globe to look at the percent of water versus land on the Earth. Toss the globe from person to person and notice where each person's index finger touches when they catch the globe. Tally the number of times the person's index finger touches water and how many times it touches land. The teacher should record the tally. Have students use the tally to find the percent of time fingers touch water. In a typical class, after many catches, it easily averages to 7 out of 10 fingers on average touch on water. This mirrors the percent of surface water on Earth. Seventy percent of the Earth's surface is covered with water. While Earth has a large percent of water on the surface, much of that water is saltwater and not useable for drinking.

2. Distribution of Water on Earth

This model can be carried out by small groups of students so that students have the opportunity to be physically involved.

Ask students to make a model to demonstrate water distribution. Fill a five-gallon aquarium with water. In the model the water in the aquarium represents all the water on Earth.

Remove 2 cups of water and put it in a clear bowl. Explain that this represents all the freshwater on Earth. (About 3% of the total amount of water on Earth) The rest (97%) is saltwater. Pour salt into the aquarium and place the salt container in front of it.

Remove ½ cup of water from the 2 cups. Explain that the 1½ cups remaining represents water frozen in polar ice caps and glaciers. Pour out the 1½ cups of water and replace with ice cubes. Pour the ½ cup of water into a jar and explain that this represents the unfrozen fresh water found on the Earth's surface, (about .05% of all the freshwater on Earth).

Fill the dropper from the ½ cup and place a drop on a microscope slide.

Ask students what they think this dropper full of water represents. (The portion of all the water on Earth that is available fresh water for human use (about 0.0025%). Explain that the rest of the ½ cup is too polluted, inaccessible, or too costly to transport. Place a few drops of food coloring in the ½ cup of water to indicate it is not available for human use.

3. Assessing What We Learned: Uses of Water

- **What are some ways people use water?** (Drinking, cleaning, laundry, irrigation, industries such as production of electricity, etc.)
- **How do animals and plants use water?** (Drinking, habitat, photosynthesis, etc.)
- **What does the word "biotic" mean?** (Living)
- **What are some biotic parts of the ecosystem?** (Plants, animals, fungi, bacteria, etc.)

- **What does the word "abiotic" mean?** ("A" means "without", "biotic" means living so "abiotic" means "without life".)
- **What are the abiotic parts of the ecosystem?** (Sunlight, air, soil, rocks, water)
- **How do the biotic and abiotic parts of an ecosystem interact?** (Living (biotic) things depend on other living things and non-living (abiotic) parts of the ecosystem to survive.)

Have students give some examples: (Plants depend on soil, air, water and the sun to provide nutrients and light to conduct photosynthesis. Some plants depend on animals to pollinate their flowers and/or spread their seeds. Animals depend on water, air, soil, rocks, and the sun to help provide water, shelter, food, and space for their habitat. Animals depend on plants and/or other animals for food.)

4. Explain that every living cell contains water.

- **What does this fact tell us about the importance of water?**
- **Could life exists without access to water in some manner?**

Vocabulary

- Abiotic
- Biotic

A Model of Distribution of Water

1. Fill a five-gallon aquarium with water. In the model the water in the aquarium represents all the water on Earth.
2. Remove 2 cups of water and put it in a clear bowl.

   This represents all the freshwater on Earth. (About 3% of the total amount of water on Earth) The rest (97%) is saltwater.
3. Pour salt into the aquarium and place the salt container in front of it.
4. Remove ½ cup of water from the 2 cups.

   The 1½ cups remaining represents water frozen in polar ice caps and glaciers. Pour out the 1½ cups of water and replace with ice cubes.
5. Pour the ½ cup of water into a jar.

   This represents the unfrozen fresh water found on the Earth's surface, (about .05% of all the freshwater on Earth).
6. Fill the dropper from the ½ cup and place a drop of water on a microscope slide.
   - **What do you think this dropper full of water represents?**
7. Place a few drops of food coloring in the ½ cup of water to indicate it is not available for human use because it is polluted.
   - **What are some ways people use water?**
   - **How do animals and plants use water?**
   - **What does the word "biotic" mean?**
   - **What are some biotic parts of the ecosystem?**
   - **What does the word "abiotic" mean?**
   - **What are the abiotic parts of the ecosystem?**
   - **How do the biotic and abiotic parts of an ecosystem interact?** Give some examples of these interactions.

   Every living cell contains water.
   - **What does this fact tell us about the importance of water?**
   - **Could life exists without access to water in some manner?**

Lesson 1.3: Properties of Water
Polarity, Cohesion, Adhesion

Essential Concept
Water has properties that make it important to life on Earth.

Objectives
1. Students know the difference between elements and compounds.
2. Students know that matter has physical and chemical properties.
3. Students recognize that chemical formulas are used to identify substances and students can determine the number of atoms of each element in chemical formulas containing subscripts.
4. Students use models to help them understand abstract ideas.
5. Students identify water as an important necessity for life on Earth.

TEKS
6.1 A, B; 6.2 C; 6.3 A, B, C; 6.4 A; 6.5 A, C; 7.1 A, B; 7.2 C; 7.3 A, B, C; 7.4 A; 8.1 A, B; 8.2 C; 8.3 A, B, C; 8.4 A; 8.5 D

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time
1 Class period

Materials
Science journals

<u>For each pair of students:</u>

Six 2½ inch blue circles and twelve 1 inch gray circles

Wax paper

Eyedroppers

Toothpicks

1 vial of blue food colored water

<u>For each group of 4 students:</u>

Glass of colored water

Celery, white carnations, white daisies, or other white flower

2 glass microscope slides

Petri dish

Special Instructions

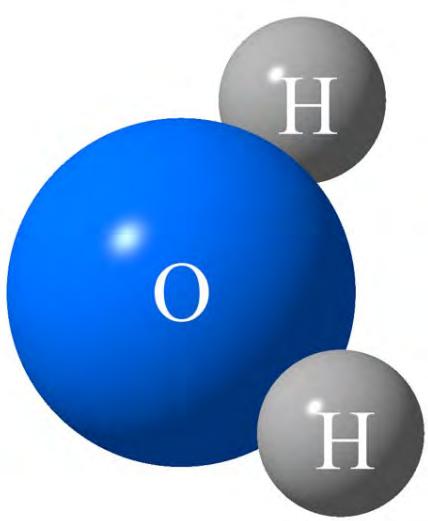
Die cut large and small circles, collect materials.

Procedure

1. Elements and Compounds

Write **H_2O** on the board. Have students review **elements** and **compounds** by asking them to explain what the symbol means. (Students should be able to explain that the H represents an **atom** of the element hydrogen and the O represents an atom of the element oxygen. Together these atoms form the **molecule** H_2O, which contains 2 hydrogen atoms and 1 oxygen atom and represents the **compound** water.

- **What does the subscript 2 mean?** (It indicates the number of atoms of hydrogen in the compound.)



Provide each student with one 2½ inch blue circle and two 1 inch gray circles to represent oxygen and hydrogen atoms. Tell students that you will use these circles to make a molecular model of the compound water. Have students put the circles together so that it looks like Mickey Mouse. This is the position that the hydrogen atoms take when they connect with the oxygen atom. This position is important because it gives the water molecule a slight positive charge on the hydrogen side and a slight negative charge to the oxygen side of the molecule. This slight charge causes water molecules to be attracted to each other and to many other forms of matter. When a neutral molecule has a positive area at one end and a negative area at the other, it is called a **polar molecule**. Water molecules cling to one another based on the attraction between the positive end of 1 water molecule and the negative end of another.

2. It Sticks Together.

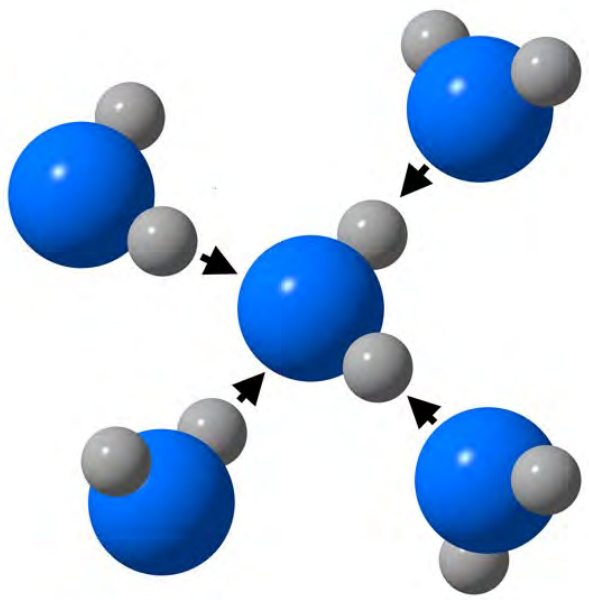
To help students see how this happens give each pair of students a piece of wax paper, a small vial of blue colored water, and 2 toothpicks. Explain that the food coloring is added to the water to make it easier to see. Ask students to use the eyedropper to drop 8 -10 drops of water randomly on their piece of wax paper. Notice how each drop looks. Write a description in your journal.

Next take turns with your partner using a toothpick to drag the water around on your wax paper.

- **What happens?** Describe it in your journal**.**
- **Can you and your partner get all the water droplets to join together? How is this happening?** (Water clings to the toothpick and slides across the slick wax paper. When it touches another drop of water they join to form a bigger drop. This continues until the drop gets too heavy to hold together and be moved.)

3. Making a Molecular Model

To illustrate this with a molecular model give each pair of students the other 5 large blue circles and 10 small gray circles. Ask students to make more water molecules on their desk. Students should think how these molecules might join together given that one side of each molecule is positively charged and the other side is negatively charged. (They should come up with the idea that opposite charges attract and arrange molecules where a hydrogen atom of one molecule is near an oxygen atom of another molecule until all the molecules are close together.) **Note:** Because water is a liquid and fluid, the arrangement of the molecules will change as the water flows. Therefore the model does not actually show the molecules touching. Have students think about how this model is different from the real water molecules and the real drops of water. (The model is 2 dimensional, larger than real molecules, atoms are not actually joined together, actual water molecules of hydrogen and oxygen are not visible to the human eye, etc.)



4. Cohesion and Adhesion.

The property of water clinging to itself is called **cohesion**. When water clings to another form of matter it is called **adhesion**. In our activity we saw both of these properties illustrated. Explain where we saw cohesion (water droplets joining together on the wax paper). Explain where we saw adhesion (water droplets clinging to the toothpicks as we moved it around on the wax paper).

Provide colored water in a glass for each group of 4 students. Have students pour a small amount of the colored water into a Petri dish and set it aside for use later. Give each group a stalk of celery. (You may also want to have each group use a different plant such as white carnation, daisy, or other white flower to see the flow of water in a different context.) Students should make a fresh cut at the bottom of the celery or flower stem and set them in the glass of colored water.

Have students write in their journals to describe the celery or flowers and the way their experiment is set up. The celery or flowers should sit in the colored water over night. Meanwhile, have each group tape 2 microscope slides together, and set them upright in the Petri dish, which contains some of the colored water from the glass. Have students describe what they have done in their journals. Set these aside to observe what happens.

Recheck these plants and the slides tomorrow and discuss any changes students observe and have them write descriptions of what happened in their journals. (The colored water will move up the plant stem and be visible in the veins of the plant. The colored water will also move up between the 2 microscope slides.)

5. Assessing Our Learning

- **Why do you think cohesion and adhesion are important properties of water? (**Cohesion and adhesion are properties of water that are very important to life on Earth because they allow water to climb up plant stems and enable blood to flow through our bodies.)
- **What would happen to plants if water did not have these properties?** (No water means no photosynthesis, which means green plants could not exist.)
- **Without green plants what would happen to animals and people?** (No plants means no food. Even if there were other food, animals could not exist without the fluids moving through their bodies. Because of its properties water is a necessity for life on Earth.)

Vocabulary

- Adhesion
- Charge
- Cohesion
- Compound
- Element
- Molecule
- Polar

Lesson 1.4: Properties of Water
Three States: Solid, Liquid, Gas

Essential Concept

Water has properties that make it important to life on Earth.

Objectives

1. Students know the difference between elements and compounds.
2. Students recognize water as an abiotic part of the ecosystem.
3. Students know that matter has physical and chemical properties.
4. Students recognize that chemical formulas are used to identify substances and can determine the number of atoms of each element in chemical formulas containing subscripts.
5. Students use models to help them understand abstract ideas.

TEKS

6.1 A, B; 6.2 C, D, E; 6.3 A, B; 6.4 A; 6.5 A; 6.12 E; 7.1 A, B; 7.2 C, D, E; 7.3 A, B; 7.4 A; 8.1 C, D, E; 8.2 C, D, E; 8.3 A, B; 8.4 A; 8.5 D

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 Class period

Safety Precautions

Only the teacher should handle the steam. Teacher should wear safety goggles and use potholder.

Materials Needed

<u>For each pair of students:</u>

Plastic 200 ml graduated cylinder

Bowls of water

Clear containers in several shapes (rectangle, cylinder, oval, etc.)

3-5 ice cubes

6 large blue circles and 12 small grey circles from the last activity

<u>For the Class:</u>

Teakettle

Hot plate

Clear plastic container with a lid for the teacher to catch steam

Procedure

1. Water in Three States.

Have each group of four students place 50 ml of water into a plastic 100 ml graduated cylinder and place it in the freezer over night. Have student record the amount of water in their graduated cylinder in their journals.

The next day, students should observe that the level of ice in the graduated cylinder is higher than the level of water you started with. Explain to students that as water freezes, it expands and takes up more space than it did as liquid water.

2. Observing and Describing Three States of Water

Give students clear bowls of water, ice cubes, various shapes of containers. Have students explore with the materials and make a data table for characteristics of **solid, liquid, and gaseous** states of water in their journals.

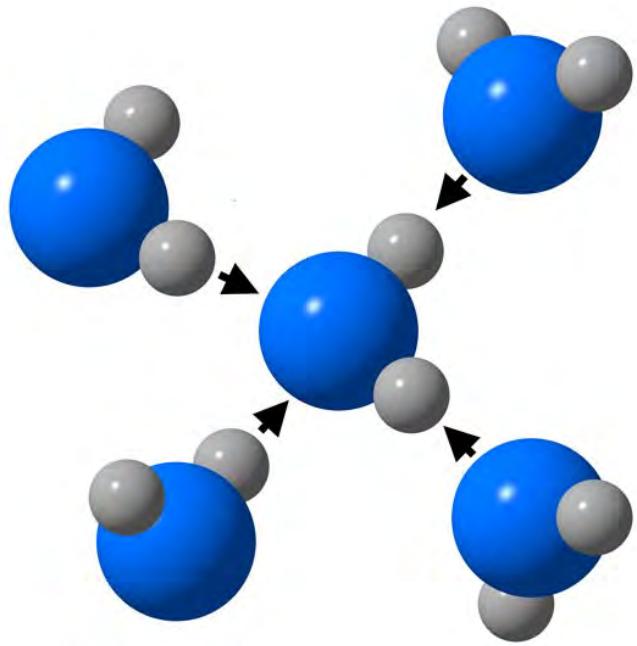
- **What characteristics does water show in the solid state?** (Students should come up with several characteristics such as: The solid maintains its shape [as long as it is not melting] in all of the containers and on its own, it doesn't pour or spread out, it will float in water.)
- **What characteristics does water show in the liquid state?** (The liquid water takes the shape of the container, pours, can be spilled and spreads out over a surface.)

Meanwhile bring a teapot of water to a boil on a hotplate. When steam comes out of the spout ask students:

- **What characteristics does water show in a gaseous state?** (It spreads out through the air, looks like tiny particles similar to smoke, and when a small amount is caught in a container by the teacher, it cools and returns to the liquid state when it condenses on the sides of the container).

3. Molecular Model.

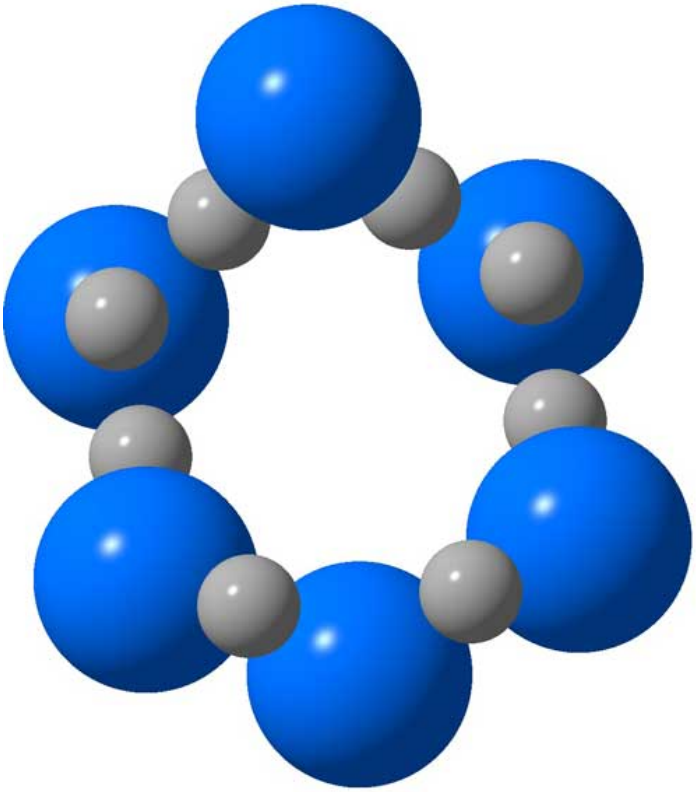
For each pair of students use the 5 large blue circles to represent oxygen and the 10 small gray circles to represent hydrogen to make a molecular model of water in each state. Remember the distinctive shape of the water molecule and the polar nature of the molecule with a positive charge on the hydrogen side and the negative charge on the oxygen side**.**



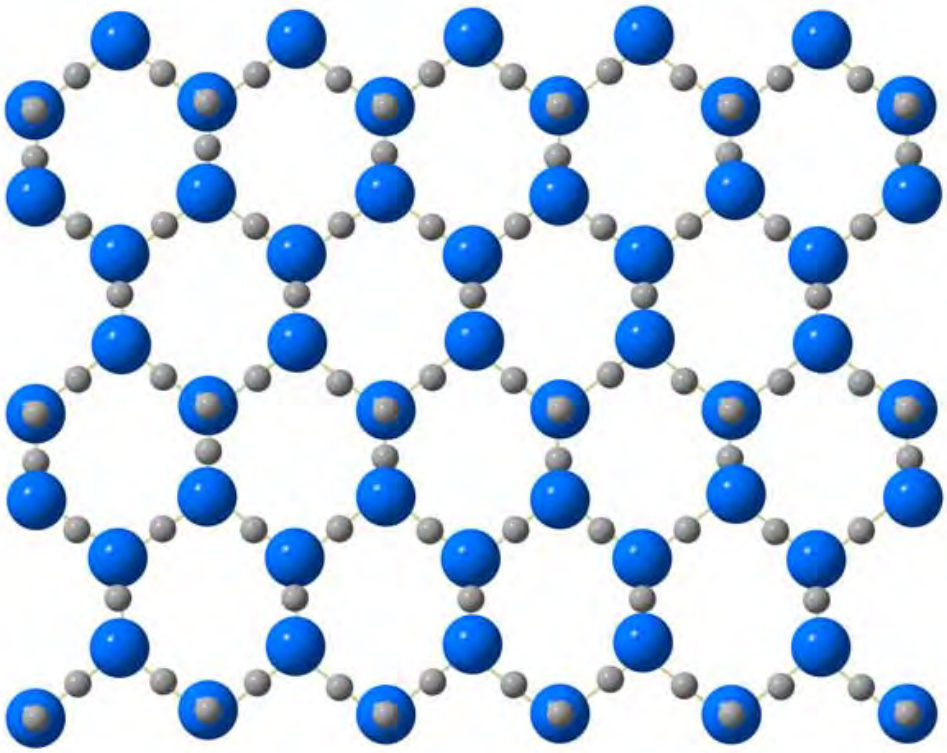
- **What would the water molecules do in a gaseous state?** (Students should demonstrate water molecules spread out on the desk so that they are fairly far apart.)
- **What would the molecules do in a liquid state?** (Students should place the molecules closer together but not quite touching with hydrogen atoms between each oxygen atom as in the previous lesson.)
- **What would the water molecules do in a solid state?** (Students should demonstrate how the molecules would be connected to each other forming a solid structure.)
- **How could we connect all of the molecules without losing any of the atoms and use the positive and negative charges to help develop the solid structure?** (Students should come up with the idea of putting the molecules in a circle connecting at one hydrogen atom in each molecule. This will leave an open space in the middle with hydrogen atoms around the outside of the circle. If students have a hard time coming up with this, give them a start by asking them to place the oxygen atoms in a circle with some space between them and add the hydrogen atoms to make the Mickey Mouse ears while connecting each adjoining water molecule.)

Ask students to describe the molecular structure of solid water (ice).

- **Why do you think the space in the middle in the middle of the structure might be important?** (The space causes the solid form of water to take up more space than the same number of molecules of liquid water. Remember the water frozen in the graduated cylinders.)



- **What would happen to the hydrogen atoms on the outside of the circle if we had more water molecules?** (Those hydrogen atoms would be attracted to other oxygen atoms and eventually create a lattice like matrix.)



4. Assessing our Learning: Water Molecule Game

If you have a group that needs to get up and move around, you can make this into a game, which can be done outside or in the classroom. Number students off from 1 to 3. All the 1s and 2s are hydrogen atoms and all the 3s are oxygen atoms.

Ask the oxygen atoms to find two hydrogen atoms to attach themselves to. They can put a hand on the shoulder of each hydrogen atom. This threesome represents a molecule of water.

Ask students to come up with ways to show each of the three states that water can take when you call out each state.

Call out, "Form Water Vapor!" (Students should move apart and spread the molecules around in the space.)

Call out, "Form Liquid Water!" (Students should move closer together with hydrogen atoms from one molecule near, but not touching, the oxygen atom of another molecule where molecules are attracted to each other, but move over and around each other as a fluid.)

Call out, "Form Solid Ice!" If students have a problem, give them hints such as, "Six water molecules make a circle." (Students should form up with one hydrogen atom of each molecule touching one oxygen atom of another molecule on the shoulder. The second hydrogen atom of each molecule will be on the outside of the circle to form ice or snow.

- **Can you see the shape of a snowflake?**
- **How is this structure different from the water vapor and liquid states?** (The structure is more stable.)

When students have the molecules put together to form the solid ice, ask them:

- **What makes this molecular structure a solid?** (The molecules are closer together and in a more organized structure.)
- **Does it take up more space in the solid form or the liquid form?** (It takes up more space as a solid. If students don't come up with the idea, relate your observations to the water that they froze in the graduated cylinder.

The solid ice molecule is put together in a lattice type structure that holds it shape better than liquid water or gaseous water. This structure leaves an open space in the middle, which takes up more space.

5. Applying What We Learned

If no one has tried putting the ice in water to see what would happen, do so at this time.

- **Why do you think the ice floats in water?** It's the same substance, just in a different state. (Students may come up with various ideas.)
- **How could the molecular structure make ice less dense than liquid water so that it would float?** (The open space in the middle makes the solid lighter than the liquid form.)
- **Why is it important for living things that ice floats?** (Without this property,

lakes would freeze solid in winter, killing fish and other aquatic life.)

- **Would a molecule have to be moving fast or moving slowly to be able to join to other molecules?** (Moving slowly)
- **In which state do you think the water molecules are moving fastest?** (The gaseous state–The molecules are moving fast and pushing on each other and other molecules in the air, which causes them to move farther apart.)

Extension

Behavior of other Substances

Ask students to think about the following question.

- **What other substance can you think of that exists in all three states of matter under normal temperature and pressure on Earth?**

There are few substances that are able to exist at normal temperatures and pressures in our world commonly in solid, liquid, and gaseous states. Ask students to brainstorm, and make a chart listing substances and the states in which they have seen that substance. Students may think of a variety of substances such a liquid steel and solid steel, liquid nitrogen and gaseous nitrogen, etc. that demonstrate some different states, but these are possible only under extreme temperature or pressure. However, they will not be able to think of a substance other than water that normally is found in all three states under normal temperature and pressure conditions. Students may say that Coca Cola and other sodas will evaporate and freeze and are liquid. Point out to students that an important ingredient of Coca Cola and other sodas is water.

- **Would other solid substances float in their liquid form?**

To try an experiment to answer this question, freeze ice cube trays of an oil. (Olive oil, palm oil, lamp oil or citronella oil) Ask students to put the solidified oil in liquid of the same oil.

- **Does the solid oil float in the liquid? (**The solidified oil will sink.)
- **Why do you think the solid oil won't float?** (Its molecular structure does not provide the open space that ice (solid water) has in its molecular structure, which allows ice to float. The solid oil is more dense than the liquid oil.)

Vocabulary

- Gaseous
- Liquid
- Molecular
- Polar
- Solid

Lesson 1.5: Properties of Water
Surface Tension

Essential Concept

Surface tension is a property of water to which some animals are specially adapted.

Objectives

1. Students will implement a comparative study of the surface tension of various liquids.
2. Students will relate the molecular structure of water including its polar nature to its surface tension.
3. Students will discuss the importance of surface tension in the aquatic environment.
4. Students will define heredity as the passing of genetic instructions from one generation to the next generation.
5. Students compare and describe how adaptations allow an organism to exist within an aquatic environment.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.3 A; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A; 7.4 A, B; 7.5 A; 7.11 B; 8.1 A, B; 8.2 A, C, D, E; 8.3 A; 8.4 A, B; 8.14 A

Aquatic Science: 10 B

Estimated Time

3 class periods including a possibility of fieldwork

Materials

<u>For each pair of students</u>

Vials of various liquids such as alcohol, vinegar, oil, soapy water

Water

Eyedroppers

Pennies

Paper towels

Beaker

25 milliliters of distilled water

Pipette

New pennies

Old pennies

1 quarter

Tiny amount of dish soap

Cup of water

Regular paper clip

Water striders or photos of water strider

Native aquarium:

- 10-gallon aquarium or small aquariums for each group
- seines and nets
- gallon jugs for creek/pond water, collected plants and other aquatic organisms

Special Instructions

Prior to class, rub a tiny amount of dish soap over both sides of the quarters and let dry.

Safety Precautions

Students and teachers should wear safety goggles.

Be sure to stress safety in the field if you go out to collect for a native aquarium.

Procedure

1. Surface Tension of Water

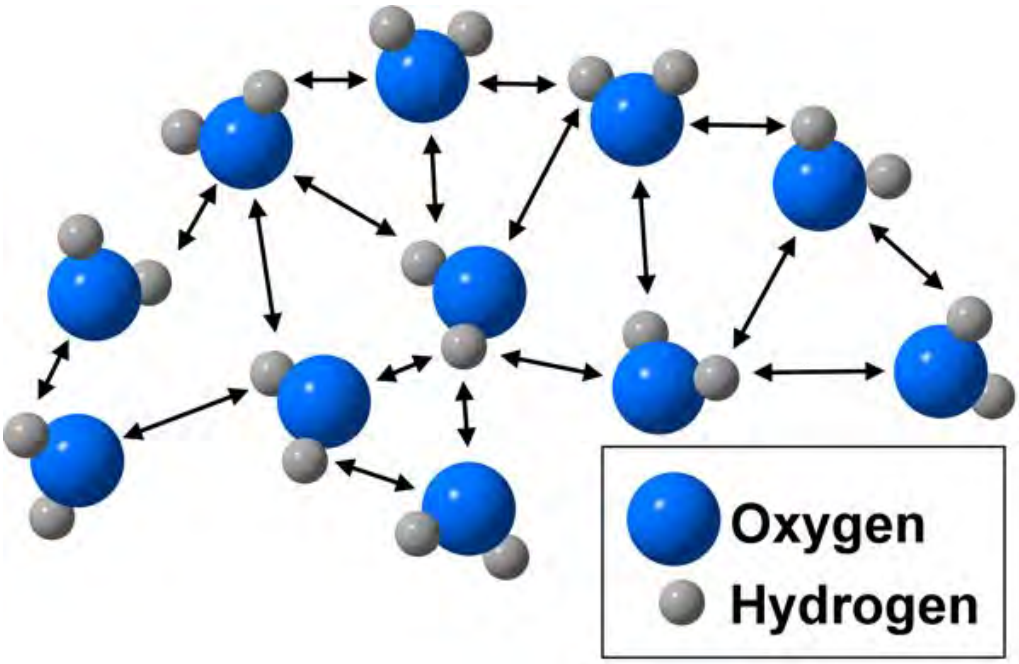
Have students predict how many drops of water they think can fit on a penny and note their predictions in their notebooks.

Try dropping water gently on the penny. Count the drops your penny holds. Have students describe what they see as the water accumulates on the face of the penny and compare the description of the water with the descriptions of the other liquids. Add your data for water to your table.

- **How are the various liquids alike or different from the water? Did the penny hold more or fewer drops of water than other liquids?** (Students should notice that the water piles up higher and rounder on the penny than any of the other liquids and should count more drops before the penny overflows.) Refer back to the students' predictions.

This property of water is called surface tension.

- **What do you think causes this to happen?** (Water's strong surface tension is caused by the attraction of water molecules to each other. The water molecules beneath the surface are pulled in all directions by this attraction, while the molecules at the surface are pulled together and in. This creates a tighter arrangement of molecules at the surface than beneath the surface and causes the round shape of a drop of water.)



- **What property of water molecules causes this to happen?** (Polarity)

2. Surface Tension of Various Liquids

Have students work in pairs. Place the penny on a paper towel. Experiment by dropping various liquids such as alcohol, vinegar, oil, soapy water, or other liquids one at a time gently on the top of a penny. Have students count the number of drops of each liquid that they can put on the penny before it runs off the edges of the penny. Students should make a table in their journals to record their results for each liquid.

Be sure to flush the eyedropper and rinse and dry the penny after each liquid is tested to be sure there is no contamination.

Describe what each liquid looks like as it accumulates on the penny. Add this data to your table. Be sure to flush the eyedropper and wash and dry the penny after each liquid is tested to be sure there is no contamination.

Extension

Prior to class, rub a tiny amount of dish soap over both sides of the quarter and let it dry.

- **How many drops of water do you think will fit on a quarter?**

(These quarters have been pretreated with a tiny amount of dish soap and allowed to dry, but students are not told about its treatment.)

Ask students to add water drops. (The water will immediately slide off the quarter.)

Encourage discussion of why the water is not piling up on the quarter. Students should realize that there is something different about the quarter.

Ask students to plan an investigation to find out what caused the water to slide off of the quarter. Provide materials to facilitate student investigations. When students discover the cause of the behavior of the water, discuss the problem of pollution in water.

- **How would pollution affect animal and plant life in the water?** (Too many phosphates from dish soap and laundry, or fertilizer in water can cause excess plant growth and eutrophication depleting the oxygen supply in water.)

3. Learning More About Surface Tension

Give each pair of students a cup that is about ¾ full of water. Have students very carefully place a regular paper clip on the surface of the water. This has to be done very carefully so it may take a few tries. The paperclip should sit on top of the water. You may see indentions at the ends where it bends the surface tension, but does not break it.

- **If the paperclip is put on the surface on end or on the edge, what happens?** (It will sink to the bottom of the cup.)
- **Why do you think the regular paper clip can stay on the surface of water?** (Students should realize that the paper clip is more dense than water and if dropped into the water will sink. It stays on top of the water because the water molecules are creating surface tension just as they did when they piled up on the penny.)

4. Observations in Nature

- **Have you ever seen anything like this in nature?** (Some students may remember seeing water striders or spiders move across the water without sinking.)

If there is a pond or creek nearby, take students to observe water striders, spiders, or other invertebrates that seem to skim across the water. Have students observe these animals closely. If you do not have a pond or creek nearby, try to capture and bring some water striders to class for close observation or use a photo. You may wish to set up a native aquarium to use for observations in this activity and future activities.

Setting Up a Native Aquarium. To set up a native aquarium, use a 10-gallon aquarium or several smaller aquariums. (One aquarium for each student group would be nice, but is not imperative.) Collect pond/creek water, aquatic plants, minnows, aquatic insects including water striders, a few rocks, or whatever is in your local pond or creek. If you have plenty of plants, you will not need a bubbler to aerate the water. If you don't have enough plants to keep oxygen replenished in your aquarium, you can use a bubbler or you can collect several gallons of extra pond water and add new pond water every day. **Do not add tap water.** It has too much chlorine and will kill the animals in your aquarium. Also, if you collect predators, (such as crayfish) be sure to keep them in a separate aquarium or they will eat everything.

Describe the water strider's adaptations in your journal. (Long legs spread the weight of the water strider over a large surface area. The unique arrangement of their legs and the surface tension of water give water striders the ability to glide across the surface of the

water. Narrow pointed ends of the legs do not penetrate the surface. Close observation shows evidence of water's surface tension where the water strider's legs dent or bend the water's surface, but do not break through.)

Photo courtesy of Valerie Bugh, larvalbug.com

You might have students do some library or Internet research to learn more about adaptations of the water striders legs.

These adaptations are characteristic of invertebrates that live in aquatic environments.

- **Do you think these would be genetic characteristics or learned behaviors? How would you know?** (It is genetic [an inherited trait] and is passed on to the young. You can see this by making many observations of these types of invertebrates in different places over a long period of time.)
- **Why would these be important characteristics to pass on to the next generation?** (The water striders legs give them many advantages in finding and catching prey in aquatic environments such as speed, and the ability to travel around and among plants and debris.)

Vocabulary

- Polar
- Surface tension

Lesson 1.6: Properties of Water
Ability to Dissolve Other Substances

Essential Concept

Water is called the "universal solvent" because many other solid, liquid and gaseous substances dissolve in water.

Objectives

1. Students know the difference between elements and compounds.
2. Students recognize water as an abiotic part of the ecosystem.
3. Students know that matter has physical and chemical properties.
4. Students recognize that chemical formulas are used to identify substances and can determine the number of atoms of each element in chemical formulas containing subscripts.
5. Students use models to help them understand abstract ideas.
6. Students will be able to explain, on the molecular level, what makes water a polar molecule. Students will also be able to show in a drawing that the polar nature of water can explain some of water's properties.
7. Students will plan and carry out a comparative investigation.

TEKS

6.1 A, B; 6.2 A, B, C, D, E; 6.3 A, B; 6.4 A; 6.5 A; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A, B; 7.4 A; 7.12 A; 7.13 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 A, B; 8.4 A; 8.5 D

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 Class period

Safety Procedures

Wear safety goggles

Materials Needed

<u>For each pair of students:</u>

Safety goggles

Clear plastic cups

Graduated cylinders

Scale

Water

Salt

Blue and gray circles from previous lesson

Small green circles and large white circles to make models of salt molecules

Blue and yellow food coloring

Corn syrup

Bottle of warm club soda

Bottle of cold club soda

Paper towels

Old newspapers

http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/thermochem/solutionSalt.html (animation of water dissolving salt) Be aware that websites come and go. Please check before assigning for student research.

Procedure

1. Will water dissolve solids?

Give each pair of students a graduated cylinder, a clear cup, and a container of water, a scale and about 7 teaspoons of salt. Have students measure out 150 ml of water into the clear cup. Students should also weigh out 40 grams of salt on a piece of notebook paper and pour it into another cup. Have student begin adding salt to the water. Students will describe what they see in their journals. Have students stir the salt and water.

- **What happens?** (The salt will begin to dissolve and will disappear.) Have students write a description in their journals.

The amount of a substance that can **dissolve** in a liquid (at a particular temperature) is called the **solubility** of the substance. The substance being dissolved is called the **solute**, (in this case, salt) and the substance doing the dissolving is called the **solvent** (in this case, water). Water is often called "the universal solvent" because it can dissolve so many other substances.

- **How do you know when a solute** (like salt) **has dissolved in a solvent** (like water)? (When the solute is completely incorporated into the solvent).

Extension

- **Is there a limit to how much solute will dissolve in a solvent?** (Yes) **How do you know?** Students should give examples such as: (We have seen this happen when you add too much sugar to your tea and some settles to the bottom.)
- **How could we find out if more salt would dissolve in the water?** (We could add more salt to our solution and see if it dissolves or settles to the cup's bottom.)
- **Will water dissolve all solids? How could we find out?** (We could try a variety of other solids such as sugar, sand, baking soda, etc.)

2. Making a Molecular Model.

Give each pair of students the blue and gray circles to make models of water molecules and small green circles and large white circles to make salt molecules. The green circles represent sodium and the white circles represent chlorine. Together the sodium and chlorine are ionically bonded to make the molecule NaCl, which is sodium chloride or salt. This molecule is made up of a positively charged sodium **ion** and a negatively charged chloride ion. An **ion** is an atom or molecule, which has gained or lost one or more of its valence electrons, giving it a net positive or negative electrical charge. The **polarity** of water molecules enables water to dissolve many ionically bonded substances.

Water can dissolve salt because the positive part of water molecules (hydrogen) attracts the negative chloride ions, and the negative part of water molecules (oxygen) attracts the positive sodium ions. The attraction between the water molecules and the salt ions begins to overcome the attraction the ions of sodium and chloride have for each other and the water pulls away the ions of the salt one by one dissolving the salt. Use your paper circles to show how this could happen.

If you have time, you might want to show this video to illustrate how the water molecules disconnect the sodium and chloride. (Be aware that websites come and go and you may need to find another site if this one is taken off of the Internet.)

http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/thermochem/solutionSalt.html

3. Will water dissolve liquids?

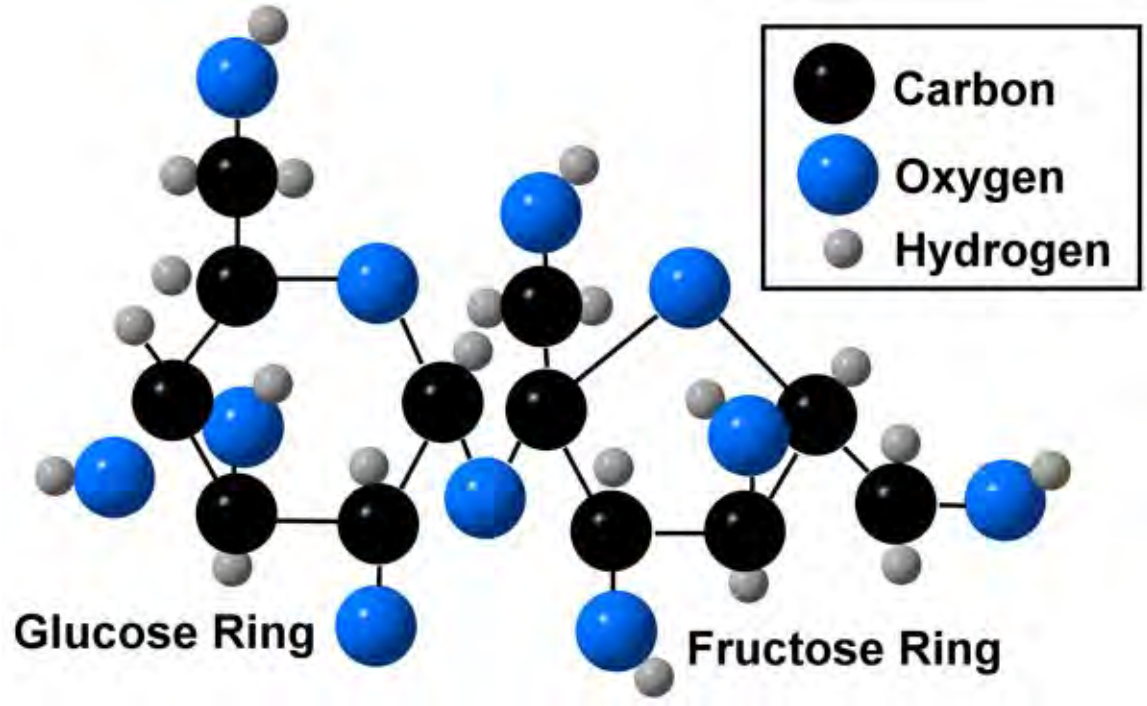
Provide pairs of students with clear cups of blue colored water (about ¾ of a cup and ¼ cup of yellow colored corn syrup. Corn syrup is mostly glucose, but also contains another sugar, fructose. Add the corn syrup to the water and see what happens. (The yellow corn syrup flows through the water and settles on the bottom of the cup. Some places you can see small spots of green where water dissolves the corn syrup. After a few minutes you may see a thin layer of green between the blue and the yellow.)

Stir the corn syrup into the water and describe what you see. (The liquid will turn green.)

- **Is the corn syrup dissolved in the water? How do you know?** (The two colors of liquid are completely mixed, changing the color, and nothing has settled to the bottom.)

Show students the diagram of sucrose molecules. Ask students to look at the different atoms in sucrose. Sucrose is a large molecule made up of carbon, oxygen, and hydrogen. Sucrose has many O–H bonds which are polar. These polar areas exhibit a positive charge near the hydrogen atom and a negative charge near the oxygen atom.

- **How do you think the glucose dissolves in the water?** (The polar glucose molecules attract the opposite charges on water's polar molecules.)



Extension

Will water dissolve all liquids? How could we find out? (We could experiment with dissolving other liquids such as mineral oil, vinegar, or alcohol and see what happens.)

4. Will gases dissolve in water?

We have seen the solids and liquids can dissolve in water.

- **Do you think that gases will dissolve in water? Why or Why not?** Let students discuss their ideas. Some students may not have thought of gases being dissolved in water, but other students may think of bubbly soft drinks.)

Provide each group of 5 students with a bottle of plain water labeled "1" and a bottle of warm club soda labeled "2" (both should have labels removed) paper towels, and enough newspapers to cover the desk and soak up spills. Have students make a data table and write their observations of the two bottles of liquid in their journals. **Are there any signs of gas in either bottle?** Open bottle number one very slowly. Write down any observations. (There will be a cracking sound as they break the plastic lid, but the water will not change.) Open bottle number two very slowly. Have students write down any observations in their tables. (The same cracking sound of the plastic lid will happen, but then there may also be a hiss and many bubbles will appear and rise to the surface and pop. Tighten the top of the cap back and fewer bubbles will continue to form.

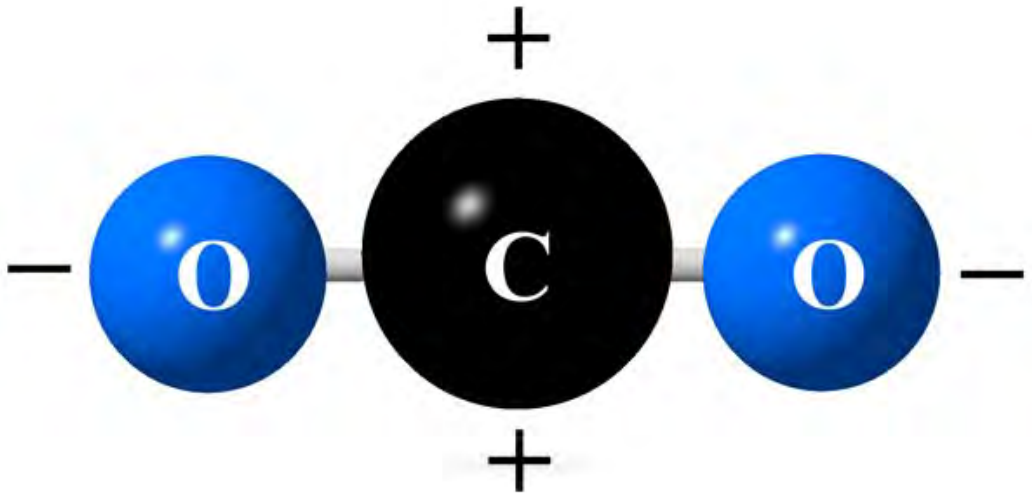
- **What do you think caused the hissing sound and the bubbles in bottle number two?** (A gas escaping)
- **What happened when the bottle cap was put back on the bottle?** (Fewer bubbles formed.)

- **What do you think is in each of the bottles?** (Plain water in bottle number one, and some kind of carbonated water in bottle number 2)
- **What is the gas that makes these bubbles?** Some students may know that the bubbles are carbon dioxide. (CO_2)
- **Could you see the CO_2 before the bottle was opened? Why not? Where was the CO_2?** (No, you could not see it, because it was dissolved in the water and when the pressure was released by opening the cap, the bubbles escaped.)

Explain to students that when club soda is manufactured, carbon dioxide gas is added to cold water under high pressure. This forces more gas to dissolve than ordinarily would. So when room temperature club soda is opened, some of the carbon dioxide escapes the solution.

5. Molecular Model.

Give students a large black circle to represent carbon and 2 large blue circles to represent oxygen. The two oxygen atoms attached on either side of the carbon atom. This creates a slight positive charge on the free (unattached) sides of the carbon atom and a slight negative charge on the free (unattached) sides of the oxygen atoms. This makes carbon dioxide a polar molecule and makes it soluble in water because the water molecules are attracted to these polar areas. The bond between carbon and oxygen is not as polar as the bond between hydrogen and oxygen in water, but is polar enough that carbon dioxide can dissolve in water. In carbonated water, molecules of carbon dioxide are thoroughly mixed and dissolved in water. Each molecule of CO_2 is surrounded by water molecules. The CO_2 molecules are not as strongly attracted by the water molecules as salt. This weaker attraction allows CO_2 to come out of solution easily.



- **Where do the CO_2 molecules go when they come out of solution?** (They go into the air. That is why if you leave the lid off of the club soda for long, it will lose its fizz).

6. **Do you think carbon dioxide will stay dissolved better in hot or cold water?** (Students will make a hypothesis.)
   - **How could we find out?** (Students will plan and implement a comparative investigation. We have data for warm club soda. We could make observations of cold club soda and compare our data. Then we could heat a sample from the cold club soda bottle while keeping another sample cool to see what happens.)
   - **What criteria will we use to decide if more carbon dioxide is escaping from the solution?** (More bubbles will come out of solution and go to the surface and pop.)
   - **If more carbon dioxide stays dissolved in the solution what do you think we will see?** (Fewer bubbles come out of solution and go to the surface and pop.)

Give students the cold bottle of club soda and ask them to label it as bottle number three.

Have students open the cold club soda slowly and make observations and record them in their table.

- **How did the cold club soda compare to the warm club soda?** (Fewer bubbles) Use this information to change or keep the hypothesis you made earlier.

7. Gather more data.

Give students 4 cups, 1 cup should be 1/3 full of hot tap water, 1 cup should have ice and water. Have students fill each of the other 2 cups with 100 ml of club soda from the cold club soda bottle. Have student place one of the club soda filled cups in the hot water bath and one in the cold water bath. Watch the surface of the club soda in both cups.

- **Which cup has the most bubbles coming to the surface and popping?** (The cup in the hot water bath)
- **Does the carbon dioxide stay dissolved better in hot water or cold water?** (Carbon dioxide stays dissolved better in cold water.)
- **How do you know?** (Fewer gas bubbles escape from the club soda in the cold bath.)
- **Why do you think carbon dioxide gas escapes faster from hot water than cold water?** (Because the carbon dioxide is only slightly attracted to the polar water molecules so that even at room temperature it will slowly escape from solution. Warming the club soda increases the escape of carbon dioxide because it causes the molecules in the solution to move faster and this movement breaks the loose attachment and allows the carbon dioxide to escape faster.)

Extension

At the beginning of class, fill glasses with tap water from a faucet with an aerator screen (which almost all faucets have). Set the glasses out, by the end of class bubbles will form all around as the oxygen and air dissolved by the agitation of the screen will come out of solution. If you have some faucets in your classroom with and without screens, the smooth laminar flow of a non-screen faucet will not produce water that out-gasses air later in the glass. Have students compare water from the two types of faucets. (**Note:** Often you can twist the aerator off of a faucet, if you don't have both types of faucets.)

- **How does water dissolve oxygen in nature?** (The agitation of waves and wind helps to aerate the water in lakes, and other surface water.)

8. Applying What We Learned

- **Based on this experiment, why do you think people store left over soda in the refrigerator?** (Less carbon dioxide escapes when the soda is colder and the molecules are moving more slowly so that the soda won't lose its fizz.)
- **Why do you think it is important in the natural environment that water can dissolve gases?** (Aquatic animals need oxygen just as land animals do. Oxygen is dissolved in the water that these animals live in. Fish and other aquatic animals are adapted to use their gills to get oxygen from the water in order to stay alive.)
- **Based on what we learned today, do you think it would be easier for aquatic animals to get oxygen in cold water or warm water?** (Cold water–More oxygen can be dissolved in cold water, when the temperature of the water gets too warm less oxygen is available for aquatic animals.)

In the summer some fish species such as gar may come to the surface of a pond to gulp air. **Why do you think this happens?** (They are responding to the external stimuli in the environment [amount of dissolved oxygen in the water]. When there is not enough oxygen dissolved in the water, fish must find another [though less efficient] way of getting oxygen. Some species, such as gar, are able to absorb oxygen through their swim bladder, which they can fill with air by gulping air from the surface.)

Vocabulary

- Dissolve
- Ion
- Solubility
- Solute
- Solvent

Lesson 1.7: Investigating Water Consumption

Essential Concept

Water is a renewable natural resource, but access to clean water is finite and conservation is important.

Objectives

1. Students will investigate their own use of water and devise ways to cut usage to conserve our water supply
2. Students will identify the constants and the dependent and independent variables in the water conservation experiment.
3. Students will make changes in the amount of water they use and will record and graph results.

TEKS

6.1 A, B; 6.2 A, B, C, D, E; 6.4 A; 7.1 A, B; 7.2 A, B, D, E; 7.4 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.4 A; 8.11 B

Aquatic Science: 2 E, F, H, J

Environmental Science: 2 E, F, I, K

Estimated Time

3 Class periods

Materials

1 *Water Use Record* sheet for each student

1 *Bar Graph Template* sheet for each student

Pens or pencils; blue and red pencils

Procedure

Day One

1. Water as a Renewable Resource

We've talked about water as an important abiotic part of the environment.

- **What are some of the reasons water is important in the environment?** (All living things require water to transport nutrients; some living things must take in oxygen, which is dissolved in water in the aquatic environment. Water provides important habitat in many biomes on Earth, etc.)

- **What properties of water are important in the environment?** (The **polarity** of the molecule allows water to have **cohesion** [stick to itself] and **adhesion** [stick to many other things]. It also causes **surface tension**, which allows dew to form [for some animals to drink] and provides a way for some animals to catch prey. It has the property of **dissolving** other materials which allows oxygen to be dissolved in the water for aquatic animals to obtain through gills or other mechanisms. The solid **state** of water is less dense than the liquid state and therefore floats allowing life to continue in the water under ice in winter and cold climates, the **3 states** allow water to be cleaned, recirculate, and be reused.)

Water has been recirculating over and over during the whole history of the Earth.

- When we have something in the environment that is so important and is reusable, what do we call this? (A renewable natural resource)
- **If water is renewable, does that mean that we can use it any way we want to and as much as we want to? Why?** (No. Water may recycle, but we have a finite amount available and it can be costly to find, clean, desalinate, and remove water from difficult places if it is not part of the small percent of clean water to which we already have access. We cannot take water for granted.)

2. Cast Beyond Tomorrow

Ask students to research the answers to the following questions as homework.

- **What is the source of your drinking water?**
- **Are there any water quality or water quantity issues about your water source?**
- **What will affect your water source in the future?**
- **Who makes decisions that affect your water source?**

How much water do we use every day and what do we use it for? (Allow students an opportunity to discuss and think through their use of water.)

To help us find out how much water we use and how we use it every day, we will keep data about our water use. Distribute a Water Use Record sheet to each student.

Instruct students to use the sheet to record their water use for the next 24 hours and bring the completed page to class the next day.

Day Two

3. Our Water Use

Have students work in groups of 4 to tabulate their group's water use. Then have each group put the amount of water used on the board and calculate a class water use total. Lead class discussion of water use findings.

- **Are students surprised by how much water the class uses each day?**
- **Why would it be important to reduce our water use?**

- **How could we reduce our daily water use?**
- **Where did we use the most water?**

4. Experimenting with Water Use

Ask students to agree upon one thing they will all change about their daily water use to conserve water (for example, take a shorter shower). Alternatively, each group could choose a different water use to change.

Using the *Water Use Record* sheet, instruct the students to record their water use for the next 24 hours (Day 2), changing the amount of water used for agreed-upon activity, and bring the completed page to class the next day.

Day Three

5. Experimental Variables and Constants

Ask students to identify the constants and the dependent and independent variables in their water conservation experiment. (**Independent variables** are the water use habits they changed; **dependent variable**s are the things that change depending on the action they have taken, such as the amount of water they used; **constants** include the person using the water and recording water use, facilities used, and the water use habits they did not change.)

6. Reporting Results of our Experiment

Have each group report their water use findings and tabulate results for their group and write their results on the board. Calculate a class water use total.

7. Graphing Our Results

Using their *Personal Water Use* information, instruct the students to create a bar graph on the template provided to show their results. Be sure that they provide the following:

- An appropriate title
- A label for each axis with appropriate units
- An appropriate number scale, and category labels
- Correctly plotted data

Have students add the *Water Use Record* sheets and graphs to their science notebooks.

- **Based on our data, what conclusions can we draw about ways to conserve water in our every day life?**
- **Where did we use the most water?**
- **Was the class able to cut their water use?**
- **If each group made a different water use change, compare water use and conservation results between groups. Which change made the biggest difference in the class total water use?**

Lead a class discussion about water conservation and challenge students to make their water use changes permanent and incorporate other water use changes.

Vocabulary

- Adhesion
- Cohesion
- Dissolving
- Polarity
- Renewable natural resource
- States
- Surface tension

Student page

WATER USE RECORD

Objective

Record and present personal water usage data.

Directions

1. Using the charts, make a tick mark in the appropriate box each time you use water, or per minute, for showers.

2. Multiply the number of "Times" (or minutes, for showers) by the "Gallons per time" and place that number in the column "Total gallons per activity."

3. Add the "Total gallons per activity" column and enter the total in the last box.

4. Using your Personal Water Use information, create a bar graph on the template provided to show your results. Be sure to provide the following:
   - Use a red pencil for your original data and a blue pencil for your data from the second day
   - An appropriate title
   - An appropriate number scale, and category labels
   - A label for each axis with appropriate units
   - Correctly plotted data

Student Page

Name: _____

Date: _____

Personal Water Use—Day 1

Activity	Times	Gallons per time	Total gallons per activity
Flush a toilet		4	
Brush teeth with water running		3	
Take a shower (count minutes)		5 per minute	
Take a bath		20	
Eat one meal		2.5	
Total Gallons Daily Water Use			

Personal Water Use—Day 2

Name:_____

Date: _____

Activity	Times	Gallons per time	Total gallons per activity
Flush a toilet		4	
Brush teeth with water running		3	
Take a shower (count minutes)		5 per minute	
Take a bath		20	
Eat one meal		2.5	
Total Gallons of Daily Water Use			

Student Page

BAR GRAPH TEMPLATE

Name: _____
Date: _____

Lesson 1.8: Reading and Research

Essential Concept

Water is important, is diversely distributed, and useable water is scarce. Water has many uses, and specific properties, but is sometimes polluted. Water quality can be determined with various tests.

Objectives

1. Students will read *Chapter 1: Water Is Life* to reinforce concepts and vocabulary and find new information.
2. Students will look at various websites and search for water quality information and write a paragraph about the quality of water in Texas.
3. Students will make a table showing water properties and their importance.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

Varies. Reading and research may be done in class or as homework. Allow at least 20 minutes for in class discussion and questions.

Materials

Student Guide, Chapter 1

Science journal

Pens and pencils

Computer and Internet

Procedure

1. Student Reading

Have students read *Chapter 1: Water Is Life*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) Why is water important? What is the hydrosphere?

Water is essential to life. The hydrosphere is all the water on Earth.

2) What are natural resources? What are aquatic resources?

Natural resources are anything found on Earth that can't be made by humans. Aquatic resources are water and all things that live in or around water.

3) How do we use water?

Uses of water may include drinking, cooking, washing, growing crops, generating power, manufacturing, transportation, etc.)

4) How much water is available for human use?

The amount of water available for human use may be described as less than 0.003%, a tiny fraction of all water or about 2 million gallons per person.

5) What is conservation? Why is it important?

Conservation is careful use. Conservation is important because water and other resources are essential and in limited supply.

6) What are the special properties of water? Why are they important?

Answers may include:

Water Property	Importance
Can take three forms: liquid, solid and vapor	Permits self-purifying (water) recycling
Solid form (ice) is not as dense as liquid form	Ice floats and lakes do not freeze solid so organisms can survive in winter Ice can break rocks by freezing and thawing
Dissolves many different things	Aquatic animals and plants can obtain oxygen from water Animals and plants can draw nutrition from water

Molecules attract one another, creating surface tension	Things can float on or move across the surface of water Water forms drops
Molecules cling to other things	Water can climb up plant roots and stems Blood can flow through tiny blood vessels
Has a high boiling point and a low freezing point; Can absorb a lot of heat before it begins to get hot	Provides living things a fairly constant environment
Transparent to light	Plants can live under water

7) How can we tell if water is polluted or clean?

We tell if water is polluted or clean by determining its quality using physical, chemical and biological tests.

8) How does water pollution affect aquatic life?

Some ways water pollution affects aquatic life include:

- Cloudy water blocks light and slows plant growth.
- Too much fertilizer causes overgrowth of algae.
- Toxic chemicals are poisonous to living things.

9) How does water's temperature affect the amount of oxygen in it?

Cold water holds more oxygen.

10) What is water quality?

Water quality is water's fitness for a particular use.

11) How do humans affect water quality?

Humans affect water quality by polluting or conserving water. Answers may include specific examples.

2. Internet Research

Have students do some Internet research on water quality in Texas. Have students use the information they find in their research to write a paragraph in their science journals about water quality in Texas.

You may want to have students Google "Texas Parks and Wildlife Water Quality", or "Texas Commission on Environmental Quality" or "Natural Resource Conservation Service Water Quality", or "United States Geological Service and Water Quality or assign some specific websites such as:

http://www.tpwd.state.tx.us/landwater/water/conservation/fwresources/biotic.phtml

http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_lf_k0700_1117a.pdf

http://www.tceq.state.tx.us/

http://www.tceq.texas.gov/waterquality

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/quality/

http://water.usgs.gov/owq/

http://ga.water.usgs.gov/edu/waterquality.html

http://www.indeed.com/q-Water-Quality-jobs.html

Be aware that websites come and go. Please check websites before assigning to students.

Vocabulary

- Aquatic organisms
- Aquatic resource
- Clean Water Act
- Decompose
- Dissolved oxygen
- Hydrosphere
- Inorganic
- Natural resource
- NRCS–Natural Resource Conservation Service
- Organic
- Reservoirs
- TCEQ–Texas Commission on Environmental Quality
- TPWD–Texas Parks and Wildlife Department
- Water pollution

Lesson 1.9: Student Investigation
Water Quality

Essential Concept

Water quality can be assessed with various technology and methods.

Objectives

1. Students use technology and methods for testing water for pollution and determining water quality.
2. Students become familiar with the use of water chemistry test kits and equipment.
3. Students identify sources of water samples
4. Students use safe practices and conservation of resources in the lab.
5. Students collect data and record information in tables.
6. Students draw conclusions based on data.
7. Students make connections between testing of water quality and careers.
8. Students identify ways human activity can affect aquatic environments.
9. Students demonstrate the use of course apparatuses, equipment, techniques, and procedures.
10. Students collect baseline quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, phosphates, nitrogen compounds, and turbidity.
11. Students identify water quality in a local watershed.
12. Students predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
13. Students analyze the cumulative impact of human population growth on an aquatic system.
14. Students identify the impact of various laws and policies such as the Clean Water Act on aquatic systems.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 8.1 A, B; 8.2 A, C, D, E; 8.4 A, B

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 B; 7 C; 12 A, B, C, E

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 E; 4 D, E; 5 B; 9 A, B, C, E, K

Estimated Time

2 Classes periods with a possibility of fieldwork

Materials

Safety goggles—one per student

At least 3 water samples for each group pre-labeled A, B, C. Sample sources may be tap water, rainwater, pond water, creek water, bay water, etc. depending on local resources

Water quality test check sheets, kits, probes, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, etc.

Water Chemistry Investigation sheet for each student

Physical Water Quality Indicators check sheet

Invertebrates & Vertebrates as Water Quality Indicators information sheet

Bug Picking Data Sheet

High school students should also have secchi disc, stop watch, tennis ball or piece of wood, salinity test

Special Instructions

Water samples and test kits and equipment must be prepared in advance.

The included *Water Chemistry Investigation* sheet may require modification depending on number of water samples and water quality test kits, meters, or other equipment used.

Safety Precautions

Students and instructors must wear safety goggles when using chemical tests.

Use extra care when handling glass.

Stress field safety for classes conducting field investigations.

Procedure

Day One

1. Water Chemistry

We've talked about how important water is and how limited our access is to water that is useable by humans and other living things.

- **What kinds of things limit the water that living things can use?** (Sediment, chemical pollutants such as fertilizers and herbicides, heat, amount of dissolved oxygen, organic wastes and decay, salts, etc.)

Today we will learn some ways to identify pollutants in water.

Use a cooperative learning activity. Divide the class into four groups. Each group will lead a class discussion of different components of water chemistry. Give each group one of the definitions. (See *Definition* sheet at the end of the lesson.)

Ask the groups to read and discuss the definitions and answer the questions.

Have students consider what it means for one water sample to have a higher or lower pH, conductivity, dissolved oxygen level or nitrate content than another.

Groups will share their ideas and information with the class.

Have students take notes in their science notebooks describing the meaning of each characteristic.

Definitions

- **pH** is a measure of acidity. Pure water has a pH of 7, which is considered neutral. In the United States, most rainwater is moderately acidic (5.5) due to contamination from acid-forming gases in the air. These gases include carbon dioxide, sulfur dioxide and nitrogen oxides. They come from the burning of fossil fuels. Acidity can cause toxic heavy metals to dissolve into the water. **What could this acid rain mean for local water supplies? Is it better to have high, low, or neutral pH levels?**
- **Conductivity** measures how easily electricity flows through the water. Salts dissolved in water allow it to conduct more electricity. Other substances that may not be dissolved, but are suspended in the water, also cause it to conduct electricity more easily. These may also cause the water to appear cloudy or dark. Some common causes of higher conductivity include wastes from animals or humans and eroded soils that have washed into the water. Water in estuaries varies in salinity. Ocean water is called saltwater and is about 35 parts per thousand salt, or 3.5%. Texas' Laguna Madre has even higher salinities, due to little rainfall, evaporation, and minimal exchange of water between the ocean and Laguna Madre waters. **Why would differences in salinity be important to local ecosystems?**
- **Dissolved oxygen** is important to support aquatic life. In general, higher dissolved oxygen is better for fish and other aquatic life. Air is 21% oxygen or 210,000 parts per million. Most of Texas' waters are 0.0005-0.0015% oxygen or between 5 and 15 parts per million**. In hot summers oxygen levels may be lower. What would this mean for local aquatic life?**
- **Nitrates** can come in many forms. Fertilizer and animal and human waste are common sources of nitrates in Texas' waters. Golf centers use a lot of fertilizer to keep their golf courses green. Nitrates may stimulate plant growth. **What sources of fertilizer might be found in your area? What would this mean for local aquatic life?**
- **Phosphates** can come from fertilizers and from household detergents. Phosphates stimulate plant growth. What sources of phosphates might be found in your area? How do they affect the life in water?

2. Testing Water Samples

Prepare in advance by setting up the room. If there are enough water samples and water quality test kits, distribute a set to each group. If there is only one set of equipment for each test, provide water samples to each group and set up stations around the room where groups take turns using the equipment at each station to test their water samples.

Distribute a *Water Chemistry Investigation Sheet* to each student.

Divide students into groups. Give each group a set of water samples. Tell students the sources of the water samples (e.g., tap water, rain water, pond water, etc.), but do not tell students which sample is which. Explain that they must figure out which is which by testing the samples.

First have students use the check sheet for *Physical Indicators of Pollution* to record observations about color and odor for each water sample.

Demonstrate the use of each kit, meter, or other equipment according to the directions accompanying it.

Have students test each sample and record their results.

Have students place the completed data sheets in their science notebooks.

Have students clean up and prepare kits, meters, or equipment for use by the next group or class.

Day Two

Finish any testing that was not completed on Day One.

3. Assessing What We Learned: Drawing Conclusions Based on Data

Have each group report the results for one of the water chemistry tests that they conducted yesterday, and their hypotheses about the source of one of the water samples. (Tap water, rainwater, pond/creek water, etc.)

- **What data do you base your hypothesis on?**
- **Which water sample would you drink? Why?**

Reveal the source of each of the water samples (e.g., A is tap water, B is rain water, C is pond water, etc.) and discuss the **data** on which your conclusions are based.

Be sure to address any misconceptions students may have about each water characteristic.

Discuss application of these testing skills during field trips to aquatic environments.

- **How would each of these tests help us to understand what is happening in a local aquatic ecosystem?**

Extension 1

Follow up the Internet research done in the last lesson (1.8) by discussing careers found when researching water quality.

- **What jobs help to monitor water quality and plan ways to alleviate environmental conditions that impact water?** (Soil and water scientists at various governmental agencies (such as TPWD, TCEQ, NRCS), university researchers, etc.)

- **What kind of education is necessary to have one of these jobs?** (At least a bachelors degree in hydrology, aquatic studies, biology, ecology or other science degree)

You may want to invite one of the scientists from one of these agencies (TPWD, TCEQ, NRCS) to visit your class and answer questions about their job and how they were trained.

Extension 2

Have students do some Internet research to learn about the **Clean Water Act** and identify the impact of this law on aquatic systems.

Be sure to check websites to be sure that they are still active.

Clean Water Act Websites:

http://www.epa.gov/regulations/laws/cwa.html

http://www.epa.gov/lawsregs/laws/cwahistory.html

- **How does this law fit into the jobs that are concerned with water quality?**

Extension 3

Take a field trip to evaluate a nearby creek or pond using the tests you have practiced and the check sheets at the end of the lesson. You may also want to collect samples for a native aquarium.

Students may start a long-term study of a local aquatic site by visiting a nearby pond or creek and collecting baseline water quality data and making observations of human activity along the banks of the creek or pond. If you have an aquatic site on the school grounds, the water quality data can be done on a regular basis along with weather data (See Lesson 2.2). (Daily, weekly, monthly, depending on your lesson plans)

Students should predict how human activities impact physical, chemical, and thermal changes in the water, which will affect the living and nonliving components of the aquatic ecosystem.

Students should look at the *Weather Data, Physical Indicators of Pollution* check sheet, water temperature, turbidity, pH, salinity, nitrates, phosphates, dissolved oxygen, *Invertebrate and Vertebrate Water Quality Indicators* information sheet, and macro-invertebrate identification sheets such as the *Bug Picking* sheet from Texas Parks and Wildlife Department.

- **Where does the water come from to this aquatic ecosystem?**

Have students analyze the cumulative impact of human population growth on this aquatic ecosystem.

- **How might this impact change over the coming years?**

Vocabulary

- Conductivity

- Dissolved oxygen
- Nitrates
- Phosphates

Definitions

- **pH** is a measure of acidity. Pure water has a pH of 7, which is considered neutral. In the United States, most rainwater is moderately acidic (5.5) due to contamination from acid-forming gases in the air. These gases include carbon dioxide, sulfur dioxide and nitrogen oxides. They come from the burning of fossil fuels. Acidity can cause toxic heavy metals to dissolve into the water. **What could this acid rain mean for local water supplies? Is it better to have high, low, or neutral pH levels?**

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- **Nitrates** can come in many forms. Fertilizer and animal and human waste are common sources of nitrates in Texas' waters. Golf centers use a lot of fertilizer to keep their golf courses green. Nitrates may stimulate plant growth. **What sources of fertilizer might be found in your area? What would this mean for local aquatic life?**

- **Phosphates** can come from fertilizers and from household detergents. Phosphates stimulate plant growth. What sources of phosphates might be found in your area? How do they affect the life in water?

Student Page

WATER CHEMISTRY INVESTIGATION

Objective

1. Record your group's observations about the color and odor of each water sample in the table below.
2. Following the directions for each meter, test kit or other equipment to test each water sample and record data in the table below.

Group: _____ (names)
Date: _____

Physical and Chemical Characteristics of Unknown Water Samples

Water sample	Temperature (^{o}C)	Color	Odor	Foam	pH	Conductivity _____ (units)	Dissolved oxygen _____ (units)	Nitrates And/or phosphates _____ (units)	Water sample source

Student Page

WEATHER OBSERVATIONS AND MEASUREMENTS

Objective

Obtain, record, and present weather data.

Name: _____

Date: _____

Location: _____

Weather factor	Observation or measurement
High temperature	
Low temperature	
Wind speed	
Wind direction	
Atmospheric pressure	
Relative humidity	
Precipitation	
Cloud cover	

Student Page

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A ***musky*** smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A ***chlorine*** smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

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Invertebrates and Vertebrates as Water Quality Indicators

Invertebrates

A stream with:

- A great variety of insects, with few of each kind, indicates clean water.
- Less variety of insects, with greater abundance of each kind, indicates that there is too much organic matter in the water.
- Finding only one or two kinds of insects in great abundance indicates severe organic pollution caused from excessive human or livestock waste or high algae populations.
- If no insects are found, but the stream appears clean there may be some type of toxic pollution, which includes chemical pollutants such as chlorine, acids, metals, pesticides, and oil.
- Excessive sediment may be caused by erosion or discharge from a pipe and may reduce the amount of water in the stream causing extreme temperatures, and causing a loss of oxygen, which may smother insects resulting in a reduction of the number of animals in the area.

Note about Invertebrates

The types of **invertebrates** found can help students know about the quality of the water. Print out the Texas Parks and Wildlife *Bug Picking Data Sheet* at **the end of this lesson** to help identify invertebrates found in creeks and indicate which invertebrates are associated with clean water and which predominate in polluted water.

Vertebrates

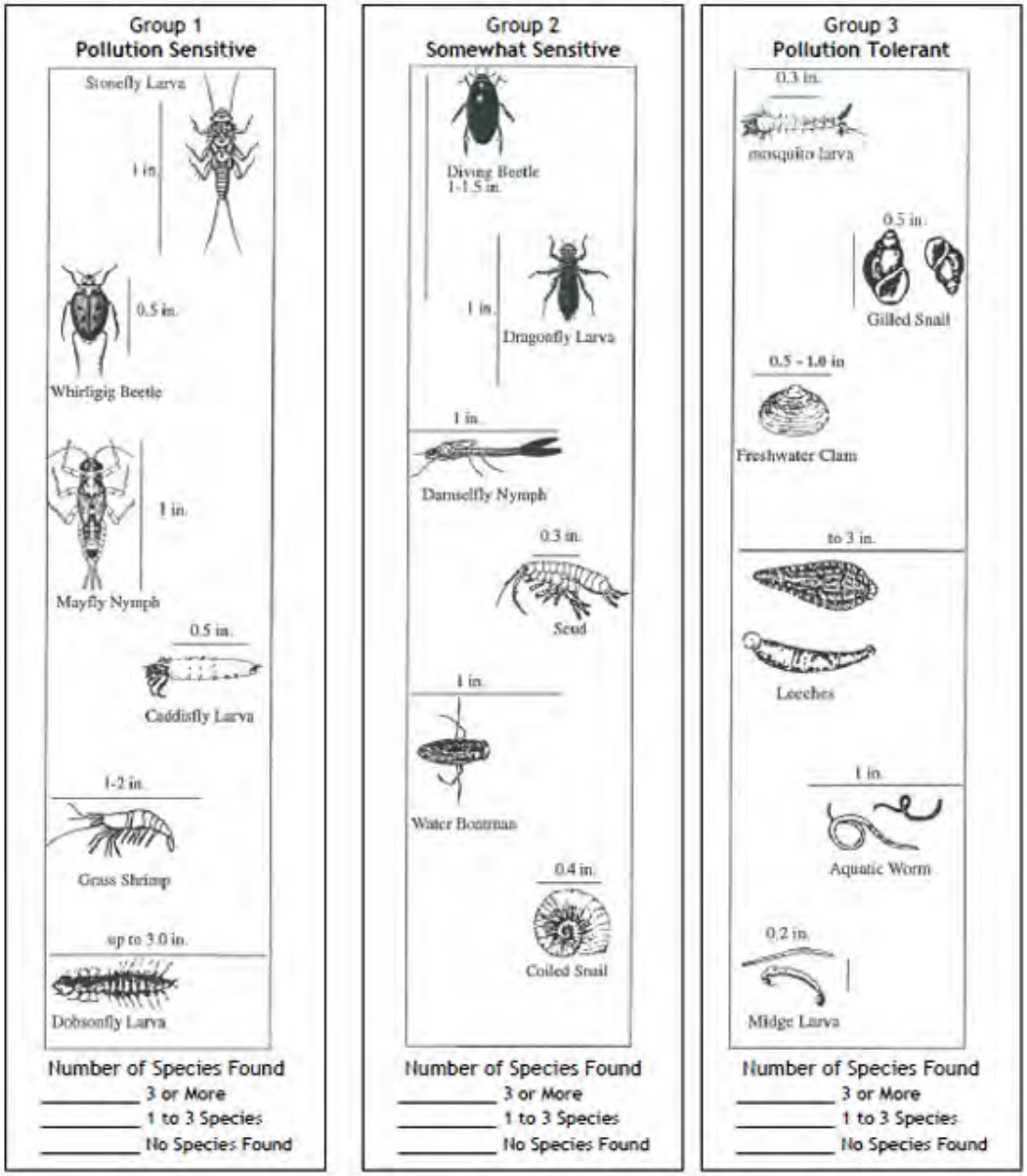
- If fish are exhibiting some odd behavior such as jumping out of the water or being non-responsive, it may indicate toxins in the creeks. A chemical analysis is needed to find the source of the toxin. Contact the TCEQ.
- If there are no fish or other vertebrates in the creek, it may indicate that the creek is stressed from urban runoff, sewage, or toxins entering the stream. Chemical analysis is needed to the find the source of the problem. Contact the TCEQ.

Student Page

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department

Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: **(Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)**

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: **Not Polluted** **OK** **Polluted**

Chapter 1 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **What proportion of the water on the Earth is fresh water?**
   - **A** 3%
   - **B** 25%
   - **C** 75%
   - **D** 97%

2. **What is water quality?**
   - **A** Water running off hot pavement
   - **B** Water's fitness for a particular use
   - **C** Water used mainly for agriculture
   - **D** All of the above

3. **Water is a unique substance. It can be found on Earth in all three states—solid, liquid, and gas. Which of the following are other properties of water?**
   - **A** Exhibits surface tension
   - **B** Acts as a solvent
   - **C** Is transparent
   - **D** All of the above

4. **In the experiment in which you recorded your daily water use, what was a constant?**
   - **A** The person using the water
   - **B** The amount of water used
   - **C** The ways in which water was used
   - **D** The temperature of the water

5. **How does water pollution affect aquatic life?**
   - **A** Cloudy water blocks light and slows plant growth
   - **B** Too much fertilizer causes overgrowth of algae
   - **C** Toxic chemicals are poisonous to living things
   - **D** All of the above

6. **How do humans affect water quality?**
   - **A** By taking biological surveys
   - **B** By creating surface tension
   - **C** By boiling and freezing water
   - **D** By polluting or conserving water

7. **What is the hydrosphere?**
   - **A** All the freshwater on Earth
   - **B** All the water on Earth
   - **C** Two hydrogen atoms and one oxygen atom bonded together
   - **D** None of the above

8. **What are natural resources?**
   - **A** Any recyclable substance
   - **B** Anything made in a factory
   - **C** Anything found in the hydrosphere
   - **D** Anything found on Earth that can't be made by humans

9. **What is conservation?**
   - **A** Careful use
   - **B** Thinking very hard
   - **C** Taking anything we want
   - **D** Taking water for granted

10. How does water's temperature affect the amount of oxygen in it?

A Cold water floats

B Liquid water turns to gas

C Cold water holds more oxygen

D Oxygen is vital for life

11. Earth's land areas, oceans, and atmosphere maintain fairly constant average temperatures. What is the best explanation for these constant average temperatures?

A Earth's Northern Hemisphere and Southern Hemisphere have opposite seasons

B Earth is tilted and rotates daily on its axis

C The continuous motion of air and water distributes the sun's energy

D Global weather systems generally move from west to east

12. A frog lives in a pond containing duckweed.

Facts About Duckweed
• Duckweed is a small plant that grows in water. • Many water birds depend on duckweed for food. • Duckweed can reproduce rapidly in water that is rich in the nutrients used in agriculture

Which of these human activities would most likely cause an overgrowth of duckweed in a pond environment?

A Gradually introducing geese into the pond

B Fishing in the pond as recreation

C Planting trees in nearby forests

D Heavily fertilizing nearby farm fields

Chapter 1 Assessment

Write your own answer for each of the following questions.

1. How much freshwater is available for living organisms—including humans—to use? Compare this to the amount of saltwater on Earth and to the total amount of all water on Earth. Explain why water is a natural resource that must be conserved.

2. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as farm irrigation, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Texas.

3. Create a chart to describe three special properties of water and to justify why these are essential to life on Earth.