Exploring the Properties of Water

Lesson Topic
Exploring the Properties of Water

RIEL Biology Element
Multiple Modalities

Time Required
Two class periods

Standards Addressed
- SC.912.L.18.12 Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent.

Science and Engineering Practice
- Developing and using models
- Analyzing and interpreting data
- Constructing explanations

Content Learning Objectives
- Students will be able to identify the properties of water and how they are important for life on Earth.

Lesson Summary
Students will begin with a short video reviewing properties of water then rotate through 8 stations that will demonstrate the properties of water. Students will have a student sheet that will have questions to guide their thinking for each station. Once completing the stations, students will have a reading that further discusses the properties. At the end, they will then take what they observed at each station and combine it with what they learned from the reading and any other prior info to connect what they observed to the property of water being shown and how that property is important to life. The lesson will focus on the properties of water: cohesion, capillary action, surface tension, specific heat, universal solvent, expansion as a solid.

Materials
- Station 1: computer, videos loaded – (1) Time Lapse Test - Freezing A Glass of Water, (2) Freezing Water Expanding
- Station 2: capillary tubes, beaker of colored water, optional: celery that has been sitting in beakers of colored water for several days
- Station 3: pennies, pipettes, cup of water
- Station 4: paper stars, shallow container (like a petri dish) of water
- Station 5: oil, water, sugar, salt, scoopulas, cups
- Station 6: paperclips and beaker of water
- Station 7: shallow dish of water, skittles or some other water-soluble candy
- Station 8: computer, video loaded – Evidence for Climate Change: Heat Capacity Demonstration

Before the Activity
The lab can be modified to support materials that are easily accessible. To make the stars in station 4, use construction paper and a 2" star punch. Print out the station directions for each station. Make copies of the student sheet as well as the properties of water reading.

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Lesson Activities

1. **Students should have already been introduced to the properties of water.** If this lab will be their first exposure, it is suggested that more detailed info is given before attempting the final questions.
2. **Students should rotate through the stations**. Each station has a set of questions on the student sheet that should be answered before moving on to the next station. The stations do not need to be completed in order. The teacher should be moving through the classroom ensuring that students are on task and following proper lab safety.
3. **The properties being addressed at each station are as follows**:
    1- expansion of ice
    2- capillary action
    3- cohesion and surface tension
    4- surface tension in the star floating, capillary action when the paper absorbs the water and the star begins to open
    5- solubility
    6- surface tension
    7- solubility
    8- specific heat capacity

Important notes:

1. **Station 2.** Students should place the tube only on the surface of the water (colored water helps them see it) and should not have their finger covering the end. An alternative would be to use a strip of paper towel and have them dip the tip in the water and observe what happens.
2. **Station 5.** Use as many disposable items as possible for this station, cleanup can be challenging. Volumes do not matter, but if using scoopulas make sure the students do not stir with them.
3. **Station 7.** Students will want to eat them, it is helpful to have extra that can be given out at the end of class

Teacher Notes

- Optional video: The Properties of Water
- Station Directions

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7. **Station 8. The video is** a balloon demo. Students may want to say that the popping is due to the latex melting (Latex melts at 180° C). If they look closely, they can see that the water balloon has dark marks on the bottom where the flame is coming in contact with the balloon. The idea is that the air heats up faster than the water and it is the increase in pressure that causes the balloon to pop.

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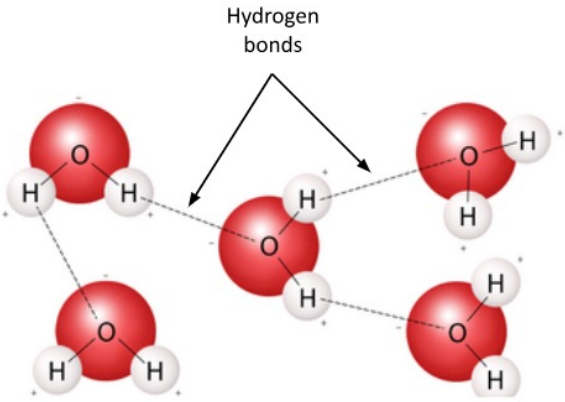
Properties of Water Reading

What are the physical and chemical properties of water that make it so unique and necessary for living things? When you look at water, taste and smell it—well, what could be more boring? Pure water is virtually colorless and has no taste or smell. But the hidden qualities of water make it a most interesting subject.

Polarity and Hydrogen Bonding

You probably know water's chemical description is H2O. As the diagram to the left shows, that is one atom of oxygen bound to two atoms of hydrogen. (If the water molecule here looks familiar, remember that everyone's favorite mouse is mostly water, too). The hydrogen atoms are "attached" to one side of the oxygen atom, resulting in a water molecule having a positive charge on the side where the hydrogen atoms are and a negative charge on the other side, where the oxygen atom is. A compound with one negatively charged side and one positively charged side is called a **polar molecule**.



Source: USGS

Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky." The side with the hydrogen atoms (positive charge) attracts the oxygen side (negative charge) of a different water molecule. This is called a **hydrogen bond**.

Surface Tension

Water has a very high surface tension. In other words, water has a thin “skin” on its surface due to the water molecules sticking together. Because of this surface tension, water tends to clump together in drops rather than spread out in a thin film. Surface tension also allows light objects to float on the surface of water.

Cohesion and Adhesion

All these water molecules attracting each other mean they tend to clump together. This is why water drops are, in fact, drops! If it weren’t for some of Earth's forces, such as gravity, a drop of water would be ball shaped -a perfect sphere. Even if it doesn't form a perfect sphere on Earth, we should be happy water is sticky.

The stickiness of water is responsible for two other important properties: adhesion and cohesion. **Cohesion** means that water molecules stick to other water molecules via hydrogen bonds. Water molecules are cohesive because they are polar molecules. **Adhesion** means that water molecules stick to other materials. Cohesion and adhesion work together to allow water to travel against gravity and move up a plant stem. This is called capillary action.

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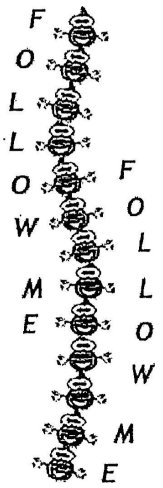
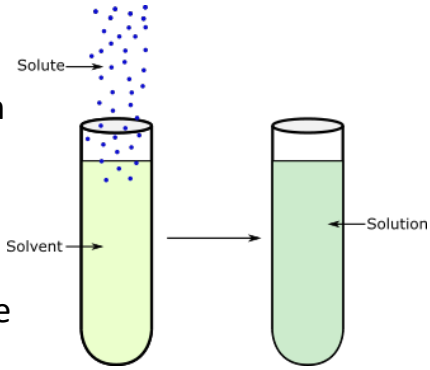
Capillary Action



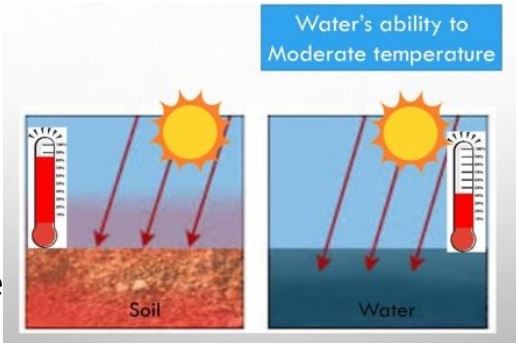
Capillary action is the ability of water to move upward, against gravity, through small openings. As water molecule #1 starts climbing, it pulls along water molecule #2, which, of course, is dragging water molecule #3, and so on. For example, water can move upward through soil or porous rocks. (Porous objects have many small holes in them). Capillary action is extremely important for living organisms. It is what allows water (and any substances dissolved in it) to move through the roots of plants and through the tiny blood vessels in our bodies.
So, the next time you spill your glass of soda (which is, of course, mostly water) on the kitchen table, think of the properties of water, which allow you to wipe it up before your parents see it. First, you can thank surface tension, which keeps the liquid in a nice puddle on the table, instead of a thin film of sugary goo that spreads out onto the floor. When you put the paper towel onto your mess the liquid attaches itself to the paper fibers because of adhesion. The liquid is then absorbed into the small holes in the paper towel and can move throughout the towel due to capillary action.

Versatility as a Solvent



Water is called the **universal solvent** because it dissolves more substances than any other liquid. This means that wherever water goes, either through the ground or through our bodies, it takes along valuable chemicals, minerals, and nutrients. For example, water can easily dissolve ionic compounds (compounds formed from the attraction of a positively and negatively charged ions) such as table salt (NaCl). Water dissolves salt by causing the sodium (Na+) and chlorine (Cl-) ions to pull away or disassociate from one another. The water molecules form a sphere around each ion.
If the water evaporates, the sodium and chlorine ions will come together again and form salt crystals.

Ability to Moderate Temperature



Water has a high **specific heat capacity**. Specific heat is the amount of heat required to change the temperature of 1 gram of substance by 1 degree Celsius. This means that water can absorb a lot of heat before it begins to get hot. The high specific heat capacity of water helps regulate the rate at which air changes temperature, which is why the temperature change between seasons is gradual, especially near the oceans. Having a high specific heat also means that water is a great coolant. When our body temperature is too high, we produce heat and thus cool us back down.

Expansion upon Freezing

As water decreases in temperature, the molecules move away from each other. This change causes water to **expand** when it freezes. As a result of the volume increase, the density of ice decreases. Unlike other substances, water in its solid form is less dense than its liquid form. This means that ice floats.

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Exploring Properties of Water

Student Sheet

Station 1

1. Record 3 observations for the first video
    a.

    b.

    c.

2. Record 3 observations for the second video
    a.

    b.

    c.

Station 2

1. Record your observations from step 1.

2. Look at the photo, what happened?

3. How do you think the food coloring traveled from the bottom to the top?

4. The celery has “tubes” like what you used in step 1 (but not made of glass). Are there similar tubes in the human body? Explain your answer.

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Student Sheet

Station 3

1. How many drops did you get on the penny before it overflowed? _____
2. Draw how your penny looked with the water on it.
3. Describe where you have seen this similar occurrence in nature.

Station 4

1. What happened to the star?

Station 5

1. Write down your predictions:
   a. water and sugar
   b. oil and sugar
   c. water and salt
2. Write your observations after mixing them:
   a. water and sugar
   b. oil and sugar
   c. water and salt
3. Why do you think the water and oil behaved differently?

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Student Sheet

Station 6

1. How many paperclips did you get to float? _____
2. What did you do to get them to float?
3. Describe where you have seen this similar occurrence in nature.

Station 7

1. What happened to the candies after you added the water?
2. What are some possible explanations for what you are seeing?
3. How might this be important to animals?

Station 8

1. Predict and explain: What will happen to each balloon. Why?
2. Watch the video, what really happened?
3. Observe and explain: Did your observations match your predictions? Provide a possible explanation for the results.

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Student Sheet

Put it all together. Use the information from each station and the reading to answer the questions.

1. What property of water is being shown in station 1? Explain.

2. Station 1: How does this benefit aquatic organisms?

3. What property of water is being shown in station 2? Explain.

4. Station 2: How do organisms benefit from this property?

5. What properties of water are being shown in station 3? Explain.

6. Station 3: How do organisms benefit from these properties?

7. What properties of water are being shown in station 4? Explain.

8. What property of water is being shown in station 5? Explain.

9. Station 5: Why is this property so important to life on Earth?

10. What property of water is being shown in station 6? Explain.

11. What property of water is being shown in station 7? Explain.

12. What property of water is being shown in station 8? Explain.

13. Station 8: Why is this property important to life on Earth?

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