Overview

Students use magnetic water molecules from 3D Molecular Designs to model properties of water. Teachers can choose one or more of the activities using the models and the Water Kit Booklet.

Learning Targets

All activities: To use models as a representations of natural phenomena.

Activity 1: To compare the relative strengths of a covalent bond, ionic bond and a hydrogen bond.

Activity 2: To understand the difference between polar and nonpolar molecules.

Activity 3: To understand the differences of water as solid, liquid and gas.

Activity 4: To understand the differences of solubility between nonpolar molecules and ionic compounds when dissolved in a polar solvent.

Activity 5: To understand the difference between cohesion and adhesion of water.

Activity 6: To understand how cohesion of water molecules causes surface tension.

Activity 7: To understand how cohesion and adhesion of water molecule cause capillary action.

Introduction

We recommend engaging students with properties of water using the formative assessment demonstration Walking the Tightrope and the Water Olympics activities as described in the accompanying lesson before introducing students to the magnetic models. These activities will likely require one class period. If putting on the Water Olympics is not practical, we recommend conducting the formative assessment and/or demonstrating some of the properties of water. At minimum, use slides 2 - 3 from the PowerPoint slide set to discuss the unique properties of water before proceeding with the Water Kit Booklet.
Lesson Outline

1. **Engage:** Demonstrate Walking the Tightrope and have students compete in the Water Olympics.

2. **Explain:** Introduce *Representations of Water Molecules* to show students different ways in which water is represented, and tell students that they will use the magnetic models for a number of activities.

3. **Explore:** Use the *Water Kit Booklet* in class with the water molecule models
   a. Have students complete selected activities in class by following the procedures
   b. Then answer analysis questions from selected activities. The answers to these questions are necessary for completing the **Student Assessment**.
   c. Things to watch for:
      i. In Activity 4, sodium and chloride should be separated by 1+ water molecules. Have student repeat if this does not occur.
      ii. In Activity 6, water molecules should form a small tower. Have students repeat if water molecules are all touching the table and flat.

4. **Evaluate:** Have students complete the Student Assessment. This can be completed as homework.

Each activity is accompanied by visuals found in the slide set:

- **A1.** bond types
- **A2.** Polar and nonpolar
- **A3.** Solid, Liquid, Gas
- **A4.** Solubility
- **A5.** Cohesion vs Adhesion
- **A6.** Surface Tension
- **A7.** Capillary Action Animation
Prep Procedures

- Read and select relevant student activities for your class
- Fill water cups with necessary models EXCLUDING unnecessary models to prevent confusion and loss.

Lab Station Inventory

For each group of 2 students:
- Water Kit Booklet
- Water cup and lid containing
  - 12 water
  - 1 sodium
  - 1 chlorine
  - 1 ethane

Extension Materials:
- Hydroxyl (-OH) group in separate bag (might look broken but it is not)

Follow up

Share with students the quote by mathematician and statistician George E.P. Box:

> “Essentially, all models are wrong, but some are useful.”

Have students discuss, in a large or small groups, in what ways the water molecules were useful in understanding properties of water, and in what ways the models were wrong. Did the model work better to show some properties more than others?

Students should understand that no matter how useful a model is, models are simplified representations of real-world events. These events are much more complicated than what can be shown by using a model.

Recommended Student Pre-Knowledge & Skills

- Basic understanding of the states of matter
- Basic understanding of the concept of volume
- Basic understanding of the difference between ions, atoms, and molecules.

Clean Up

Return neatly organized water cups, Activity Booklets, and chocolate. Lots of it. The dark stuff, no Hershey.
Teacher Notes

Reassembling hydrogens:
If unattached hydrogens are found, check the following guide to reassemble properly.

Building Ethanol
To build ethanol, remove hydrogen marked with a black dot from an ethane molecule. Insert hydroxyl group.

Extension Activities
These models can be used to teach the following concepts:

- Transpiration
- Solubility of partially polar molecules such as ethanol and methanol (see teacher background for assembling alcohols)
- Hydrophobic/hydrophilic properties (see Magic Sand materials included in Water Kit)
- Osmosis (see http://www.3dmoleculardesigns.com/Teacher-Resources/Water-Kit/Osmosis-Lesson.htm)
- pH (see http://www.3dmoleculardesigns.com/Teacher-Resources/Water-Kit/pH-Lesson.htm)

The models used in this lesson are made by 3-D Molecular Design. Additional sets, information, and lessons plans can be found at www.3dmoleculardesigns.com.
Connections to NGSS

This lesson supports:

Science and Engineering Practices

**Developing and Using Models.** Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

**Analyzing and interpreting data.** Introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Crosscutting Concepts

**Structure and function.** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Disciplinary Core Ideas

**PS2.B:** Attraction and repulsion between electric charges at the atomic scale explain contact forces between material objects

Performance Expectations:

**HS-PS1-3:** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

**HS-PS3-5:** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

**HS-PS2-6:** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Online Resources

States of Matter simulation
http://phet.colorado.edu/en/simulation/legacy/states-of-matter-basics

Effects of Temperature on Charged and Neutral Atoms
http://lab.concord.org/embeddable.html#interactives/samples/3-100-atoms.json

Surface Tension by Khan Academy
https://youtu.be/pmagWO-kQ0M

SEP Capillary Action with Water Molecules PowerPoint
https://youtu.be/EBfGcTAJF4o