TEAMS
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Wonderful Waterlock – Teacher Notes

INTRODUCTION
This is a great demonstration because it is unusual, unexpected and very thought provoking. It is a great science activity to do during the first week of school when you are talking about the importance of making careful observations of the world us. In this simple activity students make observations, form explanations, and they connect their ideas to the real world. It is also a super activity to do when you are studying matter - the stuff of the universe - because you work with a compound called Waterlock that is the coolest substance on the planet. It's amazing and unusual properties will fascinate your kids and they'll be eager to discuss some very important science concepts.

OBJECTIVES
The students will describe the how careful observations can help to produce new ideas.
The students will understand that each substance (material) has unique properties that help make it useful.

SCIENCE STANDARDS
National Science Standard: Unifying Concept
Nature is predictable and we can use evidence to explain and understand it.

Georgia Performance Standards:
Students will exhibit curiosity, honesty, openness and skepticism S(K-5)CS1
Describe materials, what they are made of, and how they change. SKP1, S2P1, S5P2

SCIENCE REFRESHER

Thinking Like a Scientist

In this exercise, students will gain experience with scientific thinking. They will see water seemingly disappear from a cup in front of their eyes, and use their powers of observation and logic to advance explanations for what they saw. *Wonderful Waterlock* is an excellent way to start students thinking like scientists – without them even knowing they're doing it.

Scientists use many different approaches when studying nature, but a grossly simplified and commonly used approach is presented in Figure 1. This approach is often referred to as the "scientific method" or the "inductive method" but it is important to realize that no one method is appropriate for every scientific undertaking. In general, the process begins with a number of observations or measurements that suggest a pattern in nature worthy of further examinations. After repeated observations of the same phenomena, a testable explanation is proposed – a hypothesis. Hypotheses are evaluated with experiments and other methods and the results analyzed. If the results are not consistent with the hypothesis, then an alternate hypothesis is proposed and tested. If the results are consistent with the hypothesis and the same results are obtained in repeated experiments, the hypothesis may "graduate" to the level of a theory. Note that the scientific meaning of "theory" is reserved for hypotheses that have undergone repeated, rigorous testing. This is very different from the common meaning of the word, which describes any explanation for an event – even explanations backed by little or no evidence.

This manner of thinking is not uncommon in everyday life. We constantly encounter problems that are solved using this approach. We observe events around us and offer and evaluate explanations for what we saw. An ability to think logically about problems and devise ways to test explanations is therefore a skill educators should seek to instill in students at all educational levels.

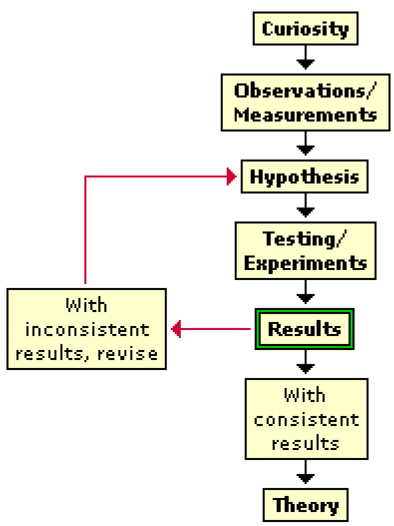


Figure 1. One representation of the steps involved in scientific endeavors.
[http://www.dosits.org/animals/sci-method2.gif]

Wonderful Waterlock and Scientific Thinking

Wonderful Waterlock allows teachers to demonstrate the scientific way of thinking in an exercise that truly engages students. It presents them with an unexpected result and challenges them to advance explanations – just like a good magic trick. The exercise has students make careful observations as the cups are being shuttled around so that they can follow the one containing the water. When the water fails to fall from the inverted cup, students must then make additional observations and advance hypotheses. These hypotheses can then be tested one by one until the solution is determined or the teacher reveals the answer. The exercise therefore enables teachers to give their students practical experience with scientific thinking, facilitating its use in more traditional experiments. The exercise can also be used to show how seemingly unexplainable events have logical answers if studied carefully.

What is Waterlock?
"Waterlock" is the trade name for sodium polyacrylate, a light-colored crystal that resembles table salt (Figure 2). It has the ability to absorb many hundreds of times its weight in water and bind up liquids in gel form (Figure 3). Waterlock is consequently used in instances where liquids are undesirable. Plumbers use it to soak up standing pools of water. Emergency rooms use it to bind up liquid blood on floors. Its most common use, however, is in disposable diapers. Sodium polyacrylate powder is encased within the diaper and wicks the liquid in urine into the diaper and away from the child's skin. The gel that forms from the interactions of Waterlock and the liquid give a used diaper its weight and feel.

Fig. 1. Sodium polyacrylate crystals

[https://www2.carolina.com/webapp/wcs/stores/servlet/CarolinaBio/images/medium/891480_chm.jpg]

Fig. 1. Sodium polyacrylate gel

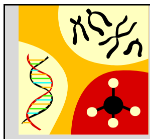
[http://calm.iki.fi/chilikuvat/waterlock-wet.jpg]

How Waterlock Absorbs Water
Sodium polyacrylate is a polymer – a long molecule made up of repeating chains. When it is surrounded by water molecules, the chain "unwinds" and exposes binding sites for water molecules. As water bonds with the crystal, a gel is formed. In essence, the molecule is like a spring that unwinds, exposing more sites that can bind with water.
Waterlock's ability to absorb water is not infinite – once all the binding spots for water are occupied, it cannot bind any additional water molecules. Hence, disposable diapers cannot be used indefinitely...

Liquid water moves from outside the Waterlock molecule to the inside by diffusion. Diffusion describes the tendency of atoms or molecules to "spread out" within a volume. Diffusion is seen when perfume molecules are sprayed into the air in one corner of a room, but spread throughout the room over time. It is also seen when a drop of ink is added to a beaker of water. Leave the water undisturbed for several hours, and the molecules of ink will have diffused throughout the liquid. These movements of molecules are not intentional, they are simply a result of the random motion of many molecules.

When molecules diffuse, they move from areas of higher concentration to areas of lower concentration. The perfume molecules were originally in higher concentration near the site of spraying but spread out over the room where their concentration was lower. The ink molecules were initially clustered together near the point of deposition at high concentration, but diffused throughout the liquid where ink concentrations were lower. After some time, the movements of the ink molecules resulted in them being spread out evenly throughout the liquid.

Water in urine therefore moves from the area of higher concentration (outside the Waterlock molecule) to the area of lower concentration (within the Waterlock molecule). The binding of water keeps water concentrations low inside the molecule and keeps liquid flowing in by diffusion. Once all the binding sites are occupied, however, the concentration of water within and outside the Waterlock molecule becomes the same, and the diaper cannot absorb any additional water. The water holding capacity of sodium polyacrylate can be reversed by adding table salt. The salt decreases the concentration of water outside the Waterlock molecule and causes it to release from its binding sites on the molecule – again moving from areas of higher concentration to areas of lower concentration.

	**Animation – Diffusion** http://www.educationusingpowerpoint.org.uk/index.html?ks3science.html~mainFrame Flash animation showing the diffusion of hamburger smell across a room. Select “Animations” at top of page and then select “Diffusion” animation. Site allows users to download animations, if desired.

MATERIALS

Wonderful Waterlock Activity:

Three 16-20 ounce plastic cups	Cups must be opaque (not see-through) and colored white on the inside to hide the Waterlock powder.
1 clear plastic cup	Clear plastic cup similar in size to opaque cups.
Waterlock powder	Two teaspoons needed per demonstration. Waterlock (sodium polyacrylate) can be purchased at the suppliers below at very economical cost: Educational Innovations Inc. http://www.teachersource.com (a.) Choose *Browse or Search the Catalogue* (b.) Enter "sodium polyacrylate" in search box (c.) Select the product in the search results. Small quantities go a long way, so the smallest size is advisable for everyday teaching. Ward's Scientific http://www.wardsci.com/ (a.) Enter "sodium polyacrylate" in search box (b.) Select the product in the search results.
Plastic teaspoon	For spooning and stirring Waterlock.
Safety Goggles	One pair for teacher.

Extension Activity:

Metric graduated cylinders or measuring cups	Size optional
Disposable diapers	One diaper per student group.
Food Coloring	For coloring water poured into diaper (optional).
Distilled Water	Performs better than tap water due to fewer salts.

EXPLORATION (Teacher-led):

Preparation

We begin this exploration by playing the shell game using three cups instead of three shells. The cups need to be identical, opaque, and white on the inside. Place about one-fourth of a teaspoon of Waterlock into two of the cups before students come into the class. Have the three cups placed out on a table for your students to see.

"Follow the Cup"

Tell the students that you are about to do a demonstration that will test how good they are at making observations. Their job is to follow the cup with the water in it as you scramble the cups around and around. Show them that the cups are empty by tipping them sideways in their direction (they will not be able to see the white powder). Pour about 1/4 cup of water into one of the cups that has the Waterlock in it and then scramble the cups around for a minute or so (the Waterlock will absorb the water and gel it in the bottom of the cup). After moving them around, have the students vote on the cup that they believe contains the water. Students generally have no trouble following the correct cup. Next, carefully invert the one empty cup to show them this obviously isn't the right one. Finally, invert the cup that they all voted on watch their surprised reaction when no water flows from the cup. Repeat this process using the second cup that contains Waterlock.

Brainstorming Explanations

Now ask students to develop ideas to explain what happened to the water. You may also choose to have them write down their ideas in their science journals or on the provided student handout. Encourage them to think of as many ideas as possible and let them discuss their ideas in small groups for a minute or two. Then discuss these ideas as a group encouraging them to be creative and "out of the box" in their thinking.

After this discussion you can tell the students that two of the cups actually contained a small amount of one the most amazing substances on the planet - Waterlock (sodium polyacyrlate). Using a spoon, show them that it is white powder that looks quite usual and ordinary. Then place a small teaspoon of this powder into a clear cup and mix it briefly. Allow the students to observe the Waterlock as it quickly absorbs the water. After a few seconds, you can invert the cup to show that water will not pour out. You can also tap the inverted cup on the table until the gelled water falls out. You can then pick it up like a snowball and show it to the rest of the class.

Essential Questions

1. What observations did you make that might help you explain what happened to the water?
2. Brainstorm 3-5 ideas that could possibly explain what happened to the water.
3. If you invented this substance, what could you use it for and how could you sell it to make a profit?
4. Write a commercial, song, poem, or infomercial that you could use to sell Waterlock to the rest of the world.

Safety and Disposal

Although Waterlock is not toxic, you should avoid letting students touch it because if crystals get from their fingers to their eyes it can be very irritating. Anyone who does touch the Waterlock should rinse their hands thoroughly after the demonstration. You can dispose of it by washing it by throwing it away or washing it down the sink with a lot of water.

You can pull the water out of Waterlock by pouring table salt (NaCl) onto it. The sodium (Na^+) and chloride (Cl^-) ions that form when the salt disassociates attract and bond water molecules, pulling them away from the Waterlcock molecule.

Explanation (Concept Building)

This is a great demonstration because the cup demonstration is very counterintuitive and thus it is curiosity stimulating and thought provoking. It helps students to recognize the importance of making good observations and it allows them to see how substances can undergo amazing changes when combined together. Waterlock is a molecule that has an amazing ability to absorb up to 800 times its own weight in water. That means that if you were a 100 pound chunk of this stuff and you jumped into a swimming pool, you would absorb over 80,000 pounds of water from the pool. As a result, Waterlock is used often in places where water and water-based spills are a problem. For example, Waterlock is used by plumbers to gel up the water from leaky pipes before it can soak in and cause major damage. But the most famous and profitable use of Waterlock is in diapers where it is sewn into the fabric so that the baby's urine (mostly water) gels rather than leaks through the diaper and pants.

Class Activity – Waterlock as a Soil Substitute

http://teams.kennesaw.edu/waterlock/costello-planter.htm

Ken Costello from Mesa Community College in Mesa, AZ shows an alternate use for sodium polyacrylate – as a soil substitute for potted plants. Set up a plant in the classroom with the used Waterlock from your class and reinforce the concepts covered in this activity as the plant grows. Remember to provide the plant fertilizer and keep it away from students' prying fingers. Mr. Costello has kindly agreed for us to mirror his materials on our site and the original activity is accessible at http://www.chemistryland.com/CHM107Lab/Lab7/Lab7Exp3polyacrylate.html.

Extension Activity

New uses for Waterlock are being developed every year. Have students brainstorm additional ways that Waterlock could be utilized to improve our communities. An extension activity has students experiment with a disposable diaper to see how much water it can absorb and at what rate. It provides them hands-on experience with experimental techniques, predictions, and basic statistics. The handout for this activity is provided. Distilled water works better than tap water for the activity, but tap water can suffice. As an optional touch, you can color the water yellow with food coloring. A typical disposable diaper can hold a liter or more liquid, so your student's results should fall out somewhere around 1,000 ml, plus or minus a few hundred milliliters.

Variation #1: Comparing the same type of diaper

Give all student groups the same type of diaper, preferably from the same batch. Observe the different student groups as they conduct the activity, noting differences in how each group follows the stated directions. Some will measure water carefully, others won't. Some groups will pour the water slowly, others fast. Some will spread the water out evenly across the diaper, others will pour it in one spot. See if all the groups wait the required 10 seconds before assessing the outside of the diaper for liquid.

When the activity is complete and all groups have turned in their results, ask the class to propose reasons for the discrepancy in results, given that all the diapers should be fairly similar (at least one group will usually have very different results from the rest of the class due to sloppy experimental procedures). Supplement their answers with your observations. Discuss how adhering to standard protocols is vitally important in science.

Variation #2: Comparing different diapers

You can also have your student groups evaluate different brands or types of diapers. You can compare the absorbency of premium and economy disposable diapers and evaluate them on the basis of cost. You can compare different brands of disposable diapers within the premium or economy categories. You can compare cloth and disposable diapers for absorbency and then introduce environmental themes by discussing the impacts of the added garbage that comes from disposable diapers. Use your creativity to come up with additional comparisons and analyses as you wish.