

**Rub-A-Dub Dub
Chemistry In the Tub:
A Hands-on Program**
An Educational Demonstration Package

Prepared by the
Cleveland Section
of the
American Chemical Society

National Chemistry Week 2002

Overview

Celebrate National Chemistry Week by exploring how chemists keep us clean with all their bright ideas! While conducting hands-on experiments, students will learn about some of the chemicals used in fighting stains in our laundry. Surface tension and water hardness and their effects on cleaning will be investigated. Students will also use a homemade water filtration system.

Table of Contents

	Page
Check-Lists	4
Experimental Setup	7
Opening Session	13
Closing Session and Clean-Up	34

Acknowledgements

The National Chemistry Week (NCW) programs of the Cleveland Section ACS began in 1994 with an idea to put together a scripted program that could be performed at any local school or library. This idea has expanded to become the centerpiece of Cleveland Section's NCW activities, which has received national recognition from the American Chemical Society. In 2002, the Cleveland Section volunteers will perform nearly sixty demonstrations at libraries, schools, and other public sites. Continuing our relationship started last year, the Cleveland Section will also be providing training and materials for Cleveland-area teachers (at the Cleveland Regional Council of Science Teachers' Fall Conference) so that they can conduct additional programs in their own classrooms. We hope to nearly double the number of teachers receiving complete demonstration kits this year.

This library/school program and other NCW events are the result of the hard work of many dedicated and talented volunteers. It all starts with our local section NCW Planning Committee. The Committee develops a theme for the program; recommends, tests, and reviews activities & experiments; writes a script; collects supplies and materials; prepares the kits; recruits sponsors and volunteers; contacts libraries and schools; and schedules shows. This Committee, as well as the rest of the Section's NCW activities, are overseen by the Cleveland Section's NCW coordinators, Paula Fox and Kat Wollyung. Committee members include Rich Pachuta, Lois Kuhns, Joe Yurko, Don Boos, Jesse Bernstein, Marcia Schiele, Betty Dabrowski, Mark Waner, Shermila Singham, David Ball, Liz Herbell, and Allison Winokur. Additional credit and thanks is given to all of the unnamed GAK (Grand Assembly of Kits) Day volunteers who gave up a Saturday in September to help count, measure, and assemble all of the necessary materials for our demonstration kits.

Our NCW efforts reach farther this year because of various sponsors who have donated money, materials, and/or services to the Cleveland Section specifically for National Chemistry Week. We are especially grateful to NASA Glenn Research Center, John Carroll University, Chardon High School, Aurora Golf and Country Club, and MeadWestvaco Corp. Specialty Chemical Division (Covington, Va.) for their numerous contributions and support.

Last and most important, we thank all the volunteers who donate their time and expertise. Without the dozens of dedicated chemical professionals to lead these activities, there would be no Cleveland Section NCW program.

Demonstrator's Guide**How Experiment Write-ups are Organized**

The materials and set-up of the demonstrations are located in the introduction section of this packet. Then, each experiment write-up is presented as follows:

- Background Information for Demonstrators
- Demonstration Instructions
- Experiment Conclusions
- Additional Information If Needed

Presentation Overview

This section describes the basic presentation technique used during the demonstrations. This is a guideline only as the technique may vary for some experiments. Make sure you follow the instructions given in each experiment.

1. Introduce experiment.

2. Do your demonstration piece.

Note: Most experiments require you to perform the experiment to show the students what to do on their own.

3. Have the students do their experiment.

Note: For some experiments your demonstration and the students hands-on work are nearly simultaneous. You are leading them as they perform the experiment.

4. Some experiments will be done by all students. For others, there will be one experiment that will be shared by all students at the table. In a few cases, only the demonstrator will perform the experiment. You are encouraged to get student helpers for the demonstrator-only experiments.

MAKE SURE TO FOLLOW ALL DIRECTIONS IN EXPERIMENTS

Some experiments may have special safety concerns due to the materials being used. Any safety concerns are listed in the section for that experiment. Any MSDS's necessary would typically be found in an Appendix, however, there are none necessary for this year's program.

For information about the American Chemical Society's NCW safety guidelines, visit www.acs.org/portal/Chemistry?PID=acsdisplay.html&DOC=ncw%5Csafetyguidelines.html

Demonstrator's Guide

Demonstration Check-Off List

The next few pages list suggested activities to complete for the program.

Activities To Do Before the Day of the Demonstration	✓ When Complete
Read through this packet to familiarize yourself with the experiments	<input type="checkbox"/>
Collect the materials you need to bring with you to the demonstration. The materials list is on page 7.	<input type="checkbox"/>
Contact the children's librarian: <ul style="list-style-type: none"> ➤ Ask the room to be arranged with 6 tables around a front table ➤ Ask to have 5 chairs around each of the 6 tables ➤ Ask for all the tables to be covered with newspapers and for extra paper towels for each table. ➤ Ask about availability of demonstration materials from list of page 7 (ex. jug of water, paper towels, newspaper) ➤ Make sure that the room is available before and after the program for set up and clean up. 	<input type="checkbox"/>

Activity To Do AT LEAST ONE DAY BEFORE the Demonstration	✓ When Complete
Build the water filtration systems as instructed in the Experimental Set-Up on page 10. This may take up to 2 hours to do. This can be done days in advance, but they need to be damp before transport to the demonstration.	<input type="checkbox"/>

Continued next page...

Demonstrator's Guide

Activities To Do When You Get To The Library	✓ When Complete
Arrive approx. 1 hour before demo time to allow for set up	<input type="checkbox"/>
Introduce yourself to the children's librarian	<input type="checkbox"/>
Ask the librarian how many students are pre-registered	<input type="checkbox"/>
Confirm that the tables and chairs are set up properly	<input type="checkbox"/>
Confirm that all tables are covered in newspaper and have paper towels	<input type="checkbox"/>
Obtain those supplies from list on page 7 if provided by library	<input type="checkbox"/>
Complete Demonstration Set-Up for all demonstrations: (see "Activities to Do On-Site Prior to Demonstration" on pages 11-12) <i>Note: This set-up is estimated to take 30-45 minutes.</i>	<input type="checkbox"/>
Set out the literature (Experiments To Do at Home, Book List, <i>ChemMatters</i> magazines, and <i>Celebrating Chemistry</i> newspapers)	<input type="checkbox"/>

Activities To Do During The Demonstration	Timing
Welcome the students and parents as they enter the room	-
Assess number of students per table and adjust to 3 - 5 per table. Record the number of students and adults.	-

Continued next page...

Demonstrator's Guide

Activities To Do During The Demonstration (Continued)	Timing
Complete the Opening Session Introduction and distribute the goggles	5 min.
Perform demonstrations	
➤ Experiment 1: Don't Mix the Reds with the Whites? - Dye Magnets	4 min.
➤ Experiment 2: Cleaning the Water – Water Filtration System	7 min.
➤ Experiment 3: Twirly-Whirly Milk – Surface Tension and Polarity	5 min.
➤ Experiment 4: Part 1: Surface Tension – Waterproof Paper and Wire	4 min.
➤ Experiment 4 optional addition: Water on a Penny	(2 min.)
➤ Experiment 4: Part 2: Using Detergents to Mix Water and Oil	2 min.
➤ Experiment 5: Hard Water vs. Soft Water	5 min.
➤ Experiment 6: This is the Way We Wash Our Clothes	12 min.
➤ Experiment 1 & 2 continued: Check up on results	1 min.
Complete the Closing Session information, collect goggles, hand out literature	5 min.
	<i>Total Time: 50 min. +</i>

Activities To Do Immediately After The Demonstration	✓ When Complete
Clean up as indicated in the Cleaning up section.	<input type="checkbox"/>
Record the number of adult and student participants on the feedback sheet.	<input type="checkbox"/>
Give any left-over literature to the librarian.	<input type="checkbox"/>
Give feedback sheet and box of goggles to the librarian so that they can be returned by interlibrary mail.	<input type="checkbox"/>

Supplies Required for Demonstration

Items for the Demonstrator to Provide (marked w/ * in individual experiments below)

- 1 gallon jug for waste collection
- 1 large garbage bag for waste collection, if none at site
- 1 gallon jug of water, if none at site
- 1 funnel for aiding in pouring waste liquids into gallon jug for transport from demonstration room to disposal area, if desired
- 1 roll paper towels, if none at site
- Newspaper for covering tables, if none at site
- Scissors
- 2 or 3 of your own bottles of shampoo or soft soaps containing sodium lauryl sulfate or sodium stearate (modern synthetic surfactants) or bar soap
(Note: Small shavings of bar soap such as Ivory are a good negative example that works poorly in our cold/room temperature water, while synthetic shampoos work well at these low temperatures.)
- Measuring cup set, if desired (1/2, 1/3, 1/4 cup, tsp and tbsp)

Optional: For optional section of experiment #4 “water on a penny” :
31 clean pennies

Optional: Hairspray, dilute ammonia (such as in window cleaners), shampoo, or other stain remover for demonstration #6. Note: Ammonia plus chlorine bleach produces poisonous gas! Please do NOT bring chlorine bleach or other potentially hazardous chemical for use in this demonstration. Think ahead as to the safety issues of your cleaning agent. Thank you.

Notice: If you will be performing multiple demonstrations on the same day, you will need to sanitize the goggles between demonstrations. You will need:
Small quantity of household bleach
Wash bin or bucket
Rags, old towels, or cotton paper towels for drying (soft so as not to scratch the goggles)

General:

- 1 box to hold kit contents
- 30 copies *Celebrating Chemistry* newspapers
- 30 copies each of “Book List” and “Experiments To Do at Home”
- 1 demo feedback form and return envelope (library kits only)
- 1 mailing envelope for returning vials (library kits only)
- 10 copies of *ChemMatters* magazine (library kits only)

- 1 box of goggles and sanitation plan (30 child size and 2 adult size)
(library kits only)

Experiment 1: Don't Mix the Reds with the Whites? - Dye Magnets

- 1 bottle containing 160ml+ of liquid laundry detergent
(NOTE: this detergent will also be used in Experiments 3, 4, and 6)
- 14 zipper sandwich bags
- 1 pipette
- 7 1-inch x 1-inch squares of heavy-duty paper towels marked with water-soluble ink
(sad face).
- 14 1-inch X 2 inch right triangles of Woolite Dye Magnet (WDM), quaternary ammonium anion exchange resin sheets
- 7 1-inch x 1-inch squares of Woolite Dye Magnet (WDM), quaternary ammonium anion exchange resin sheets, cut into and marked with water soluble ink (happy face).
- *water (approx. 1/3 cup * 7 tables = 2 1/3 cups total)

Experiment 2: Cleaning the Water – Water Filtration System

- 1 2-liter pop bottle, cut and with a hole in the lid
- 6 20-oz. pop bottles, cut and with holes in the lids
- 15 cotton balls or polyester batting pieces
- 1 plastic spoon (approximately 1 tsp)
- 1 gallon-sized freezer bag filled with 5 cups of sand
- 1 quart-sized zipper bag containing 2 cups of activated charcoal
- 1 20 oz pop bottle filled with _ tsp of cocoa powder; capped
- 1 snack-sized zipper bag marked “garlic” filled with _ tsp of garlic powder
- 7 wooden splints or stirrers
- 1 beral pipette with flavoring (sealed w/ hot glue; in zip bag labeled ‘flavor’)
- 6 3 oz paper cups labeled ‘dirty water’ or ‘dirty’
- 1 9 oz clear plastic cup labeled ‘dirty water’ or ‘dirty’
- * scissors

Experiment 3: Twirly-Whirly Milk – surface tension and polarity

- 7 containers of milk (with fat), half-and-half, or creamer
- 7 3-oz plastic cups marked ‘det’ or ‘D’ for liquid laundry detergent
(These will also be used in Experiment #4)
- 7 petri dish tops (or bottoms)
- 3 pipettes with different food colors (hot glue sealed; inside snack bag ‘color’)
- 1 plastic spoon (approximately 1 tsp sized) (For expt. 3 and 6)

21 cotton swabs

* scissors

Bottle of liquid laundry detergent from Experiment #1

Experiment 4: Part 1: Surface Tension– waterproof paper and wire

Experiment 4, Optional Addition: Water on a Penny

Experiment 4: Part 2: Using Detergents to Mix Water and Oil

- 1 vial containing 2 oz. surfactant solution marked 'Surf' in sandwich-sized zip bag
- 7 plastic 3 oz cups marked 'surf'
- 7 2-inch aluminum wires
- 7 1x2 inch pieces of waterproofed paper
- 7 portion cups
- 39 disposable pipettes (extras included for if adding the optional "penny" experiment)
- 7 coffee stirrers
- 7 plastic 3 oz cups marked 'water'
- 2 vials each containing 35 ml of pre-colored oil; marked 'oil'; in zip bag
- 5 empty vials with lids
- 7 3-oz plastic cups marked 'det' or 'D' for liquid laundry detergent from Experiment #3
- * 2 or 3 of your own bottles of shampoo or soft soaps containing sodium lauryl sulfate or sodium stearate
- * water (approximately 1/2 cup + 20 ml * 7 tables = 4 1/2 cups)
- * Optional: If performing "Water on a Penny" additional experiment: 31 clean pennies

Experiment 5: Hard Water vs. Soft Water

- 14 vials of 35ml each distilled water; 7 marked 'H'; 7 marked 'S', in zip bag(s)
- 7 zipper snack-size plastic bags containing 2 pea-sized pieces of Ivory soap
- 7 zipper snack-size plastic bags marked "E" containing 1/8-1/4 tsp Epsom salt
- 7 salt packets

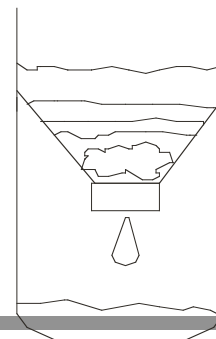
Experiment 6: This is the Way We Wash Our Clothes

- 7 16-oz clear, plastic cups for washers marked 'W'
- 7 16-oz clear, plastic cups for rinses marked 'R'
- 7 plastic forks
- 1 vial containing 1 Tbsp or 15 mL vinegar; marked 'vin'; in a sandwich sized zip bag
- 1 Tbsp borax in snack-size zipper bag marked 'borax'
- 1 Tbsp washing soda (sodium carbonate) in a snack-size zipper bag marked 'soda'
- 1 Tbsp non-chlorine bleach in snack-sized zipper bag marked 'nc bleach'
- 7 stained muslin fabric swatches
- 1/2 of a white poster board (labeled with stains and cleaning agents)
- 6 paperclips
- Bottle of liquid laundry detergent from Experiment #1
- 1 plastic spoon from Expt #3
- * paper towels
- * water (20*7 = 140 oz = 8 _ cups)

Activities to Do At Least ONE DAY BEFORE the Demonstration: Preparation of Water Filters for Experiment 2

This may take up to 2 hours. These filtration systems can be made days in advance, but they need to be kept damp before transportation to the demonstration.

1. Wash the sand in the bag one or two times to remove any fine particulate matter.
2. Prepare the one 2-L demonstration bottle filtration system
 - a. Invert the top portion of the bottle so that the cap is downward.
 - b. Place 3 cotton balls or polyester batting pieces in the neck tightly against the cap.
 - c. Place about 6-9 spoonfuls (6-9 tsp) (spoon provided) of sand on top of the cotton balls.
 - d. Place about 1/2 cup of activated charcoal on top of the sand.
 - e. Place another 1/2 to 1 cup of sand on top of the charcoal
 - f. Smooth out the sand and compress it slightly with your fingers
 - g. Place this unit into the bottom portion of the pop bottle, cap down.
 - h. VERY GENTLY pour about 1/4 cup of tap water on the surface and allow it to filter through. SAFETY NOTE: The charcoal produces some heat and steam upon initial water additions; this is normal. Continue rinsing with _ cup portions of water until the filtrate is clear. This may take about _ hour.
 - i. Cover with plastic wrap to keep moist until the demonstration.
3. Prepare each of the six 16-20-ounce bottle filtration systems as follows:
 - a. Invert the top portion of the bottle so that the cap is downward, and place it into the bottom portion of the pop bottle. See diagram.
 - b. Place 2 cotton balls or polyester batting pieces in the neck tightly against the cap.
 - c. Place about 6 spoonfuls of sand on top of the cotton balls.
 - d. Place about 1/4 cup of activated charcoal on top of the sand.
 - e. Place another 1/2 cup of sand on top of the charcoal.
 - f. Smooth out the sand and compress it slightly with your fingers.
 - g. VERY GENTLY pour about _ cup of tap water on the surface and allow it to filter through. See SAFETY NOTE above. Continue rinsing with _ cup water portions until the filtrate is clear. This may take about _ hour.
 - h. Cover each with plastic wrap to keep moist until the demonstration.
4. Pack these prepared filters carefully so that the contents will not shift or fall over during transportation to the site.
SUGGESTION: Set the filtration systems directly into a box. Surround each with newspaper. We have found that the 6 smaller filters typically fit into a shoe-box. The clear bottom portions can be carried separately, if desired.



5. Fill the 20 oz clear pop bottle with the 1/2 tsp cocoa powder inside (as supplied with your demonstration kit) with tap water, cover and shake. This is the "Dirty water."

Activities to Do On-Site Prior to Demonstration

General:

- Refer to page 5 for items to verify (7 tables, covered with newspaper, each with paper towels, etc. & obtain supplies)

Experiment 1: Don't Mix the Reds with the Whites? - Dye Magnets

- Add between _ to _ cup of water to each of seven sandwich-size zipper bags.
- Use a pipette to add one drop of liquid laundry detergent to each bag; zip close the bags
- Place each of these bags into a second zipper bag (for better spill or breakage control), zip closed, and place one on each of the student and demonstrator tables.
- Place one marked paper towel square (sad face) and one marked dye-magnet square (happy face) on each of the student and demonstrator tables.
- Place two dye magnet triangle sheets (unmarked) on each table.

Experiment 2: Cleaning the Water – Water Filter

- Carefully wet the surface of the filtration systems if they dried out overnight.
- Place the flavoring pipette, the bag labeled 'garlic', the empty 9 oz plastic cup labeled "dirty water", and one wooden stirrer on the demonstrator's table. Have scissors nearby to cut open the pipette later.
- Place the 20 oz bottle containing the cocoa water on the demonstrator's table.
- Place one empty 3 oz cup labeled "dirty water" and one wooden stirrer at each student table.
- Set out the filtration systems on the demonstrator's table. Do not yet place them at the student tables! We do not want to risk their being knocked over.

Experiment 3: Twirly-Whirly Milk

- Place one milk container, one petri dish top or bottom, and 3 cotton swabs on each of the students' tables and on the demonstrator's table.
- Place the 3-4 food-coloring filled, sealed pipettes in their zipper bag on the demonstrator's table. Have scissors nearby to cut open the pipettes later.

Demonstrator's Guide

- Add approximately 1 and 1/2 teaspoons of the detergent (using the plastic teaspoon provided) to each of the seven cups marked 'det' or 'D'. Place one on each of the student and demonstrator tables. These will be used for Experiments 3 and 4.

Experiment 4: Part 1: Surface Tension – Waterproof Paper and Wire

Experiment 4, optional: Water on a Penny

Experiment 4: Part 2: Using Detergents to Mix Oil and Water

- Place one portion cup at each table and fill each at least 2/3 full with tap water
- Place approximately 20 ml of clean water in each of the seven cups marked 'water' and distribute them among the student and demonstrator tables.
- Distribute the surfactant solution evenly among the 7 cups marked 'surf' and place one on each student table and one on the demonstrator's table
- Take the two vials of colored oil marked 'oil' and the empty 5 vials. Distribute the oil such that each vial contains approximately 10 ml each.
- Place one wire, one piece of waterproofed paper, one wooden stirrer, and one vial of colored oil marked 'oil' on each of the students' tables as well as on the demonstrator's table.
- Place 1 pipette on each student table and 2 on the demonstrator's table.
- Place the shampoos and soaps you brought from home on the demonstrator's table.
- If performing the optional "water on a penny" demonstration, distribute the pennies 5 per student table, and one on the demonstrator's table. Also place an additional 5 pipettes on each student table, and one on the demonstrator's table.

Experiment 5: Hard Water vs. Soft Water

- Place one vial of water marked "H", one vial of water marked "S", one bag of Epsom salt, one bag of soap pieces, and one packet of table salt on each of the students' tables and on the demonstrator's table.

Experiment 6: This is the Way We Wash Our Clothes

- Distribute forks, paper towels and stained fabric swatches to each of the student tables and the demonstrator's table.
- Fill each washer and rinse cups (marked 'W' and 'R') about half full with water.
- Place one water-filled 'rinse' cup on each student and demonstrator table.
- Place a water-filled 'washer' cup on the demonstrator table and on the 1st student table
- To the remaining 5 'washer' cups, distribute the rest of the liquid laundry detergent evenly among the cups. (There should be approximately 105 ml, which is about 3 tsp per cup.) A plastic spoon is provided with Expt #3 to aid in this distribution.

Experimental Setup

Demonstrator's Guide

- Place a laundry detergent solution 'washer' cup on each of the five remaining student tables.
- Distribute the borax, non-chlorine bleach, and washing soda bags, as well as the vinegar vial, to the student tables 3 through 6 (one item per table).
- Attach the paper clips to the labeled poster board in preparation of the students hanging their laundered swatches. Leave this on the demonstrator's table.

Opening Discussion

Introductions

Do the following:

- Introduce yourself as a chemist, and introduce the American Chemical Society as the largest organization in the world devoted to a single profession.
- Introduce National Chemistry Week - what it is and why we do it. (*Hint: it is a nationwide event put on by volunteers like you to let non-chemists know about chemistry and how it has improved our everyday life.*)

What is Chemistry and Chemicals?

Do the following:

- Explain that chemistry is the study of everything around them.
- Ask volunteers to name some chemicals. Then ask more volunteers to name something that isn't a chemical.

Remember: everything around us is a "chemical".

Be very careful in correcting the students. Encourage their participation while explaining that anything they name really is a chemical.

What Do Chemists Do?

- Ask the participants to tell you what a chemist does, what a chemist looks like.
- Tell them BRIEFLY and in simple terms what you do as a chemist.

Note: This should last no more than 1 minute. Remember to leave the physical chemistry lecture and the "big" chemistry words at home!

- Tell them that chemists use their knowledge to answer questions about the world around them. This is very exciting, as they will soon see.

Introduce the Items on the Tables

Do the following:

- Tell them not to touch anything until told to do so. Remind them never to taste or smell anything, as if they were in a laboratory.

Note: Some of the items in the demonstration are actual food items. Remind students throughout the demonstration not to eat or drink anything!

Introduce Today's Presentation: Rub-A-Dub Dub, Chemistry in the Tub

Tell the students the following:

- When we hear the word “chemical” in the news, it is often in a story about a ‘bad’ or ‘dangerous’ chemical spill, or how a chemical has been found to be harmful to our health.
- Have the students try to name a few helpful ‘chemicals’. [Medicines and vitamins, gasoline and oil for cars, fertilizers, cleansers/detergents.]
- Tell the students that there are also many chemicals that help us stay healthy. Detergents or cleaners are some of the most common products that help keep us healthy by keeping us clean and free of germs.
- Remind the students that these helpful chemical detergents and cleaners have become so important to us that we now have entire aisles of cleansers in the grocery stores as well as many television commercials for different brands of toothpastes, cleaners (such as Oxyclean), shampoos, and more.
- Tell the students that we will be using the scientific method to guide us in our investigation of the properties of some cleaners used for keeping our bodies, homes, or laundry clean. We will make observations, form a hypothesis, use experiments to test our hypothesis, and then evaluate the results of the experiment to accept or reject the hypothesis.

Introduce the Items on the Tables and Distribute Goggles

Do the following:

- Tell the students that various items have been gathered for them on their table.
- Tell them not to touch anything until instructed to do so.
- Most of the items can be found around the house. Some can be found in our own kitchens. *Remind them never to taste or smell anything, as if they were in a laboratory!*
- Tell the students that even though most of our items are relatively harmless today, we will still be good chemists and take the safety precaution of protecting our eyes.
- Put on a pair of the adult sized goggles. If you have an assistant, ask them to do the same.
- Distribute the goggles and help the students put them on. Adjust the straps as necessary.

Experiment 1: Don't Mix the Reds with the Whites??? - Dye Magnets

Experiment Summary

- The experiment shows how a quaternary ammonium anion exchange resin can be used to remove unfixed dye material (anions) from wash water thus preventing accidental dyeing of other clothes.
- The experiment will be done at each table including the demonstrator's, and will take approximately 5 minutes.

Introduce the Experiment

Tell the students the following:

- Did you ever hear that all the white socks in the laundry turned pink? What happened?
- Sometimes when you are getting ready for school, one of your parents might get a load of laundry started while they drop you off for the bus. Parents often tell their laundry helpers that you must never mix colored clothes with white clothes in the same wash load. New, unwashed, dyed clothing may contaminate the wash water with colored dye.

Why? All of the dye may not be fixed to the cloth in a new piece of clothing. Unfixed dye will bleed into the wash water and will color the white clothing.
- Chemists have invented something that will prevent the white clothing from being colored by collecting and holding onto the extra dye in the wash water.

Perform the Experiment Simultaneously with the Students

Do the following:

- Tell the students that water and liquid laundry detergent are in the bags of water.
- Place the ink-marked 1-inch square paper sheet (sad face) into the bag, seal the bag well, shake, and comment on what happens. [The water-soluble ink is washed off the paper and dyes the water.]
- Place the ink marked 1-inch square Woolite Dye Magnet sheet (happy face) into the bag, seal the bag well, shake, and comment on what happens. [The ink does not come off.] (This step immediately shows the final results of the experiment. Namely, that the ink strongly bonds to the anion exchange resin.)
- Place two pieces of the triangular, Woolite, quaternary ammonium anion exchange resin sheets into the bag. More sheet area will accelerate the ink adsorption.

Experiment 1

Demonstrator's Guide

- Seal the bag well; shake it vigorously for one minute. Repeat the shaking process, many times, throughout the entire one-hour demonstration period; perhaps having the students pass the bags around and shake every time we start a new experiment.
- Set the bags aside and we will come back to them later.

Experiment 2: Cleaning the Water – Water Filtration System

Experiment Purpose & General Methodology

- The students will use a water filtration system to clean ‘dirty’ water.
- This experiment will be done per table. The initial introduction and experiment will take 7 minutes to complete. Towards the end of the program, you will return to the water filter and discuss the results and conclusions.

Introduce the Experiment

Tell the students the following:

- Each morning we need clean water to drink, brush our teeth, take a shower, do our laundry, or cook. But where does all this clean water come from?
- The total amount of water on Earth is fixed. The water available today is the same amount that was available five million years ago. Every drop of water we use for washing, cooking or drinking has been used countless times before. There are efficient, modern methods for purifying “wastewater.”
- Ask students how they would define “wastewater” and what might be in it, without getting too gross.
- “Wastewater” is the water that flows down the drain of your sink, shower, and toilet. In towns and cities it is collected by sewer pipes and transported to a wastewater treatment plant. Along the way, it is mixed with more wastewater from your neighbors, local industry, dirt from the road, leaves and twigs, spilled gasoline and maybe even that long lost sock from the laundromat.
- When the water arrives at the wastewater plant it first flows through a screen to catch large objects like leaves and twigs and socks. From there it goes through several more chambers to settle out the solids and remove the odors and bacteria.
- We are going to simulate this with our filtration system today. [Pull out the 2-liter filtration system]
- There are a number of layers of different material here. The top layer is sand which will filter out the large particles, but not the bad odors or dissolved materials.
- The next layer is activated charcoal which removes the odors and other dissolved materials.
- There is another layer of sand to trap any particles that have gotten through this far.
- At the very bottom of the opening are cotton balls to stop any of the very fine particles from coming through, and only pure water should filter out.

Experiment 2

Demonstrator's Guide

- We are now going to distribute our “dirty water.”

Perform Experiment Simultaneously with the Students

Do the following:

- Distribute about 50 ml of the “ Dirty H₂O” (water plus cocoa powder) to the cup labeled as such at each station and 100 ml to your container. Have the students examine and smell their sample.
- Cut off the end of the flavoring pipette, and add 3-5 drops of the flavoring to each cup and let the children smell the solution after stirring with the wooden stick. Remind the students that although we added flavoring, we should never taste our experiments.
- Now use the spoon to add a “small pinch” of the garlic powder to each dirty water cup. Have the students stir with the wooden stick and again allow each student to smell and examine the liquid. Be sure to close the bag of the leftover garlic to decrease the odor in the room.
- At the demonstration table, show how to carefully add the dirty water to the top of the filtration unit. Show the students how you pour the water slowly so as not to move the top sand layer much or create a pit in the center of the sand.
- The students should be given the filtration systems now (do not do this earlier –students may knock it over and disturb the layers.). Have one student pour the contents into the system and let it begin to filter through.
- The demonstrator should walk around the room and add a small amount of fresh water to each of the dirty water cups. Have another student swirl the water around in the cup gently and then add this water to the filter as well. This will prevent our dirty water cups from adding unpleasant odors to our library room. (Although probably unnecessary, you may choose to collect the dirty water cups and dispose of them in your garbage bag at this time.)
- Tell them you will all set these filters aside and come back to them later. The demonstrator should be sure that they are off to the side so as not to be knocked over.

*** Now is a good time to have the next student gently shake/mix our solution from the dye-magnet experiment and pass it to the next student.

Experiment 3: Twirly-Whirly Milk – Surface Tension and Polarity

Experiment Purpose & General Methodology.

- The students will observe the movement of water-based food coloring in fatty milk and the effects of addition of soap to the movement. The movement is a result of water and fat not being soluble in each other, but later mixing to some extent upon addition of soap.
- This experiment will be done per table, and should take 5 minutes to complete.

Introduce the Experiment

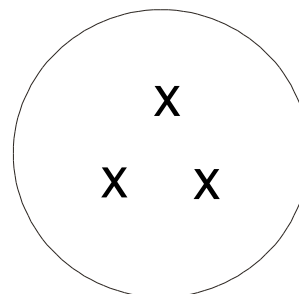
Tell the students the following:

- Perhaps you had milk along with your breakfast this morning. When you were done and put your glass or bowl in the sink to be washed, if you have added water you may have noticed that the milk and water doesn't mix well, and that the milk coats the glass or bowl.
- We are going to study this more.
- Caution students not to drink the milk used in this activity. This is our laboratory.

Perform the Experiment as a Demonstration, then Simultaneously with the Students

Have the students do the following:

- Locate the small container of milk in each petri dish on the table.
- The demonstrator will then carefully cut open the tip of the food coloring pipettes and place a few drops of various colored food coloring on the surface of the milk without stirring (see diagram to the right). Tell the students to not bump the table, stir, or mix in any way. Gently place the pipettes back into the bag (with most of the food coloring in the bulb of the pipette).
- Watch to see whether the colors spread out or stay together in the milk.
- Have one student touch one end of the dry cotton swab to the surface of the milk near a food color drop (without stirring) and observe what happens.
- Have another student wet the other end of the dry cotton swab with the liquid laundry detergent (cup marked 'det') and touch it on or near another of the food color drops on the surface of the milk without stirring. Observe the movement of colors and the milk. Encourage the other students to take turns with a soapy cotton swab.



Conclusions

Tell the students the following:

- When the food coloring is placed on the surface of the milk, the drops remain essentially intact with little to no spreading. (In contrast, food coloring placed in water diffuses throughout the water and colors it.) This lack of spreading is due to the fact that the water-based food color does not readily mix with the milk. This is because milk is a suspension of fat globules in water and the food color is a water-soluble dye. In general, fat globules and water (and thus food color) do not dissolve in each other. As a result, there is little mixing.
- When soap (or detergent) is added to the surface of milk, the soap spreads out over the surface and causes the food color to swirl about. The soap is a chemical that has a 'watery' part and a 'fatty' part in its structure. This allows the soap to be able to mix with the fats in the milk and the watery food coloring causing a swirling motion.

Additional Information If Needed: Technical Background

Reference: "Teaching Chemistry with TOYS", Sarquis, Jerry L.; Sarquis, Mickey, John P. Page 99, 1995 McGraw Hill, ISBN 0-07-064722-4.

- Figure 1 shows the structure of sodium stearate, a common soap molecule. Soap (and detergent) molecules have two distinctly different parts. The long chain of carbon and hydrogen atoms is referred to as the nonpolar tail (hydrophobic, water fearing) and the charged group on one end is called the polar head (hydrophilic, water loving).

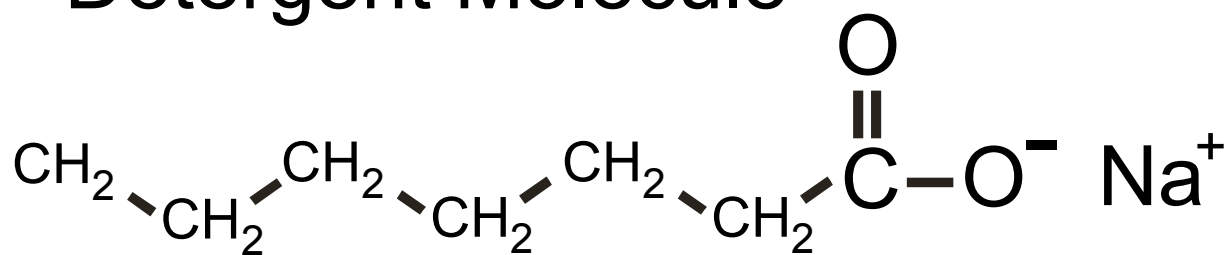
*FIGURES 1 and 2 are on the NEXT PAGE.

- Like the nonpolar tail of soap, fats and oils also contain large numbers of carbon and hydrogen atoms. This similarity in structure allows the nonpolar tail of soap to dissolve in globules of fats and oils, creating structures called micelles, see Figure 2. Micelles look much like oranges with cloves poked through the rinds. Part of the swirling and churning motion you see when you add soap to the dish of milk is a result of the attraction between the soap molecules and the fat molecules in the milk.
- As the soap spreads across the surface of the milk, more and more fat globules are pulled to the spreading soap. As these fat globules congregate, the water in the milk is pushed away, taking the food color with it. The movement in the milk will subside as the soap becomes "used-up" (forming micelles). The addition of more soap can often reactivate the swirling and churning motion. Eventually however, the system will reach equilibrium (uniform distribution of fat globules-soap micelles), and the motion will stop.

Demonstrator's Guide

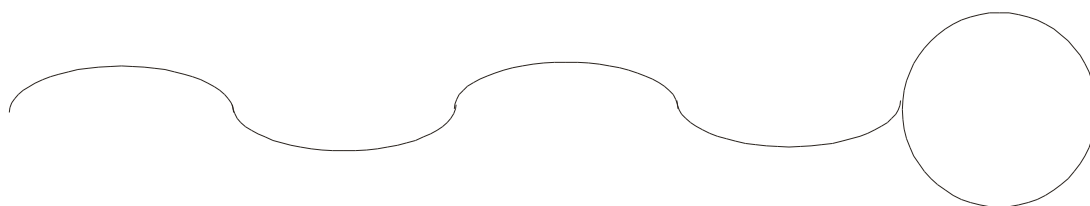
*** Now is a good time to have the next student gently shake/mix our solution from the dye-magnet experiment and pass it to the next student.

Detergent Molecule

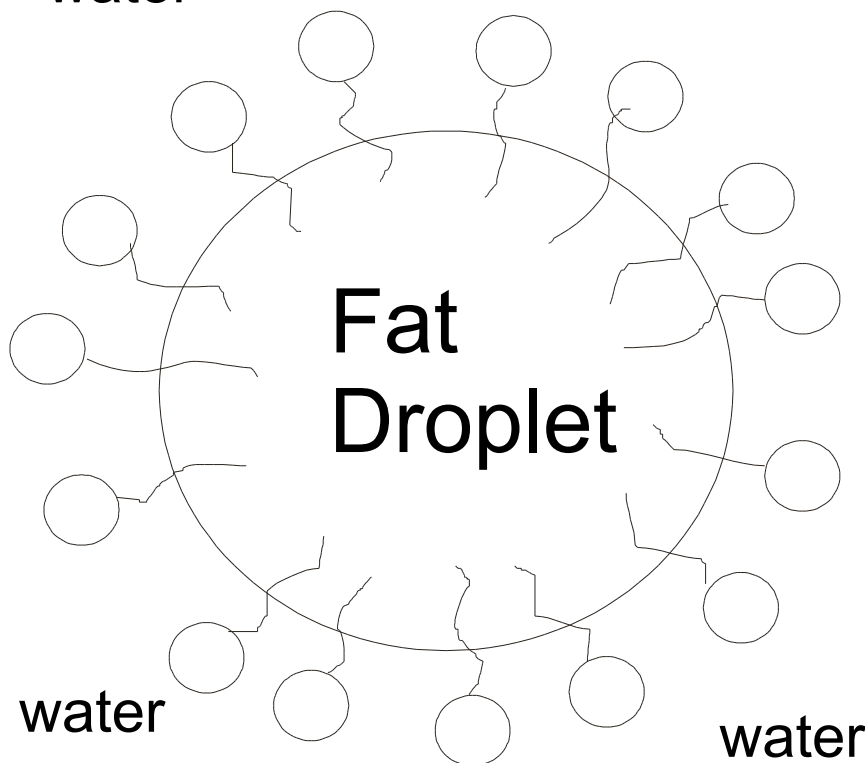


Nonpolar Tail

Polar Head



water



Detergent forms micelle around the fat droplet.

Experiment 4: Part 1: Surface Tension – Waterproof Paper and Wire

Experiment Purpose & General Methodology

- The students will investigate the properties of surface tension.
- This experiment will be done by each student, and will take 5 minutes to complete.

Introduce the Experiment

Tell the students the following:

- Now that we've learned a little about how fat and water do not mix, let's study some other properties about water that can be helpful in understanding how cleaning agents work.
- All surfaces to be cleaned need to be 'wet' to help the cleaning detergent interact with the 'dirt' to be removed. To be 'wet' means more than to have water 'on' it. It means that water needs to flow, coat the surface, and maybe actually penetrate into the surface.
- Surface tension is a property that may prevent the wetting of our material to be cleaned, so we need to know what surface tension is and how to adjust it.

Perform the Experiment Simultaneously with the Students

Do the following:

- Have the students use one of the pipettes to remove some clean water from the portion cup and place one drop of water on the right side of the piece of waterproofed paper. Ask the students what they see. [Answer: The water beads up on the paper as a droplet.]
- Have the students empty the clean water in the pipette back into the portion cup.
- PERFORM the first half of the OPTIONAL EXPERIMENT "WATER ON A PENNY" HERE, IF DESIRED. SEE PAGE 26 (Do the steps using the clean water from the portion cup. When the students are done adding the water to the pennies, have them return the excess clean water to the portion cup.)
- Demonstrate the next step slowly and carefully. Make sure that the students know that if they do not perform it correctly, that they will not be able to see the rest of the experiment!

Tell the students to hold the wire about inch over the surface of the water in the portion cup, parallel to the surface of the water, and gently drop it. Do not drop the wire from a greater

Demonstrator's Guide

height or hold the wire at an angle, or the wire will fall through the surface and sink to the bottom of the dish. It is very difficult to get the wire dry enough for a second attempt.

- Ask the students what happens. [The wire should remain on the surface.]
- Have one of the students fill the pipette (same one as they just used with water) with surfactant solution from the cup marked 'surf'. Have the students take turns, and add a few drops of the surfactant solution, one drop at a time, to the surface of the water in the portion cup, but not to allow the drops to fall directly on the wire. Ask the students what they observe. [The wire moves away from the side the surfactant was dropped on.]
- Continue adding the surfactant, dropwise until the wire sinks.
- Have the students empty the surfactant pipette back into the container marked "surf".
- Next, using the same pipette, have the students place a drop of the surfactant-water from the portion cup on the other/left side of the piece of waterproofed paper. Ask the students what they observe? [The surfactant water does not bead up. It spreads out on the paper.]
- RETURN TO THE second half of the OPTIONAL EXPERIMENT "WATER ON A PENNY" HERE IF DESIRED. SEE PAGE 26. (Do the steps which repeat the experiment with the surfactant-water from the portion cup. Return excess surfactant-water to the cup. Then go over the conclusions to the 'penny' experiment before returning here.)

Some Conclusions

- Explain to the students: The water beads up on the treated paper and the metal wire is originally held up due to the surface tension of the water. (The wire does not float due to its density or weight.)
- The wire initially sits on top of the water. Molecules in water attract each other. In the middle of a drop or in the bulk of the water, molecules pull toward each other equally in all directions. But at the surface, molecules of water are only pulled into the water, for there are no molecules to pull in the opposite direction, so the water pulls its surface tight around it like a stretchy skin. This is why the clean water beads up on the paper. It is this surface tension, and surface 'skin' that also holds up the wire.
- For water to clean, it must 'wet' or be absorbed into the surface of the item to be cleaned. To wet the surface, the surface tension must be reduced. This is one of the things that surfactants/soaps/detergents do.
- As the surfactant is added, the wire moves away from the surfactant droplets because the surfactant weakens the surface tension of the water. The water on the other side of the wire still has a very high surface tension (where the water molecules are pulling each other strongly) and it pulls the wire towards it. The addition of more surfactant continues to lower the surface tension of the water. The wire finally sinks when enough surfactant has been

Demonstrator's Guide

added to completely lower the surface tension to the point where it is no longer strong enough to hold the wire up. The surface tension is “broken” by the surfactant. The lower surface tension of the surfactant-containing water also prevents the water from beading up on the paper. The surfactant has caused the water to lose its strong skin; it no longer beads up.

Additional Information If Needed: Technical Background

The water strider (a.k.a. pond skater, a.k.a. pond skimmer), a pond insect, uses surface tension to walk on the surface of the water. The skin created by the surface tension is strong enough to bear the weight of the tiny insects.

Continue to Perform the Experiment Simultaneously with the Students

Do the following:

- Using a clean pipette and the vial of colored oil marked ‘oil’, the demonstrator will place two or three drops of colored oil into each of the portion cups at each student table, in a manner as to create one large droplet of oil in the center of each cup.
- Ask the students what they observe. [The oil stays on the surface in a droplet on the surface.]
Note: When we added the oil, it stays on the surface because it is less dense, or not as heavy, as the water, therefore it floats on the surface much like a piece of cork or plastic; it is not being held up by surface tension. However, the oil stays in a droplet form because the oil also has its own surface tension, that is much lower than the water.
- Have one of the students fill their pipette with laundry detergent from the container marked “det” and add it into the portion cup.
- Have the students slowly and gently stir the mixture with the coffee stirrer. Ask the students what they observe upon gentle stirring. [The oil breaks up into smaller and smaller droplets.]

More Conclusions

- Soaps and detergents are long chain molecules (chemicals) that have one end that is water-soluble and one end that is oil-soluble. At first, the oil stays in a bead so that very little of it is in contact with the water.
- When the oil is broken up by stirring, the oil soluble end of the surfactant goes into the fresh oil surface. The water soluble end keeps other oil drops away by forming micelles. Micelles have negatively charged surfaces which repel each other (like magnets do) and remain dispersed in the water. As the drops get smaller and smaller, eventually they become so small they are nearly invisible. With enough stirring, it may look like the oil is dissolved in the water, but in reality it is in tiny droplets surrounded by the surfactant.
- Our stirring of the oil droplet in the surfactant solution shows that mechanical action is also necessary for detergents to work. This is why most washing machines have agitators.

Experiment 4: Part 2: Using Detergents to Mix Oil and Water

Perform the Experiment Simultaneously with the Students

Do the following:

- Have the students locate their cups with clean water marked 'water'
- Have the students pour their water into their vial containing colored oil marked 'oil', and close the vial tightly.
- Have one of the students shake the closed vial for 10 seconds.
- Have a student count the number of seconds it takes for the two layers to separate.
- Tell the students that we will now compare some of our cleaning products. Using the detergent or surfactant solution from the experiment, soap brought from home, or the modern surfactant (sodium lauryl sulfate) containing shampoos brought from home, the demonstrator will add two to three drops of a product into the student's vials using a different product and/or different amounts of products in each student vial.
- Have one of the students close the vial tightly, and shake for 10 seconds.
- Have a student count the number of seconds it takes for the two layers to separate.
- Compare the time needed for each product to separate the water and colored oil.

Conclusions

Tell the students the following:

- This experiment reminds us that water and oils do not mix. Thus, water is not good for cleaning away oil when used all by itself. At home, you've probably noticed that it's nearly impossible to wash butter off your fingers with just water. This is why we use soap.
- Earlier we discussed sodium stearate, a common soap molecule, which is a naturally-occurring fatty soap. Sodium lauryl sulfate is another molecule for cleaning but it is a modern surfactant in many detergents. Recall that soap (and detergent) molecules have two distinctly different parts. The long chain of carbon and hydrogen atoms is referred to as the nonpolar tail (hydrophobic, water-fearing) and the charged group on one end is called the polar head (hydrophilic, water-loving). As before, the long nonpolar tail dissolves in the oil, and the polar head dissolves in the water. This is why the oil and water can now mix.
- Discuss how the different products needed different times to work well. The product that keeps the oil and water mixed together the longest is the best detergent for this job since it does not allow the water and oil to separate. Note that modern synthetic detergents made by chemists typically work much better than the naturally occurring fatty soaps.
- Different oils may need different products to mix the best with the water in order to be washed away. Product manufacturers also need to use more gentle chemicals for washing our

Demonstrator's Guide

faces versus those for washing our pots and pans. This is why there are entire aisles of cleaning supplies and soaps and shampoos in the stores.

Additional Information If Needed: Technical Background

- The first surfactant was soap made by treating tallow (animal fat) with wood ashes. Castile soap was made from pure olive oil instead of animal fats. Later sodium hydroxide replaced the wood ashes. 'Soft soap' is made with potassium hydroxide instead of sodium hydroxide. Bar soap or 'regular' soap with the sodium hydroxide has the disadvantage that the calcium from hard water causes it to precipitate as soap scum. This soap also does not work well in cold water due to lower solubility. Soft soap does not precipitate out as soap scum and works better in colder water.
- Sodium lauryl sulfate was one of the first synthetic detergents. It is made by reacting lauryl alcohol with sulfuric acid, and neutralizing the resulting hydrogen laurylsulfate with sodium hydroxide. Modern chemistry has produced thousands of surfactants. They all have one hydrophobic and one hydrophilic end, which can be anionic, cationic, or nonionic.

Demonstrator's Guide

Optional Surface Tension Experiment - Water on a Penny

This experiment can be incorporated between putting the water droplet onto the waterproofed paper and dropping the wire into the dish. You can use it to explain the 'skin' on the surface of the water, then challenge the students to use the water's skin to hold up the wire. After the wire sinks, use the surfactant solution on the penny and on the waterproofed paper.

Supplies Needed: clean pennies (one per student), cup of water (one per group), soap or detergent or surfactant solution (one per group), beral pipettes (one per student), paper towels (one per student)

Introduce the Experiment

Tell the students the following:

- We can examine the surface tension of water by seeing how many drops of water will fit on a penny before spilling off.

Perform the Experiment Simultaneously with the Students

Do the following:

- Ask the students to place the clean penny in front of them.
- Ask each student to fill a pipette with clean water.
- Carefully count the number of drops of water you can drip onto a penny before it spills off [it should take about 25-50 drops].

- Dry the penny with a paper towel and repeat the experiment using the soap or detergent or surfactant solution [it should take less than 5 drops].

Conclusions on the Water on Penny Experiment

- Ask the students if soapy water had an effect on the number of drops they could get on a penny.
- The surface of water is held together by a strong force called "surface tension." You can image this force making water look like it has an elastic "skin" all over it. With pure water, the "skin" is strong, so you can pile up many drops of water on the penny without the water falling off.
- When soap is added to the water, it weakens the "skin" or the surface tension, so less drops of water can be piled on the penny.
- Most dirt is oily and has a very low surface tension. When plain water comes in contact with grease or oil it beads up like wax on a car (wax has low surface energy like grease and oils). In order for the water to help clean the grease or oil it must spread out along the surface (or "wet")

Demonstrator's Guide

the surface). Soaps and detergents lower the surface tension of the water (by getting in the way of the strong water-to-water bonds) and allow the water to spread out over the grease or oil.

Experiment 5: Hard Water vs. Soft Water**Experiment Purpose & General Methodology**

- The students will learn the difference between “soft” and “hard” water.
- The students will learn why it is so difficult to wash up using hard water.
- This experiment will be done per table, and will take 5 minutes.

Introduce the Experiment

Tell the students the following:

- Ask students if they have ever heard of hard or soft water.
- Does hard water really feel hard and soft water feel soft? (Answer: No. They don't look or feel different from one another, but they are different chemically.)
- Depending on the hardness of the water, washing up can be easy or more difficult. Ask the students if they know which (hard water or soft water) is easier to use for washing up.
- Our experiment will help us understand the meaning of “hard” and “soft” water and will help us determine which is better to use when washing.

Perform the Experiment along with the students.

Do the following:

- Add one small piece of soap (about the size of a pea) to the vial marked “H” and another piece of soap to the vial marked “S.” The “H” water will become our example for hard water, while the “S” water will become our example of soft water as we continue the experiment. Shake both vials to dissolve the soap and make a head of bubbles in each container.
- Have a student at each table find their table-salt packet, open it, and add a few crystals of table salt to the vial marked “S”. Shake the vial. What happens? [Answer: The soap head should be unaffected.]
- Add as little as possible Epsom salt to the vial marked “H” (as little as a single crystal or two should work). Shake the vial. What happens? [Answer: The soap head formed should collapse immediately.]

Conclusions

Tell the students the following:

- The table salt added to the “soft” test tube represents the salt on your body, such as when you sweat. Salt is composed of the elements sodium and chloride and does not interfere with the foaming action of the soap, so it is easily washed away with “soft” water.
- The Epsom salt that was added to the vial marked “H” represents hard water. Hard water contains chemicals similar to those in Epsom salt which make foaming difficult and create a sticky soap scum film inside the vial. Remember, hard water = hard to make a lather.
- Water softeners are popular in areas with hard water because they make bathing and washing clothes easier.

Additional Information If Needed: Technical Background

- The soap used must be Ivory; other brands tested did not work as well.
- Water hardness results from calcium, magnesium, and iron in water. In nature, water becomes hard by picking up calcium or magnesium when it flows over or through rocks that contain limestone and other minerals.
- Calcium, magnesium, and iron form stearate salts when mixed with soap (which is mainly sodium stearate and other sodium salts of fatty acids). These calcium, magnesium, and iron stearates are much less soluble in water than the sodium salt and precipitate upon mixing. The solid precipitate correspond to “soap scum” or bathtub ring.
- Most detergents and shampoos have been formulated so as not to lose their effectiveness when used with hard water. Detergents often contain sodium lauryl sulfate which does not form precipitates in the presence of calcium or magnesium ions.
- Many homes have water-softening devices that remove the dissolved metal ions. The most common type of water softener utilizes an ion-exchange resin that replaces any Mg^{+2} , Ca^{+2} , and Fe^{+2} ions in the water with Na^{+} ions which form soluble stearate salts. Laundry aid agents, such as Calgon, borax, and washing soda, are marketed to remove hard water cations by causing them to become part of larger soluble anions, or by precipitating them as carbonates, which can be washed away with rinse water.
- The chemical formula for Epsom salt is $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$.

*** Now is a good time to have the next student gently shake/mix our solution from the dye-magnet experiment and pass it to the next student.

Experiment 6: This is the Way We Wash Our Clothes

Experiment Purpose & General Methodology

- This experiment will illustrate the difference in cleaning and stain removal by various combinations of laundry products.
- Each table will have the same type of stained fabric, but each table will be testing different combinations of laundry aids. The experiment concludes with a comparison of results.
- This experiment will be done per table, and will take about 12 minutes to complete.

Introduce the Experiment

Tell the students the following:

- We started a discussion about laundry earlier, with our dye magnets, but we're not quite ready to go back to it yet. But let's talk more about laundry.
- Discuss with the students what happens when their clothes are laundered--what kind of stains do they get on clothes and do they all come out in the wash. Ask them what might be used to help get the stains out.
- Tell the students that one of the first experimental scientists, Robert Boyle, (17th century) believed that grape juice stains could wash out most easily when the grapes were still ripe on the vine. He also believed in magic and astrological-based notions! Today, through our studies of science and chemistry, we understand more about what stains are made of and how to get them out of our clothes.
- Ask the students why it is important to tell the person that washes their clothes that they have gotten something on their clothes before the clothes are washed. [Different stains are better cleaned by different cleaning agents.]
- Point out the types of stains that have been put on the fabric sample:
 - Dirt (potting soil), ketchup, ball-point pen ink, and Kool-Aid (from drink mix)Remind the students that these are some of the more difficult stains that their parents try to get out of their laundry, so they may be a challenge for us to clean too.
- Mention that cotton (a natural fabric was chosen for this experiment) and that other fabrics might have different results than those they are going to observe.

Experiment 6

Demonstrator's Guide

Perform the Experiment as a Demonstration, then Simultaneously with the Students

Do the following:

- Tell the students that you have already added laundry detergent to cups on tables 2-6 but not to your own (demonstrators) cup or the cup on table 1.
- If they have a bag at their table marked 'borax', 'nc bleach' (non-chlorine bleach), 'soda' (washing soda) or a tube marked 'vin' (vinegar) they should add it to their plastic cup marked 'washer' and stir with fork.
- They should take their sample of stained fabric and dip it into the 'washer' and use the fork to swish the fabric around for about 30-60 seconds to simulate the action of a wash machine.
- When they are done with the wash cycle, they should use their fork to remove the sample from the soapy water and put it into the cup marked 'rinse' to rinse the fabric.
- When they are done rinsing the fabric sample, they should pat it dry with a paper towel and one student from each table should bring it up to be put on the poster. That student should tell the demonstrator which other cleaning item was added to your washing solution, so that the demonstrator can paper-clip the cloth above the correct label on the poster-board.

Conclusions

Discuss/Tell the students the following:

- Ask the students to look at the different test strips and discuss which laundry solution did the best job--that is got the most stains out.
- Discuss with them which stains were the hardest to get out overall.
- Discuss which laundry solution was better for each individual stain.
- Tell the students that...

Borax, sodium tetraborate decahydrate, $\text{NaBO}_4 \cdot 10 \text{H}_2\text{O}$, is a laundry booster used to enhance soil and stain removal and brighten whites and colors. Laundry boosters work by buffering the alkalinity needed by other wash ingredients and by softening the water.

Washing soda, sodium carbonate, NaCO_3 , is another laundry booster. It is highly alkaline (much more so than baking soda) and acts to neutralize or adjust the acidity of other wash ingredients. Alkalinity is useful in removing acidic, fatty, and oily soils. Therefore, detergents are more effective when they are alkaline. Sodium carbonate also softens water by precipitating calcium ions from hard water.

Bleaches whiten and brighten fabrics and help remove stubborn stains. They convert soils into colorless, soluble particles that can be removed by detergents and carried away in the wash water. Oxygen (color-safe) bleach is more gentle than chlorine bleach (usually a sodium hypochlorite solution) and works safely on almost all washable

Experiment 6

Demonstrator's Guide

fabrics. Non-chlorine bleaches often contain sodium perborate which bleaches stains by releasing oxygen (through the intermediate hydrogen peroxide) in the wash. In some products, a bleach activator is used for better performance at lower water temperatures.

Vinegar, acetic acid, works well on dissolving acidic stains like coffee, tea, fruits, and berries. Vinegar can also be used as a fabric softener to neutralize detergent residues (generally alkaline) in the wash water. Since many other detergents work better in alkaline/basic solutions, vinegar is not typically in our laundry detergents; it is more often used as a pre-treatment stain remover. Vinegar is also used to help remove odors in laundry.

- Point out (and possibly demonstrate) that they might need some special stain removers for difficult stains such as using hair spray to get out ball point pen ink, ammonia to get out mud, or shampoo to get out grease.
- Optional: IF you chose to demonstrate stain remover(s) that you brought from home, remember that the demonstrator's cups and student table #1 cups had plain water in both the washer and rinse cups. You may use them safely for your washing with your own stain remover. If you wish to add your stain remover to detergent, use the cups from table #2 which had detergent-water. Reuse the demonstrator's or the table #1 stained cloth since they were only washed with water so far.

Additional Information If Needed: Technical Background

Information taken from Hill, John W. and Doris K. Kolb, Chemistry for Changing Times, 7th ed., Prentice Hall, New Jersey, 1995.

- In primitive societies, even today, clothes are cleaned by beating them with rocks in the nearest stream. Sometimes plants, such as the soapworts of Europe or the soapberries of tropical America, are used as cleaning agents. The leaves of the soapwort and soapberries contain saponins, chemical compounds that produce a soapy lather. These saponins were probably the first detergents.
- Ashes of plants contain potassium and sodium carbonate (washing soda). The carbonate ion, reacts with the water to form an alkaline (basic) solution. This basic solution has detergent properties. These alkaline plant ashes were used as cleansing agents by the Babylonians at least 4000 years ago.
- The molecules of synthetic detergents are enough like those of soap to have the same cleaning action, but different enough to resist the effects of acids and hard water.
- Laundry detergents contain surfactants (that stabilizes the suspension of non-polar substances such as oil and grease), and may contain sodium carbonate, aluminosilicates (zeolites), and optical brighteners.
- Liquid laundry detergents often have linear alkylsulfonates as their surfactant which is an anionic surfactant (the working part of the molecule is an anion with a nonpolar part and an

Experiment 6

Demonstrator's Guide

ionic end.) Some liquid detergents contain nonionic surfactants. Nonionic surfactants are great for removing oily soil from fabrics but they are not as good as the anionic surfactants in keeping dirt particles in suspension. Many of these nonionic surfactants have the property of being more soluble in cold water than in hot and this makes them particularly suitable for cold-water laundering.

Finishing up Experiments 1 & 2:

Return the students' attention to Experiment 1: Dye Magnets:

Complete the Performance of the Experiment Simultaneously with the Students

Do the following:

- After all the other demonstrations are complete, observe the triangular WDM sheets. What do you observe? [They should have adsorbed most of the water-soluble ink and turned a color.]

Conclusions

Tell the students the following:

- The piece of paper marked with water-soluble ink (sad face) is made of heavy duty paper towel and represented a new unwashed dyed piece of clothing. The ink runs because the dye is not fixed to the cloth. The unfixed dye is a negatively charged particle called an anion.
- The square piece of Woolite Dye Magnet sheet marked with water-soluble ink (happy face) is made from the dye magnet material and shows how tightly the ink is adsorbed on the anion exchange resin.
- The two triangles are also dye magnets which later collect the excess dye from the water. The exchange a non-colored anion in the dye magnet for the colored dye anion in the water. Thus the excess dye in the water is collected by the dye magnet which prevents the coloring of other pieces of material in the water. (No more pink socks from bring washed with the red shirts!)
- NOTE: The water may be colored by trace amounts of ink. However, the square piece of paper should not be colored, although it might be slightly colored if we have too much dye for the small piece of dye-magnet to 'soak up'. If desired, have the students use the fork from the washing mashine experiment to remove the square to verify our progress.

Additional Information If Needed: Technical Background

- Dye Magnet, quaternary ammonium anion exchange resin sheet, will prevent the white clothing from being colored. The negatively charged unfixed dye is called an anion. This anion will be attracted to and tightly bond to the anion exchange resin in the Woolite Dye Magnet sheet. The uncolored anion from the dye magnet is exchanged for the colored anion of the dye in the water.
- The manufacturer calls it a dye 'magnet' to make it simple to understand. Actually, a magnet can attract iron fillings to it across a distance. The dye magnet needs to have contact with the dye in the water in order for the anion exchange to occur.

Return the students' attention to Experiment 2: Water Filter:

Complete the Performance of the Experiment Simultaneously with the Students

Do the following:

- Remove the top portions of the filtration systems and collect them in the garbage bag for disposal.
- Students should examine the filtrate's color and odor. Do not allow the students to drink this water. Although it has been cleaned quite well, we are not a treatment center and the water may not be clean enough to be labeled as drinking water.

Conclusions

Discuss/Tell the students the following:

- Discuss again the importance of filtering our water. Although some water evaporates and returns to the water system as rain, much of our water is collected as wastewater from homes and storm sewers, and filtered and treated at wastewater treatment plants.
- Add that this is why it is best to not throw trash on the ground – it gets into the water system and is one more item that needs to be cleaned out. Throw trash in a trash container.

Detergents can do their part in keeping us clean; we should also do our part in keeping the environment clean!

Closing Session

Close Demonstration

- Thank the students and parents for coming to this year's demonstration and learning about how chemistry keeps us clean. Tell the students that you will now collect the goggles and give them some items to take home.
- Collect the goggles.
- Hand out the Experiments To Do at Home, the Book List, and the NCW activity newspapers.
- Tell the students that you have only 10 copies of ChemMatters magazine, which is written for older children, and that if they have an older brother or sister or good friend that they may want to take one home for them.

Clean up

After the students leave, clean up the room

- Return items borrowed from the library to a librarian. Give any leftover literature to the librarian.
- Collect the vials and caps from the hard and soft water demo. Rinse with water. Place them into one of the gallon-sized zipper bags (since they are wet), and seal the bag. Place this into the large mailing envelope to be returned via interlibrary mail.

If you have time, please feel free to wash and rinse other vials at the library and fit more into the mailing envelope (sealed in more than one zip bag if necessary since they are wet). We will reuse collected vials next year.
- In the liquid-waste gallon jug, combine all waters first; use a funnel to prevent spilling. This liquid waste can be put down the sink safely with running water.
- All solid waste can be collected in the large garbage bag and thrown into the regular trash.
- If you are performing another demonstration for this year's National Chemistry Week, sanitize the goggles between demonstrations with a dilute bleach solution as instructed in the paperwork supplied. Be sure to dry them with soft cloths to prevent scratching.
- If you are done your demonstration(s) for this year, place the used goggles into their box. (There is no need to clean them when you are through. Our committee will clean them for the next year and/or for other programs.)
- Complete the Feedback Form, place it into the collection envelope and seal the envelope.
- Give the envelope containing the demo feedback form, the envelope filled with vials in zip lock bag(s), and the box of goggles to the children's librarian with instructions to put it into interlibrary mail.

