Chemistry—Our Health, Our Future!

A Water Park Adventure

An Educational Hands-On Demonstration Package

Prepared by the
National Chemistry Week Committee
of the
Cleveland Section of the American Chemical Society
for
National Chemistry Week 2011

Overview

This year our hands-on demonstration program explores chemistry as it relates to our bodies and our health. Our mythical characters, Milli and Avogadro, visit a water park and learn about clean water and some of its properties as they enjoy a day of swimming. After an accident in which Milli falls on the wet concrete, breaks her finger and bruises her arm, they learn that chemistry can come to the rescue to help put her finger in a cast and to care for some other minor injuries that she suffered.
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 the Cleveland Section's NCW activities. On several occasions it has received national recognition from the American Chemical Society. In 2011, the Cleveland Section’s volunteers will perform about 50 demonstrations at libraries, schools, and other public sites. Also during the year we inaugurated another Outreach Program in which our volunteers participated in NCW-related programs at area events in which various experiments from previous years were demonstrated.

Our NCW efforts reach many students each year because of various sponsors who have donated money, materials, and/or services to the Cleveland Section specifically for National Chemistry Week. We would like to especially thank our partners at the Cuyahoga County Public Library (CCPL) for the use of their facilities and for creating flyers, our NCW Introductory video and the video demonstrating this program. Graftech International Corporation generously contributed materials to this program, and we extend our thanks to them. We also extend our thanks to John Carroll University, NASA Glenn Research Center, and other anonymous sponsors for their numerous contributions and support.

Last and most important, we thank all the volunteers who donated their time and expertise. 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 recommends, tests, and reviews activities & experiments; writes a script including a story line to hold the attention of small children; 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, was overseen by the Cleveland Section's NCW co-coordinators for 2011 Bob Fowler and Natalie Zarlenga. Committee members include Don Boos, Betty Dabrowski, Lois Kuhns, Vince Opaskar, Margaret Pafford, Marcia Schiele, Shermila Singham and Laura Sterk. Additional credit and thanks is given to the many GAK Day (Grand Assembly of Kits Day) volunteers (including local university students) who donated their time beforehand or gave up a Saturday in September to help count, measure, and assemble all of the necessary materials for our demonstration kits. A final thank you goes out to the dozens of dedicated chemical professionals who lead the presentations and activities in schools, libraries, and other public locations. Without them there would be no Cleveland Section NCW program.
Story Line

This year our hands-on program explores chemistry as it relates to our bodies and our health. We’ll join our make-believe friends, Milli and Avogadro, at a water park for a day of swimming and fun, and learn about clean water and some of the properties of this amazing chemical. After a minor accident in which Milli falls, we’ll learn that chemistry can come to the rescue!

To cool off a bit we’ll pretend to join them in a visit to the Great Kat Lodge Water Park. We will learn how water is cleaned for use in pools and for drinking. We’ll explore some of the properties that make water such an amazing chemical, and we’ll see how chemistry can come to our aid when we’re injured.

New for 2011

There are several new items for 2011 to which we call the volunteers’ attentions:

1. This year’s program features two new videos which were created in conjunction with our partners at the CCPL. The first video lasts about 5 minutes and is a general introduction to the Cleveland Section’s NCW program. It can be viewed at: mms://librarytv.cuyahogalibrary.org/chemistryweek. The second video demonstrates this year’s program in its entirety and takes the place of Dress Rehearsal at JCU. It can be viewed at mms://librarytv.cuyahogalibrary.org/chemistrykits. Please note that neither video had yet been posted at the time of this writing (September 8, 2011), but they will be shortly. These videos may require that a video player be downloaded to your computer. There are several free selections available.

2. While not difficult, there is considerable pre-demonstration setup time required at home the day before the program is conducted. Please see details starting on page 14.

3. For the first time in several years, we were privileged to win a ChemLuminary award from national ACS last year for “the most creative use of the yearly theme”, and in our opinion the reasons were two-fold: first, a wonderfully imaginative program created by our Planning Committee and second, the inclusion of actual student feedback we received from a teacher who utilized our program after receiving a kit at CRCST. We’ve created new feedback forms for the students at the program, and we’d appreciate your assistance in getting the students to fill them out and then returning them.

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’s write-up is presented as follows:

- Experiment Purpose & General Methodology
- Introduce the Experiment
- Performance Details
- Conclusions
- Additional Information if Needed: Technical Information
- Any additional information for the anyone who receive this script/kit
Each presenter obviously does not need to cover all of this material with the students. Some is only for the adult/parent audience. Pick out what you are comfortable explaining.

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. The program this year consists of 7 experiments.

- For most experiments your demonstration and the student’s hands-on work are nearly simultaneous. You will lead them as they perform the experiment.

- Five experiments will be done by all students. For the other two (Exps. 1 & 6), there will be one experiment that will be shared by all or some of the students at the table; please encourage multiple students to assist when an experiment is done as a group at a table.

At the end of the day the students will NOT be able to take home the experimental materials or chemicals that they used, but they will each be given our hand-out with a list of library books, links to on-line chemistry sites, and info about water. They will also take home their UV bracelet.

VOLUNTEERS

This year the NCW Committee is replacing the annual “Dress Rehearsal” demonstrations with a video hosted on the Cuyahoga County Public Library’s web site as indicated on page 3. This video demonstrates this year’s NCW program in detail and may be viewed by anyone interested in hosting our program. In addition, this script provides enough detail for a competent adult to be able to perform the presentation. The Cleveland ACS and NCW Committee do not require background checks on its volunteers nor do we require formal educational/teaching experience from all of its volunteers.

MAKE SURE TO FOLLOW ALL DIRECTIONS IN EXPERIMENTS

If experiments have special safety concerns due to the materials being used, they will be listed in the section for that experiment. For this year’s program, eye protection should be worn at all times and students should be specifically told to not touch their eyes; if exposure should occur, flush with water and report the incident to the librarian and parent. The low concentrations of our chemical solutions make them irritants. For skin contact, washing with soap and water will suffice; any coloration of the skin is temporary and will wash/wear off. Websites for where to obtain a Material Safety Data Sheet (MSDS) are listed in the appendix and are found on our website. For information about the American Chemical Society’s NCW safety guidelines, visit www.acs.org/portal/Chemistry?PID=acsdisplay.html&DOC=ncw%5Csafetyguidelines.html

Cleveland Section ACS “National Chemistry Week” website:

http://www.csuohio.edu/sciences/dept/cleveland_acs/NCW/

National American Chemical Society’s “National Chemistry Week” website:

www.acs.org/ncw
### Demonstration Check-Off List

<table>
<thead>
<tr>
<th>Activities To Do Well Before the Day of the Demonstration</th>
<th>Completed?</th>
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<tbody>
<tr>
<td><strong>Contact your library and</strong></td>
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<tr>
<td>- Verify the date and time of your 1-hour program</td>
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<tr>
<td>- <em>Set up Experiments 1 &amp; 7 (pp. 14 &amp; 15) before leaving for your demonstration. This setup may require an hour to perform.</em></td>
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<tr>
<td>- Also schedule AT LEAST an hour and a half before and a half-hour after your program for set-up and clean-up. Modify the setup time appropriately depending on how familiar you are with the materials in your kit and if you will have an assistant.</td>
<td></td>
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<tr>
<td><strong>Read through this packet</strong> to familiarize yourself with the experiments and verify that you have all the items as listed in the kit contents.</td>
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<tr>
<td><strong>If you’re using a pre-printed hard copy of the script, obtain the Script Errata/Addendum Sheet which will posted on our website (ref. page 4).</strong></td>
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<tr>
<td><strong>Please check your kits upon receiving them.</strong> Vials and bottles containing solutions may have shifted during storage and transportation. Check for leakage; correct situations. Store vials and bottles in as upright a position as possible.</td>
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<tr>
<td><strong>Please do not store kits in an overly warm area</strong> (such as in a car on a hot day). The kit contains many vials and bottles containing solutions that may leak under pressure created by higher temperatures.</td>
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<tr>
<td>Contact us with any questions: Bob Fowler at <a href="mailto:fowler@en.com">fowler@en.com</a> or Natalie Zarlenga at <a href="mailto:KARSTNK@kellyservices.com">KARSTNK@kellyservices.com</a>.</td>
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</tr>
<tr>
<td><strong>Collect the materials you need to bring</strong> with you to the demonstration. This materials list is on page 10. The librarian may be able to provide some of the items, but you need to call to verify that – do not assume they have anything.</td>
<td></td>
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<tr>
<td><strong>While not necessary, it’s recommended that you to ask a friend and/or contact the children’s librarian well in advance and request a student assistant or librarian to be your assistant.</strong> Having someone available to help set-up the room before the program and collect trash as the program progresses can help keep supplies organized. That person can also assist if multiple students need assistance or have questions about the experiments.</td>
<td></td>
</tr>
<tr>
<td>If you wish to add other experiments or demonstrations into your program, you must contact the Head Children’s Librarian through your local librarian ahead of time to get approval. Be careful and think “safety first”. Neither the NCW Committee nor the Cleveland ACS approves of any experiments added to your program, and you are responsible for your own actions.</td>
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### Information and Checklists

#### Presenter’s Guide

<table>
<thead>
<tr>
<th>Activity To Do about ONE WEEK BEFORE your program</th>
<th>Completed?</th>
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<tbody>
<tr>
<td>Contact the children’s librarian who is helping you to coordinate our program:</td>
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<tr>
<td>➢ VERIFY that they limited registration to 25 students.</td>
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<tr>
<td>➢ Ask the room to be arranged with 5 student tables with 5 chairs each, an additional front table for the presenter and a small side table/area for literature, photo permission forms, and goggles.</td>
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<tr>
<td>➢ Ask for all the experiment tables to be covered with newspapers and for extra paper towels for each table. Otherwise take newspaper and do this during setup.</td>
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<tr>
<td>➢ Ask about availability of demonstration materials from the list of page 10 (ex. paper towels, newspaper).</td>
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<tr>
<td>➢ Ask if the librarian and/or an assistant will be available to assist with the program or inform them if you will also be bringing an assistant.</td>
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<tr>
<td>➢ Make sure that the room is available before and after the program for setup and clean up. <strong>Set-up will take approximately 1.5 hours</strong> on your own. When you call the librarian, <strong>make sure that the room will be available and that you can access it 1.5 hours before the start time.</strong> If the librarian and/or that friend/student assistant are available to help with set-up, this will cut down the time.</td>
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<tr>
<td>Offer that a librarian and/or student assistant are welcome and encouraged to stay for the entire program. (They might even offer to be an assistant if given the opportunity.)</td>
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<thead>
<tr>
<th>Activity To Do AT LEAST ONE DAY BEFORE the Demonstration</th>
<th>Completed?</th>
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<tbody>
<tr>
<td><strong>Read over the experiments a few times and become familiar with them.</strong> Our program is designed for ~ one hour, but this assumes you are familiar with the program and are not strictly relying on reading the script step by step on site.</td>
<td>□</td>
</tr>
<tr>
<td>Complete the setups for Experiments 1 and 7 (see pp. 14 &amp; 15).</td>
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<tr>
<td>Gather all the items needed for your presentation as provided in the materials list starting on page 10. Do NOT assume your librarian will supply any materials unless agreed upon in advance, and even then, call and verify he/she remembered your requests. Do NOT assume you can easily obtain water in the library; at some sites, faucets are close to the sink bottom and allow little room for easily filling bottles or cups.</td>
<td>□</td>
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</tbody>
</table>
### Activities To Do When You Get To The Library

| NOTE: Arrive at least 1-1/2 hours before show time to allow for introductions and set-up depending on how quickly you think you can perform the steps listed in the Experimental Setup section. DO NOT assume that a librarian will be present to help you set up for the experiments. |
| Introduce yourself to the Children’s librarian. |
| Confirm that the tables and chairs are set up properly. |
| Confirm that all tables are covered in newspaper and have paper towels. |
| Obtain those supplies from the list on page 10 if provided by library. |
| Optional: Ask the Children’s Librarian or an assistant to take pictures during the demonstration (subject to parents/guardians having given permission). |
| Complete Demonstration Set-Up. See Experimental Set-Up: “Activities to Do On-Site Prior to Demonstration” starting on page 15.  |
| **Set-up note!** If you follow the script as originally written, there are many cups and other items on the tables. Depending on the size of your tables, and the activity level of your students, you may choose to distribute fewer items originally. If so, then perhaps keep the remaining experiments’ material at your presenter’s table—on a tray if you have one—and distribute these items throughout the program. |
| Set up an ‘Entrance’ area table to allow space for goggle distribution and fitting by the parents, photo permission form signing, and (at the end of the program) distribution of literature. |
| You may wish to set up an ‘Exit’ area table to allow space for end-of-program activities: goggle return and literature distribution. |

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### Activities To Do At The Start of The Demonstration

<table>
<thead>
<tr>
<th>Timing</th>
</tr>
</thead>
</table>

| Ask the parent/guardian for permission to photograph the children for possible use on our website and obtain their signatures to this effect. (If that permission is not obtained, make sure that that student is positioned in such a way in the room that they won’t be included in the photographs, or do not take any photographs. |
| Hand out goggles and help adjust to the correct fit (if necessary). |
| Assess number of students per table and adjust to 3-5 per table. Record the number of students and adults on the provided Demo Feedback form. Do not allow any student to sit alone at a table as some experiments require two people to perform. |

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# Perform demonstrations:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Type</th>
<th>Time (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1: Deodorizing and Decolorizing Water</strong></td>
<td>Group</td>
<td>10</td>
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<tr>
<td>Attraction: The FUN*nel</td>
<td></td>
<td></td>
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<tr>
<td><strong>2: Sunscreen</strong></td>
<td>Individual</td>
<td>5</td>
</tr>
<tr>
<td><strong>3: Water hardness</strong></td>
<td>Individual</td>
<td>10</td>
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<tr>
<td>Attraction: Fountain of Foam</td>
<td></td>
<td></td>
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<tr>
<td><strong>4: Water on a Penny</strong></td>
<td>Individual</td>
<td>5</td>
</tr>
<tr>
<td>Attraction: The Big Tip*per</td>
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<tr>
<td><strong>5: Floating Paper Clip</strong></td>
<td>Individual</td>
<td>5</td>
</tr>
<tr>
<td>Attraction: The Aqua Plunge</td>
<td></td>
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</tr>
<tr>
<td><strong>6: Casting a Broken Finger</strong></td>
<td>Group</td>
<td>10</td>
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<tr>
<td>First Aid Station</td>
<td></td>
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<tr>
<td><strong>7: Soothing the Pain with Hot and Cold Compresses</strong></td>
<td>Individual</td>
<td>10</td>
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<tr>
<td>First Aid Station, cont.</td>
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Return to Experiment 1                                   2 min.

Complete the Closing Session information                  2 min.

Collect goggles & hand out literature & say “Thanks for coming”. Allow students to take home items as mentioned in the Closing Session on page 40. Be aware to not show favoritism by giving out items that you cannot give to all students. 2 min.

Note: Times are approximate. Be familiar with the experiments before you arrive so you do not waste time ‘reading’ the script. You may choose to omit an experiment so that your program does not run over time, or change an experiment from hands-on to a demonstration. **Plan ahead** to determine which experiment you might skip over or abbreviate. **Total Time: ~ 60 min**

## Activities To Do Immediately After The Demonstration

<table>
<thead>
<tr>
<th>Activity</th>
<th>Completed?</th>
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<tbody>
<tr>
<td>Clean up as indicated in the <strong>Clean Up</strong> section (p. 41).</td>
<td></td>
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<tr>
<td>Complete your Feedback Form. Put it, the children’s feedback forms and any completed Photo Permission forms in the manila envelope provided and return them to <strong>Julia Boxler YTH</strong> via the library’s mail system along with the goggles.</td>
<td></td>
</tr>
<tr>
<td>Give the mailing envelope(s) (including the reusable items, the feedback forms and the photo permission forms) along with the box of student and adult goggles to the librarian for return to Julia Boxler via interlibrary mail. <em>(Those outside of the CCPL network can return items to your nearest CCPL branch for return to Julia Boxler-YTH. See <a href="http://www.cuyahogalibrary.org">www.cuyahogalibrary.org</a> for branch listings.)</em> Please return all materials within two weeks of NCW.</td>
<td></td>
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<tr>
<td>Give any leftover literature to the librarian <em>(CCPL library kits only).</em></td>
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</table>
### Activities To Do Once You Get Home

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<tr>
<th>Completed?</th>
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</table>

If you didn’t complete a Feedback form and return it via the inter-library mail, we still need feedback about your program. Please email Bob at jrfowler@cox.net requesting an electronic form; complete it and return it to him. This information may be useful to other presenters who have not yet performed their 2011 presentation. It will also be used to justify our expenses for funding of future programs.

Smile! You have just shared your joy of science and chemistry with children, possibly inspiring them to become great scientists, chemists, biologists ….
Supplies Required for Demonstration

Items for Presenter to Provide (or to request in advance from the librarian — do not assume that the library will have these materials)

1. newspapers for covering 6 long tables with a few layers of paper (if none at site)
2. 1 large garbage bag for solid waste collection
3. 1 bucket for liquid waste collection (optional if sink is within the demo room)
4. A pen (for filling in forms)
5. 1 teaspoon and one tablespoon
6. 1 roll of paper towels.
7. Small plastic tray(s) for arranging plastic cups on, filling same and then distributing.
8. It’s a good idea to bring an extra gallon of water (Note: It may be difficult to transport water from library restrooms with shallow sinks or fountains with low spigots, so do NOT plan to use this method to obtain water unless you have investigated the water availability at your site.)
9. Three measuring cups:
   a. ¼ cup
   b. ½ cup
   c. 1 cup
10. 1 pair of scissors
11. A long extension cord for use with the UV light.

Optional: IF you care to take pictures, bring a digital camera for taking photos. Make sure students’ parents have given their permission for the children to be photographed on the ACS form and that the students and adults to be photographed are all wearing goggles. You might want to assign the photography chores to an assistant during the demonstration. It is better to have close ups of one or a few students to show what they are doing and their excitement.

Note: If you will be performing multiple demonstrations on the same day, you will need to sanitize the goggles between demonstrations. You will also need:

1. small quantity of household bleach
2. wash bin or bucket
3. old towels or cotton paper towels for drying (soft so as not to scratch the goggles)
   …OR…
4. individual sanitizer wipes (soft so as not to scratch the goggles)
Supplies Included
Presenter’s Guide

Items Provided in Each Demonstration Kit:

General
1. 1 kit box containing materials for 7 Experiments and literature, most for distribution:
   a. 1 copy of this year’s script
   b. 25 copies each of the two-sided “Book & Website List”/“Experiments to do at Home” handout
   c. 1 Program Feedback Form (designed for either teacher programs or library programs)
   d. 25 copies of the Student Feedback Form and 25 small pencils for completion of these forms.
   e. 25 copies of the ACS photo permission form.
   f. 26 moist towelettes in a baggie
   g. 2 large manila envelopes for returning the Feedback and Photo Permission Forms and reusable supplies to the NCW via interlibrary mail (addressed to Julia Boxler - YTH) (library kits only)

   NOTE: Initially, one of the return envelopes will contain much of the paperwork for your program and pencils for the students’ use in completing Feedback forms at end. This was done to help prevent folding and wrinkling in storage/transport.

2. 1 box of goggles (25-30 student & 2 adult size, addressed for return to Julia Boxler - YTH).

Materials by Experiment

Sign-In: None for 2011

Experiment 1: Deodorizing and Decolorizing Water (Group Experiment)
1. 6 20-oz. pop bottles, cut in half and with holes in the lids
2. 12 cotton balls
3. 1 plastic spoon (approximately 1 tsp)
4. 1 large plastic bag filled with 4 cups of sand
5. 1 quart-sized plastic bag containing 1.5 cups of activated charcoal
6. 1 20 oz pop bottle filled with ½ tsp of cocoa powder; capped (no holes in cap)
7. 1 snack-sized plastic bag marked “G” filled with ½ tsp of garlic powder
8. 6 wooden stirrers
9. 1 beral pipette with flavoring (sealed; in zip bag labeled “F”)
10. 6 3 oz cups labeled “DW”
11. 1 9 oz plastic cup
Experiment 2: Sunscreen (Individual Experiment)

1. 156 UV color-change beads (translucent beads that turn various colors when exposed to UV light)
2. 78 small squares of clear transparency sheet with 3 labeled circles—26 labeled SPF 0; 26 labeled SPF 30, and 26 labeled SPF 70
3. 1 10 ml vial filled with sunscreen lotion of SPF 30 in a plastic bag labeled “30”
4. 1 10 ml vial filled with sunscreen lotion of SPF 70 in a plastic bag labeled “70”
5. 26 3 oz paper cups labeled “0”
6. 32 3 oz paper cups labeled “30”
7. 32 3 oz paper cups labeled “70”
8. 52 cotton swabs
9. 26 tri-fold paper towels
10. 1 UV light
11. 26 multi-colored pipe cleaners
12. 2 long, thin wooden splints (to remove lotion from vial to cup)

Experiment 3: Water hardness (Individual Experiment)

- 26 10 ml vials marked “H” in zip bags with 8 ml distilled water in each
- 26 10 ml vials marked “S” in zip bags with 8 ml distilled water in each
- 1 snack-size plastic bags marked “IS” containing approx. 6 tsp of Ivory flakes each
- 1 snack-size plastic bag marked “ES” containing approx. 6 tsp Epsom salt each
- 6 2 oz portion cups marked ” IS”
- 6 2oz portion cups marked “ES”
- 26 salt packets
- 12 plastic spoons

Experiment 4: Water on a Penny (Individual Experiment)

1. 26 pennies
2. 26 4 oz plastic cups labeled “W”
3. 26 beral pipettes
4. 26 tri-fold paper towels
Supplies Included

Presenter’s Guide

Experiment 5: Floating Paper Clip (Individual Experiment)
1. 26 large paper clips
2. 26 plastic forks

Experiment 6: Casting a Broken Finger (Group Experiment)
1. 1 9 oz portion cup (to use as a container for water)
2. 1 paper towel cut into 6 1” strips (for wrapping finger)
3. 6 intact pairs of plastic gloves
4. 1 plastic bag containing urethane cast material (3M Scotchcast plus®) (DO NOT OPEN UNTIL READY TO DO DEMO WITH STUDENTS)
5. 1 paper strip cutting guide 11.5” in length marked “3M Scotchcast casting tape cutting guide”

Experiment 7: Soothing the Pain with Hot and Cold Compresses (Individual Experiment)
1. 52 plastic sandwich bags, empty, unmarked
2. 26 plastic sandwich bags, empty, marked “C”
3. 26 plastic sandwich bags, empty, marked “H”
4. 26 teaspoons
5. 26 trifold paper towels
6. 6 4 oz plastic cups marked “CA”
7. 6 4 oz plastic cups marked “BS”
8. 6 4 oz plastic cups marked “CC”
9. 1 plastic quart bag marked “CA”, containing 1 ½ cups of citric acid crystals
10. 1 plastic quart bag marked “BS”, containing 3 cups baking soda
11. 1 plastic quart bag marked “CC”, containing 1 ½ cups calcium chloride
Activities to Do At Least ONE DAY BEFORE the Demonstration:

1. **Preparation of Water Filters for Experiment 1**

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. Prepare each of the six 16-20-ounce bottle filtration systems as follows:
   1. 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.
   2. Place 2 cotton balls in the neck tightly against the cap.
   3. Place about 6 teaspoonfuls of sand on top of the cotton balls.
   4. Place about ¼ cup of activated charcoal on top of the sand.
   5. Place another ½ cup of sand on top of the charcoal.
   6. Smooth out the sand and compress it slightly with your fingers.
   7. Trying to minimize disturbing the sand surface, VERY GENTLY pour about ¼ cup of tap water on the surface and allow it to filter through. SAFETY NOTE: the charcoal may produce some heat and steam upon initial water additions; this is normal. Continue rinsing with ¼ cup water portions until the filtrate is clear. This process may take about ½ hour.
   8. Cover each with plastic wrap to keep moist until the demonstration.

2. Pack these prepared filters carefully so that the contents will not shift or fall over during transportation to the site.

3. **SUGGESTIONS:**
   1. For stability during transit, perhaps tape the two halves together in the configuration shown in the diagram, and then remove the tape during setup at the library.
   2. Set the filtration systems directly into a box. The six will fit nicely into a shoe box surrounded with newspaper, or we have found that typically they can be tucked into a corner of your kit box and secured there by packing the other experiments’ bags around them.
2. Setup for Experiment 7

Fill the 52 unmarked bags with ¼ cup of tap water. Use the measuring cup for this purpose. Seal the bags. Store these in an upright position until needed.

Activities to Do On-site Prior to Demonstration

General:

1. Verify room setup. (5 student tables with 5 chairs each, one presenter table, all covered with newspaper, each with paper towels, etc.) One additional table at room entrance.

2. Obtain any supplies requested from librarian (see page 10)

3. On the entry-table place the ACS Photo Permission forms and a pen. IF you plan to take photos during your presentation for NCW/ACS use (on Cleveland NCW ACS website and/or for submission to National ACS for awards or annual reports) you MUST obtain a signed photo permission form for each and every person in the photo. Do NOT take photos of anyone without written approval. Also, everyone in any photo must be wearing goggles.

4. Place goggles where they can easily be distributed.

5. Put all copies of the Student Feedback Form and pencils on the demonstrator’s table.

6. On the entry/exit table place the literature, book/website/take-home handouts and gift bag to be distributed at the end of the program to each child as you collect the goggles.

Note: In the following the term station refers to each of the 5 places at all 5 student tables plus the demonstrator’s table (i.e., 26 places total).

Experiment 1: Deodorizing and Decolorizing Water (Group Experiment)

- Carefully wet the surface of the filtration systems if they’ve dried out.

- On the demonstrator’s table place the following:
  1. the 20 oz clear pop bottle with the ½ tsp cocoa powder inside (as supplied with your demonstration kit) filled with tap water, covered and shaken. This is the “Dirty Water (DW).”
  2. the flavoring pipette (removed from the bag marked “F”)
  3. the bag labeled “G”
  4. scissors nearby to cut open the pipette later
  5. the 20 oz bottle containing the cocoa water
  6. all 6 filtration systems. Do not yet place them at the student tables! We do not want to risk their being knocked over.
  7. the 9 oz cup filled about 2/3 full with tap water.
On each students’ table place
1. one wooden stirrer
2. one empty 3 oz cup labeled “DW”

**Experiment 2: Sunscreen (Individual Experiment)**

- At each station place the following:
  1. 3 3 oz paper cups: 1 marked “0”, 1 marked “30” and another marked “70”.
  2. 3 small squares of clear transparency sheet, each with a circle—1 labeled “SPF 0”, 1 labeled “SPF 30”, and 1 labeled “SPF 70”
  3. 6 UV beads. Cover the beads with the tri-fold paper towel provided.
  4. 2 cotton swabs
  5. 1 pipe cleaner

- Using one the two wooden splints provided, divvy the sunscreen lotion in the 10 ml vial in the baggie marked “30” between the 6 cups marked “30”. Do the same with the SPF 70 lotion. Place one of these cups on each table.
- Place the UV lamp on the demonstrator’s table. Connect with your long extension cord so you can reach all the tables.
- Note: when it comes time to perform this experiment, you may need to close the curtains and/or dim the lights somewhat for this experiment—observe how the beads are reacting to the light in the room as you’re setting up, and proceed accordingly.

**Experiment 3: Water hardness (Individual Experiment)**

- Divvy the Epsom salt in the baggie marked “ES” among the 6 2 oz. cups marked “ES”.
- Do the same with the Ivory soap pieces in the baggie marked “IS”.

- On each table place:
  1. one 2 oz. cup with Epsom salt marked “ES”
  2. one 2 oz. cup with Ivory soap pieces marked “IS”
  3. two plastic spoons

- At each station place:
  1. one 10 ml vial of distilled water marked “H”
  2. one 10 ml vial of distilled water marked “S”
  3. one packet of table salt.
Experiment 4: Water on a Penny (Individual Experiment)

- At each station place the following:
  1. 1 penny
  2. 1 beral pipette
  3. 1 4 oz plastic cup labeled “W”. Fill each 4 oz cup about ¾ full with tap water.
  4. 1 paper towel

Experiment 5: Floating Paper Clip (Individual Experiment)

- At each station place the following:
  - 1 large paper clip
  - 1 plastic fork

Experiment 6: Casting a Broken Finger (Group Experiment)

- At the demonstrator’s table place the following:
  a. The plastic bag containing the 3M urethane cast material. NOTE: Do not prematurely open the bag of 3M Scotchcast material! It will start to harden upon exposure to the moisture in the air.
  b. 1 pair of plastic gloves and the scissors you brought from home.
  c. The 11.5” paper strip guide marked for cutting the cast material.
  d. The 6 1” strips of paper towel for wrapping the finger

Experiment 7: Soothing the Pain with Hot and Cold Compresses (Individual Experiment)

- Distribute the citric acid from the bag marked “CA” evenly into each of the 6 cups marked “CA”.
- Distribute the baking soda from the bag marked “BS” evenly into each of the 6 cups marked “BS”.
- Distribute the CaCl₂ from the bag marked “CC” evenly into each of the 6 cups marked “CC”.
- Fill 52 unmarked plastic sandwich bags with ¼ cup of room-temperature water in each and seal. THIS MAY BE DONE THE DAY BEFORE TO SAVE SETUP TIME.
- Place the following at each station:
  1. 2 plastic sandwich bags, unmarked filled with ¼ cup of tap water
  2. 1 plastic sandwich bag, empty, marked “C”
  3. 1 plastic sandwich bag, empty, marked “H”
  4. 1 teaspoon
  5. 1 trifold towel
• Place the following on each table:
  1. 1 4 oz plastic cup marked “CA” containing citric acid
  2. 1 4 oz plastic cup marked “BS” containing baking soda
  3. 1 4 oz plastic cup marked “CC” containing calcium chloride
Greet the Students (and Parents) Upon Their Arrival, Distribute Goggles, and Organize the Seating

- If you plan to take pictures, ask the parents/guardian to give or withhold their permission for the student to be photographed via the ACS consent form. **Don’t forget to obtain their signatures on the forms provided.**
- Help or have the students’ parents put on their goggles. Adjust the straps as necessary. *(Note: These goggles are sanitized each year and prior to each demonstration.)*
- Ask each student to PLEASE not touch any of the materials before the program begins. Some experiments may be ruined if they do.
- Distribute the students 3-5 per table. *(Note: You might want some librarian assistance with this: IF you plan to take photos and some of the parents have denied permission, you’ll want to put all of the children who aren’t going to be photographed at a separate table.)*

Opening Discussion

**Introduce the Items on the Tables:**

- Tell the students that various items have been gathered for them on their table.
- Some of the items can be found around the house, but others are laboratory chemicals. Emphasize that students should NOT touch anything until instructed to do so. **Never taste or smell anything, as if they were in a laboratory!**
- Tell the students that some of our items today can stain clothes or hands if we’re not careful. Mention to mom and dad that the chemicals can be washed off with soap and water if any hands get stained. We will also be **good** chemists and take the **safety** precaution of protecting our eyes with our goggles.
- Put on a pair of the adult-sized goggles. If you have an assistant, ask them to do the same. Verify that all students have goggles on.

**Introduce Yourself and the Program**

- Introduce yourself as a chemist or chemist/science teacher/engineer (or state your interests in chemistry), 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-scientists know about chemistry and how it has improved our everyday life.)*
Introduce Today's Presentation:

- The theme of NCW this year is “Chemistry—Our Health, Our Future!” Ask the students: “Have you ever gone to a water park….or did you cool off in your yard this summer by running through a sprinkler, have a squirt gun fight, or go swimming? You know that the water in a pool must be clean so that no one gets sick. We’ll do some experiments to clean up dirty water and to find out more about this amazing chemical. Water has some very interesting properties that are important to our health and the health of our planet, and that allow you to have fun, like in a water park.”

- Then ask some or all of the following:

1. How much of our body is water? Ans: about 80% of a baby's body is water. Adult: 60-70%--which is more than half.

2. How much of the earth is water? Ans: about 75%, i.e., 3/4, of the earth is covered with water.

3. What do we have in common with dinosaurs? Ans: we may be drinking the same water they did. The earth is a closed system...the same water that was used by the dinosaurs is still being used by us today.

4. How much water do we use a day in the US? Ans: how many gallons....think how much a gallon of milk is.......we use up to 100 gallons a day....mostly from flushing.

5. Which liquid can dissolve the most stuff? Ans: water - the universal solvent.

6. What dissolves in water that you drink everyday? Ans: salt, sugar, coloring (dyes).......milk, juice, etc. is mostly water.

7. Water is so awesome—it floats when it freezes. Why is this important? Ans: think of the fish and frogs that can still live in ponds in winter. If water didn’t float, it would sink and slowly fill the pond completely with ice killing all this wildlife. Floating ice is also a great insulation against cold: it protects the fish from freezing. That’s why water temperature in ponds and lakes never gets lower than 33°F even in the coldest winters.

Now that we’ve thought a little about water, let’s pretend to visit a water park with some make-believe friends called Milli and Avogadro.
Experiment 1: Deodorizing and Decolorizing Water

1st Water Park Attraction: The FUN*nel (Group Experiment)

Experiment Purpose & General Methodology

- The students will use a water filtration system to clean ‘dirty’ water.
- This experiment will be done per table as a group. The introduction and experiment will take about 10 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:

- When we go to a water park we need clean, safe water to swim in. 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 ―raw‖ water (i.e., water for drinking drawn from lakes and streams) and what might be in it, without getting too gross. Ans: it might have bits of trees and leaves and probably some dirt (suspended solids).
- When raw water arrives at the treatment plant it first flows through a screen to catch large objects like leaves and twigs and maybe even a long-lost sock. From there it goes through several more chambers to settle out the solids, remove any odors and then be sterilized.
- We are going to do a clean-up of “dirty” water (we’re making our own “dirty” water with some food items, so it’s safe). We will do this by filtering. (Point out the filtration systems on each table.)
- There are a number of layers of different materials in the top of the funnel. The top layer is sand, which will filter out large particles like leaves, but not bad odors or dissolved materials. (Some very small particles dissolve in water; can you give an example? sugar, salt, food coloring; think of Kool-Aid®).
- 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.
- We are now going to distribute our “dirty water.”

Performance Details

- Fill each of the cups labeled “DW” at each station (including yours) about 2/3 full with the “Dirty H₂O” (water plus cocoa powder). Have the students examine and smell their sample. The cocoa simulates what scientists call “suspended solids”.
Experiment 1 – Deodorizing and Decolorizing Water

Presenter’s Guide

- Invert the flavoring pipette and cut off its end. Carefully add 3-5 drops of the flavoring to each cup and let the children smell the solution after one of them stirs it 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 while another student holds the bottom so it doesn’t tip over.

- The demonstrator should walk around the room and add a small amount of fresh water from the 9 oz cup 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. Go on to the next experiment.

- Note our clever funnel set-up using recycled bottles! We’ll call this first “attraction” in our water park the FUN*nel.

Conclusions

Drinking water treatment plants first allow any suspended solids to settle out from the raw water and then they filter it several times through filters made of sand and gravel. Activated charcoal absorbs organic compounds which give water color and odor. This is a physical process, not a chemical change. Note that few bacteria are removed by filtration of the kind that we performed. In fact drinking water is chlorinated to kill harmful bacteria before it’s pumped to your home. It’s also fluorinated to help prevent cavities.

Interestingly, filtration is an important step in nature’s way of purifying water in the water cycle. Water in nature seeps into the ground, passing through gravel, sand and even rock. This removes nearly all suspended matter. As water flows down rivers and streams, oxygen dissolves in it, and bacteria clean the water. This is the water cycle in nature.

By contrast in a municipal wastewater treatment plant, filtration is not the main method of purification. Rather, suspended solids are first settled out from the wastewater and then air is bubbled through it so that bacteria have sufficient oxygen to digest the “dissolved solids” (i.e., waste materials) aerobically. Since bacteria are not removed by the filtration process, you might want to point out that wastewater treatment plants typically chlorinate it before releasing it to rivers and streams.
Experiment 2: Sunscreen (Individual Experiment)

Experiment Purpose & General Methodology

- The students will learn about sunscreens and SPF ratings.
- This experiment will be done by each student and will take approximately 5 minutes to complete.

Introduce the Experiment

Tell the students the following:

- When we go to a water park, we will be in a lot of sun. Before Milli and Avogadro dive in, they realize that they need to protect themselves from the elements.
- Ask the students what they do to protect themselves from the sun when they go swimming. Students will probably respond with SUNSCREEN.
- Why do we need sunscreen?: for protection from ultraviolet….burns, wrinkles, and cancer. As summer approaches, our hemisphere tilts toward the sun, days become longer, and the sun’s rays become more intense.
- This experiment will show you that sunscreen really works!

Perform Experiment with the Students and Discuss How Sunscreens Work

Tell the students to do the following:

- Find the six UV (ultraviolet)-sensitive beads on the table before them (covered with the paper towel). Explain that these beads absorb UV light and change color. Have them place two UV beads in each of the 3 oz cups labeled “0”, “30” and “70”. Tell the students to line the cups in a row so that cups are almost touching and cover them with the trifold paper towel.
- Tell the students to pass the cup labeled “30” down the table. When it’s their turn, dip one of their cotton swabs into the material (don’t drip it and make a mess!) and carefully “paint” the transparency circle labeled “SPF 30” with this material. Repeat this process using the cup labeled “70” and the second cotton swab. The entire area of the circles labeled SPF 30 and SPF 70 is to be covered—neatly—using these two materials. Tell the students to remove the paper towel from the cups and quickly cover the cup labeled “0” with the square piece marked “0”. Do the same with the cups marked “30” and “70”. The circles on the square should be placed so that they cover the openings in the cups.
- While they are covering the circles inform the students…
  - To be sure you are protecting yourself from damaging rays, sunscreen should be one part of an overall strategy to keep your skin healthy. In Australia, the country that has the highest rates of skin cancer in the world, people are urged to “slip, slop, slap”. That is, slip on a shirt, slop on sunscreen, and slap on a hat when you need to spend time in the sun. Staying out of the sun during peak hours (10 a.m. to 4 p.m.) is also recommended.
  - Sunscreen lotions absorb certain wavelengths of light before they reach the body. UV light with a wavelength range of 400–320 nm and 320–290 nm are referred to as UVA light and
UVB light, respectively. Different wavelengths have different energy. Depending on the type and amount of sunscreen present, only a percentage of UV light will actually reach your skin.

- Ask the students if they know what SPF on the sunscreen labels means? (Sun protection factor). You will discuss this more in a moment.

- Now ask the students to carefully pick up their cups (don’t tilt the cups and drop the plastic covers off!) and place them, one by one, next to student No. 1’s cups. When completed, there should be a 3X5 matrix (if you would) of cups near the end of the table so that you can easily expose all the cups to the UV light. Point out that this UV light is similar to those used in tanning salons.

- Now go the each table and hold the UV lamp over the beads long enough for their colors to change (typically <10 sec).

- Tell the students to retrieve their cups and examine the beads in them. What differences do they notice between the beads in the 3 cups? Ans: the beads in the cup marked “0” should display the brightest colors, those in “30” an intermediate brightness and those in “70” should be the least bright.

- Ask them what happened and why. Ans: increasing SPF values should decrease the exposure to the UV light, although the increased effect is marginal about an SPF value of about 50. (In fact in 2012 the FDA is adopting a new standard making SPF 50 the highest value offered.) Ask the students if they can see how using a lotion with an SPF factor of at least 30 can help minimize the effect of harmful UV rays from sunlight.

- When the students have completed examining the UV beads, tell them to remove the beads from the cups and string them on their pipe cleaners to make a bracelet or armband. (Even the boys can wear the bracelets—tell them it’s really a scientific device.) Once more pass the UV light over each student’s bracelet to excite the colors in the beads. Make sure to tell the students that they can achieve the same effect using bright sunlight—maybe they can even string the beads on their shoelaces for some more fun.

Conclusions

- Sunscreen lotions absorb certain wavelengths of light before they reach the body. Depending on the type and amount of sunscreen present, only a percentage of UV light will actually reach your skin. The sun protection factor (SPF) on sunscreen bottles is related to this percentage. Very simply, if you can prevent half as much light from hitting your body, you can stay in the sun twice as long (SPF 2). If only 3% of the light gets through, then you can stay out 33 times longer (SPF 33). The actual SPF for a particular lotion is more complicated and is determined experimentally by measuring actual burn rates.

- Ask them again what to do to protect themselves: Slip, Slop and Slap. Do not become deluded! The best course of action is still to avoid sun exposure during peak hours (10 a.m.–4 p.m.). If you must be out, wear a hat. Remember, a backward baseball cap might look really cool, but it does not protect your face, forehead, and ears. Your best bet is a hat with a large brim. My unofficial observation is that the goofiness and the sun protection of a hat are directly proportional, so lather up with sunscreen, wear your silliest hat, and get out there!
Technical Information

- Without the sun, there would be no life on Earth. It keeps our planet warm. Plants need the sun's radiant energy for photosynthesis. People need small amounts of exposure to activate vitamin D in their bodies, a substance important to bone-building and other biological processes.

- You can have too much of a good thing though. Too much sun can cause sunburn. Over time, too much sun can age the skin, making it leathery and inelastic. Researchers have also noticed a strong correlation between too much sun when you are young and skin cancer when you are older.

- Sunlight is made of many different kinds of light. These kinds of light have different energies and their properties are a result of these energies. Not all kinds of light cause sunburn. Only ultraviolet (UV) light damages skin.

- Light energy is measured in wavelengths (γ); the smaller the wavelength, the greater the energy. UV light is usually broken down into three subtypes:
  - UVA, 320-400 nm wavelength
  - UVB, 290-320 nm wavelength
  - UVC, 200-290 nm wavelength

- UVC light will do the most damage to your skin. Fortunately, this kind of light is completely absorbed by the atmosphere. Too much UVB light is responsible for sunburns. UVA light can damage your eyes over time. UVB and UVA go right through the air and clouds, which is why you can still get sunburned on an overcast day. Scientists aren't sure which type of UV light (UVA or UVB) causes the increased likelihood of skin cancer.

- “Broad Spectrum” sunblock lotions are popular these days because—although UVB light causes sunburns—scientists aren’t sure whether UVA, UVB, or some combination of the two is responsible for causing skin cancer. Broad spectrum lotions typically absorb a wide range of wavelengths, including UVA and UVB. To achieve broad coverage, the lotions use multiple sunscreens that are selected on the basis of either a favorable property (waterproof, hypoallergenic) or a wavelength range they absorb. Most dermatologists recommend that consumers apply a broad spectrum SPF 30 or higher every two hours.

- Sunscreens work by absorbing some of the UV light before it reaches your skin. Compounds such as cinnamate, oxybenzone, salicylates, and dibenzoylmethanes absorb UV light at different wavelengths, so many manufacturers put more than one UV-absorbing compound in their spray or lotion to give better protection from the sun. Most sunscreens block UVB rays.

- These five active ingredients are good examples of typical sunscreen compounds.

**Octyl salicylate** is one of a class of sunscreen compounds called salicylates. They absorb UVB light over the full range but are not particularly effective sunscreens because they have low absorptivity. Their saving grace is that they are stable, hypoallergenic, and waterproof.

**Oxybenzone** absorbs both UVA and UVB light but is generally considered a UVA blocker.
Octyl methoxycinnamate is part of a class of sunscreen compounds called cinnamates that absorb strongly in the UVB range but are not waterproof. In this formulation, and in many others, it is used in combination with waterproof ingredients such as octyl salicylate (above).

Octylcrylene is a relatively new sunscreen that provides superior coverage in the UVB range.

Titanium dioxide (TiO₂) does not absorb UV light at all, but rather blocks light from reaching your skin by reflecting or scattering it. It is sometimes referred to as a “nonchemical” sunblock (as a chemical enthusiast, you should find this silly because, of course, it’s a chemical). TiO₂ is different from the compounds above because the skin does not absorb it; it works by physically blocking the light. TiO₂ sunscreens are extremely effective and hypoallergenic. It might surprise you that another consumer product also uses TiO₂—white paint! TiO₂ sunblocks were not widely used in the past because they stayed white when applied (remember the white noses?). The particle size of new “micronized” TiO₂ formulations is so small that TiO₂ sunblock is invisible on skin.

\[ \text{Octyl methoxycinnamate} \]

\[ \text{oxybenzene} \]

\[ \text{octyl salicylate} \]

\[ \text{octocrylene} \]
Experiment 3: Water Hardness: 2nd Attraction: Fountain of Foam (Individual Experiment)

Experiment Purpose & General Methodology

- The students will learn the difference between “soft” and “hard” water.
- The students will learn why it takes so much soap to wash up using hard water.
- This experiment will be done per student, and will take about 10 minutes.

Introduce the Experiment

Tell the students the following:

- At the water park, we want to visit the attraction called the “Fountain of Foam”. Who doesn’t love fountains and waterfalls… and bubbles! How can we get soap bubbles to stick around a long time? It depends on what kind of water we use. And the kind of water depends on the salts that are dissolved in it.
- Before Milli and Avogadro begin their day of swimming, they’re going to have lunch. Just as it’s important to have clean water for swimming, it’s important to have clean hands before eating lunch. This experiment will show them how hardness in water sometimes makes it difficult to wash your hands thoroughly. When we stop for lunch at the water park, we will wash our hands first. Depending on the kind of water we use, we’ll have lots of suds or hardly any.
- 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 have different chemicals dissolved in them.)
- 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.
- This experiment will show you that sunscreen really works!

Perform the Experiment along with the students.

Do the following:

- Ask the students to find the portion cup marked “IS” with the soap particles. Using the teaspoon take out one piece of soap (or enough flakes to be the size of a watermelon seed) and carefully transfer into the vial marked “S”. Add the same amount of soap to the vial marked “H” and pass the portion cup down to the next student.
- 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.
- Make sure that the students carefully and fully close the cap on each vial; then shake both vials to dissolve the soap and make a head of bubbles in each container.
Experiment 3 – Water Hardness

Presenter’s Guide

 Have each student find their table-salt packet, open it, and add a “pinch” (a few crystals of table salt) to the vial marked “S”. Shake the vial. What happens? [Answer: The soap head should be unaffected.]

 Ask the students to find the portion cup marked “ES”. Using the teaspoon, add a small amount—one crystal is best but use the smallest amount possible—of the Epsom salt to the vial marked “H”. Shake the vial. What happens? [Answer: The soap head formed should collapse immediately and the liquid becomes very cloudy with small particles.]

 Pass the portion cup marked “ES” around the table again and add a few more crystals. A precipitate, equivalent to the ring around a bath tub, will be formed. Ask the students if they’ve ever seen a ring around the bathtub. If so, it’s caused by the hardness (minerals) in the water reacting with the soap.

 Set the “S” water vial aside for use in the next 2 experiments.

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 chlorine and does not interfere with the foaming action of the soap. Soap 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. Perhaps you have head about the “ring around the tub.” Remember, hard water = hard to make a lather.

 Water softeners are popular in areas with hard water because they make washing clothes and bodies easier.

 Getting clothes and ourselves clean takes less soap in soft water because the “hardness” in hard water combines with soap, forms unsightly rings and requires that more soap be used than with soft water.

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 MgSO$_4$ · 7H$_2$O.
Experiment 4: Water on a Penny: 3rd Attraction: The Big Tip*per (Individual Experiment)

Experiment Purpose & General Methodology

- At a water park, there can be a big bucket handing above your head which fills with water. When the bucket is full, it suddenly tips over and spills out, drenching you and your friends. We’re going to do a similar thing on a mini scale, by putting water on a penny, drop by drop, until the water suddenly spills over, and soaks your paper towel. We’ll call this attraction the Big Tip*per.

- After making sure that they covered their skin with sunscreen, Milli and Avogadro enjoyed several hours of swimming. When they took a break from swimming, they decided to play this game with water in which they will see how much water can be placed on a penny.

- This experiment will be done by each student and will take approximately 5 minutes to complete.

Introduce the Experiment

Tell the students the following:

- We’re all going to get a penny and count how many drops of water we can put on it. Make a guess as to how many. We’ll see who’s right!

Performance Details:

Do the following, leading the students:

- Ask the students to place their penny in front of them.
- Ask each student to fill their pipette with tap water. Explain that they need to pinch the bulb of the pipette to expel the air and then put the tip under the water before they let go of their pinch. The water will rise into the pipet.
- 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 thoroughly with the paper towel and squirt any remaining water out of the pipette back into the cup marked “W”. Repeat the experiment using the soap and table salt solution used in the last experiment (from the vial marked “S”). It should take less than 5 drops. Note: tell the students not to use all of the solution from the vial marked “S” since we’ll need a few drops for Experiment 5.
- Tell them to sit the pipette and the cup marked “W” aside for use with the next experiment.

Conclusions

Tell the students the following:

- Ask if the hard water had any 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 imagine 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.

➢ Soap is a class of chemicals known as surfactants or surface active agents.

➢ When a surfactant is added to the water, it weakens the “skin” or the surface tension, so less drops of water can be piled on the penny.
Experiment 5: Floating Paper Clip: 4th Attraction: The Aqua Plunge (Individual Experiment)

Experiment Purpose & General Methodology

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

Introduce the Experiment

Ask/tell the students the following

- At the water park we want to grab an inner tube and float down the Lazy River. You float mainly because you’re lighter than the water you displace (or push aside). However, a water strider (a spider-like insect that walks on water) stays completely on the surface of the water. This is due to something called surface tension, which we will explore in this next experiment.
- If we’re floating in an inner tube, we won’t be falling into the water, but we’ll send something on a dive here! So we’ll call our next attraction “The Aqua Plunge.

Do the following:

- Tell the students to place the paper clip on the fork and hold it about ½ inch over the surface of the water in the portion cup marked “W”, parallel to the surface of the water. Now gently lower the fork into the water leaving the paper clip floating on the surface. Tell them to do this carefully since it’s often very difficult to get the paper clip dry enough for a second attempt.
- Ask the students what happened. [The paper clip should remain on the surface.]
- Have the students pick up their pipette (same one as they just used with Exp. 4) containing surfactant solution from the cup marked “S” from Experiment 3. Have the students add a few drops of the surfactant solution, one drop at a time, to the surface of the water in the portion cup away from the paper clip. Do not allow the drops to fall directly on the paper clip. Ask the students what they observe. [The paper clip moves away from the side the surfactant was dropped on.]
- Continue adding the surfactant, dropwise until the paper clip sinks.
- Have the students empty the surfactant pipette back into the container marked “S”.

Conclusions

Tell the students the following:

- Explain to the students: the metal paper clip is originally held up due to the surface tension of the water. (The paper clip isn’t floating because of its density or weight.)
- The paper clip 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 penny. It is also this surface tension, the surface ‘skin’ that also holds up the paper clip.

- 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 paper clip moves away from the surfactant droplets because the surfactant weakens the surface tension of the water. The water on the other side of the paper clip still has a very high surface tension (where the water molecules are pulling each other strongly) and it pulls the paper clip towards it. The addition of more surfactant continues to lower the surface tension of the water. The paper clip finally sinks when enough surfactant has been added to completely lower the surface tension to the point where it is no longer strong enough to hold the paper clip 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.

- All surfaces to be cleaned need to be ‘wet’ to help 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.

- The water’s surface tension actually makes it easier for Milli and Avogadro to float in the pool, so they can now go and enjoy their swim knowing that they and the water they’re swimming are both clean and the water’s properties actually help them have fun. (Archimedes’ Principle is, of course, the governing factor in floating or sinking, but no sense going into that unless the students ask.)
Experiment 6: Casting a Broken Finger: A Visit to the First Aid Station (Group Experiment)

Experiment Purpose & General Methodology

- One student at each table will have a cast made of one of their fingers based on modern, quick-setting casting material. This group experiment will take approximately 10 minutes to complete.

Introduce the Experiment

- The demonstrator should prepare the urethane Scotchcast plus® strips for the modern casts while telling them the information below. If you have an assistant they can be doing this while you introduce this experiment. Wearing polyethylene “rubber” gloves, cut the Scotchcast material into 12 inch strips using the paper guide as a template. Lay the strips on the empty zipper-bag work surface so they can be easily transported to the student tables. When you are done cutting six strips, wipe off the shears with a dry paper towel or newsprint to remove most of the urethane. Leave the scissors open on the demonstrator’s table (to prevent the scissors from sticking shut as any residual urethane cures). Note: Any residual urethane that has fully-cured on the scissor blades can be removed later with a sharp blade (like a razor blade) or scraper.

Tell the students the following:

- Uh-oh. Milli fell on the slippery concrete around the pool! She hurt her finger and bruised her arm. We need to take her to the First Aid Station at the water park.

- At the First Aid Station, a doctor looks at Milli’s finger and takes some X-rays. It’s determined that she broke her finger. The doctor has several materials to choose from to make the cast. Some are more old-fashioned and some are made of modern high-tech material.

- We’ll investigate one of the new technologies for putting a cast on Milli’s finger. You may try the older method using the information we have supplied on your take home sheet. This takes several hours to harden but our new technology takes just minutes!

Perform Experiment Simultaneously with the Students

Do the following, leading the students:

- Have one student at each table wrap his finger with a strip of paper towel and cover it with a glove.

- The demonstrator should carry the Scotchcast strips and water container to each table and…

- Wearing the polyethylene “rubber” gloves, dip the Scotchcast into the water container and GENTLY (not tightly) wrap it around the student’s finger – have them hold their finger straight! We want their finger to heal properly! (NOTES: The urethane Scotchcast material has a strong attachment to skin. Wrap the tip of the finger that is completely covered with the paper towel and glove. Also: The material hardens rather quickly. Do not allow the
student to bend their finger; this helps ensure that the student can easily remove the cast if it sets up too quickly – although this is not expected under proper supervision.)

- Tell the student to remove/slip off the cast from their finger after about a half a minute or when the material starts to harden and is still slightly flexible (yes they can touch it safely at this point). (Demonstrators should make sure that each child removes their cast in a timely manner, so that the cast does not over-harden on their finger. While the cast is expected to be easily removed if loosely wrapped on a straight finger, it is better to remove the cast while it is still slightly flexible. Use good judgment!) Repeat for rest of tables.

- Ask the students to examine the cast. The new material gets hard very quickly, and stays only slightly flexible. The old material that used to be used was Plaster of Paris and would still be ‘wet’ and very flexible at this time. Tell the students they can check on their cast material later in the program to determine how long it took to finally become hard.

Conclusions

Tell the students the following:

- The high tech casting material is made of a piece of mesh material that has been saturated with chemicals containing short polymer chains and cross-linking agents. You can picture these as short pieces of a chain (make two interlocked loops with your fingers to demonstrate this idea). When the material is exposed to water, even water moisture in the air, a reaction starts that causes the short polymer chains to link together into longer chains. Also, the cross-linking agents connect them together all along the length of the chains – forming a web or mesh that is very strong and hard. This reaction happens very fast and allows the doctor to quickly cast a broken bone such as Milli’s finger.

- The old Plaster of Paris cast material is messier to use and takes more time to harden, making your doctor visit longer – Who wants that?!

Additional Information If Needed: Technical Background

- Here is a site that describes the old Plaster of Paris method of casting:
  http://en.wikipedia.org/wiki/Orthopedic_cast
Experiment 7: Soothing the Pain with Hot and Cold Compresses:
First Aid Station, Cont. (Individual Experiment)

Experiment Purpose & General Methodology

- The students will obtain an understanding of how doctors treat bruises and sore muscles.
- This experiment will be done by each table and should take about 10 minutes to complete.

Introduce the Experiment

 Tell the students the following:
- Milli not only broke her finger in the fall, but she’s bruised her arm as well.
- What’s one of the first things that you might do when you have a minor injury like Milli’s bruise? (Put something cold like ice on it.)
- But what do you do if you’re at a water park and there isn’t any ice around? Chemistry provides an answer!
- Has anyone ever seen or used one of those cold packs that you can keep in a first aid kit until it is needed? One of the more common types feels like a plastic bag full of pellets. The pellets are usually a type of salt, called ammonium nitrate, and there is an inner pouch that contains water. To activate the cold pack, it must be squeezed so that the inner pouch breaks and releases the water. As the ammonium nitrate pellets dissolve in the water, they absorb heat from their surroundings (the water… and your skin) and the cold pack feels cold. And hopefully, your bruise feels better!
- A chemical reaction or a physical process that absorbs energy from its surroundings is called endothermic.
- Tell the students that we will create an endothermic reaction to make our own cold pack.
- Then we’ll do the opposite. We’ll create a hot pack in case the doctor wants us to use that.

Perform Experiment Simultaneously with the Students

Part I – Endothermic Reaction/Cold Pack

Do the following, leading the students:
- Have each student locate their plastic bags containing water and have the students feel and describe the temperature of the water – it should be room-temperature or lukewarm. Note: Our fingers and palms of our hands are not very good at sensing temperature. The best way to feel the temperature would be to hold the bag against the inside of the wrist or the back of the hand. Both bags should feel the same since they have reached room temperature.
- Have the students help each other with the following steps: one student carefully opens the other’s bag containing water and holds it open.
• Have one student locate the cup marked “CA” (containing citric acid) and measure out one level teaspoon of the powder then place the contents into the water of the bag his/her neighbor is holding open. Agitate gently (remember, the bag is open at this point!) to dissolve and disperse the citric acid.

• Have the students use the paper towel at their station to wipe off the teaspoon before placing it into another chemical to prevent contamination. (also reactions).

• Warn the students not to get startled during the next step. Hold the bag steady. Have a student locate the cup marked “B” (containing baking soda) and measure out one rounded teaspoon of the powder then place the contents into the citric acid solution in the open bag. An immediate reaction, bubbling (due to the formation of a gas, CO$_2$) will occur!

• Keep the reaction bag open (unsealed) until the bubbling stops, then carefully seal the bag and place it in the empty bag marked “C” to help guard against leaks. Have the students examine their bags and feel that the water in the bag has gotten cooler! Note: Use the back of the hand or inside of the wrist like before.

• Tell the students to now trade and do the same for their neighbor.

• Have the students use the paper towel at their station to wipe off the teaspoon once again before the next experiment.

Conclusions for Endothermic Reaction/Cold Pack

*Tell the students the following:*

- The chemical reaction between citric acid and baking soda is an acid-base chemical reaction. Carbon dioxide is the gas that is given off.
- We know that the reaction is endothermic (it uses up heat to occur) because we felt the reaction solution get colder. The reaction absorbs heat from its surroundings (the water and our skin), so it feels cold.

Introduction for Part II – Hot Pack

*Tell the students the following:*

- Many times, after the initial pain and swelling of an injury subsides, a doctor tells you to put heat on an injury to help it heal.
- How do you put heat on an injury? You could use an electric heating pad or a hot water bottle, but those require access to electricity or hot water, and you’re at a water park. Again, chemistry can provide another solution in the form of portable heating packs!
- There are various kinds of chemical heating packs, ranging from supersaturated solutions of a salt called sodium acetate that give off heat as the salt crystallizes, to the chemical reaction of iron rusting, to pellets of calcium chloride that give off heat as they dissolve in water.
- A chemical reaction or a physical process that gives off energy to its surroundings is called exothermic.
Later on, when Milli gets home, she may want to use a heating pack on her arm to help the pain subside, so she might buy one at a pharmacy. While we cannot make one here as good as the ones we can buy at the store, we will use other items to create an exothermic reaction to make our own hot pack.

**Part II – Exothermic Reaction/Hot Pack**

_Do the following, leading the students:_

- Have the students locate their other plastic bag containing water and have the students feel and describe the temperature of the water – it should be room-temperature or lukewarm.
- As in the previous experiment, have a student carefully open the bag.
- Have a second student locate the cup marked “CC” (containing calcium chloride) and measure out one teaspoon of the powder then place the contents into the water in the open bag.
- Carefully seal the bag and place it in his/her neighbor’s empty bag marked “H” to help guard against leaks. Gently agitate the bag to disperse the calcium chloride pellets.
- Have the students examine their bags to feel that the water in the bag has gotten warmer!
- Tell the students to now do the same for their helpful neighbor.

**Note:** The calcium chloride pellets can get very warm! Do not let students squeeze the pellets that have not fully dissolved.

**Conclusions for Endothermic Reaction/Cold Pack**

_Tell the students the following:_

- In our hot pack, the calcium chloride gives off heat as it dissolves in the water. This is a physical process, not a chemical reaction.
- We know that the process is exothermic (it gives off heat when it occurs) because we felt the reaction solution get warmer. The process gives off heat to its surroundings (the water and our skin), so it feels warm.

**Additional Information If Needed: Technical Background**

- The chemical reaction for our cold pack is:
  \[ \text{H}_3\text{C}_6\text{H}_5\text{O}_7 \text{(aq)} + 3 \text{NaHCO}_3 \text{(s)} \rightarrow 3 \text{CO}_2 \text{(g)} + 3 \text{H}_2\text{O} \text{(l)} + \text{NaC}_6\text{H}_5\text{O}_7 \text{(aq)} \]

- The dissolution equation of our hot pack is:
  \[ \text{CaCl}_2 \text{(s)} \rightarrow \text{Ca}^{2+} \text{(aq)} + 2 \text{Cl}^- \text{(aq)} \]

  Each gram of CaCl₂ that dissolves releases 160 cal into the water.
Return to Experiment 1

Before closing the session, ask the students to observe the results of Experiment 1.

Conclusions

Ask the students the following:

- What’s happened? By this time all of the “Dirty Water” should have percolated through the filtration system so there should be clear liquid in the lower reservoir.

- Ask one of the students at each table to remove the top section of their filtration systems and put it in your large garbage bag. Tell them not to tip the bottom section over but to examine the water carefully. It should be clear. What happened to the suspended solids? Ans: they were trapped primarily in the sand filters.

- Then ask the student to smell the water—being careful to use the chemist’s tried and true methods for smelling such a sample. [We “waft” the sample by moving our hands over the container toward yourself. DO NOT stick your nose into the sample.] Are there any odors present? Ans: there shouldn’t be. Why not? Ans: the activated carbon has removed the odors. You may want to briefly discuss the mechanism of adsorption and explain where the odors went.

- Now ask the students what might still be in the water. Ans: Not much. If anything, some soluble salts. If there had been sugar in the cocoa, this would be still be present. These latter are “dissolved solids” and the filtration system wouldn’t normally remove such materials.

- How would these “dissolved solids” be removed? Ans: if the material is organic like sugar would have been, the way it’s done in municipal wastewater treatment plants is by utilizing bacteria which use these “dissolved solids” for their food.

- Tell the students that any dissolved solids left behind would cause the water to be seriously polluted even though you can’t see the pollution. That’s why it’s never a good idea to taste water that doesn’t come from a tap or a bottled water source.

- Tell the students that we’ve demonstrated how water can be cleaned of suspended solids and odors. Their own drinking water treatment plants do exactly the same things.
Closing Session

Close the Program:

- Finish the Story: Say: “I hope you enjoyed our adventures at the water park with our friends Milli and Avogadro.”
- Distribute the Students’ Feedback Form and give the children 5 minutes or so to complete them.
- Remind the students to check our website for information on how to participate in our Chemistry and Poster Contests where each student receives a small token for entering and can win local and national cash prizes. They should also be able to find us by searching under “Cleveland” and “National Chemistry Week”.
- Thank the students and parents for coming to this year’s demonstration and learning about science and chemistry.
- Remind the students to share our experiments with their family and friends. To the students say “I’m sorry but due to some of the chemicals we used, and the great fun mess we’ve made (say this to keep it light-hearted) we cannot take our experiments home with us except for the bracelet with the ultraviolet detecting beads. We also have a fun handout and a list of books you can get from the library relating to today’s study of water.
- Have students come up to the closing area to turn in their Feedback Forms, their goggles, and pick up their take-home sheet. Put the Feedback Forms into one of the manila envelopes provided for return to Julia Boxler at the main library. Put the goggles back into their box and also return these to Julia.
1. **CLEAN UP FOR LIQUIDS:**
   - Add a few cups of water to the bucket to prepare for dilution of our chemicals.
   - Then pour all other excess liquids into your bucket. Then pour into a toilet and flush.

2. **GENERAL CLEAN UP PROCEDURES FOR EXPERIMENTS**
   - All solid waste can be placed into a regular trash bag.
   - Check with the librarian if they are willing to take the trash; otherwise, please dispose of it with your own trash.

3. **PLEASE FILL IN AND RETURN THE FEEDBACK FORM**
   - We need this information to write the reports required by ACS National and industrial donators of supplies.

   **USE ENVELOPES PROVIDED** labeled “Julia Boxler YTH” (via inter-library mail):
   - Into one of the envelopes place:
     - Signed photo permission forms w/ a description of the photo to which it belongs
     - Completed Feedback form
     - *Unused* teaspoons, pipets, etc (non-crushable items).
     - **NO VIALS OF SOLUTIONS PLEASE**
   - Into one of the gallon sized baggies (squeezing out the excess air) and then into the second envelope place:
     - *USED Vials*--rinsed well. Please cap and wipe the outside of the vial before placing in the envelope. Remove air from the bag before sealing it to reduce volume and be sure it is sealed.

1. **GOGGLES:**
   - 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 written directions found on the inside cover of the goggle container. Be sure to dry them with soft cloth or soft paper towels to prevent scratching. Please stack them into their box without twisting or crushing!
   - If you are finished performing your demonstration(s) for this year, place the used goggles into their box. Please stack them without twisting or crushing! (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.)
2. **LASTLY AT THE LIBRARY**
   - Return items borrowed from the library.
   - Give any leftover literature to the librarian. (You may save a copy for yourself though!)
   - Give the mailing envelope (containing saved supplies and feedback form) as well as the box of goggles to the Children’s librarian with instructions to put it them in the interlibrary mail to *Julia Boxler - YTH*. (Or take to your nearest CCPL library, as instructed at the start of this script).

7. **AT HOME:**
   - If you didn’t return a completed hardcopy of the feedback form please email to Bob Fowler at [fowler@en.com](mailto:fowler@en.com), and he’ll send you an electronic version to complete.
   - If you took any photos to share, and have submitted signed permission forms to use them, email the photos to Bob Fowler fowler@en.com or Natalie Zarlenga at [KARSTNK@kellyservices.com](mailto:KARSTNK@kellyservices.com). Please be kind to our in-boxes and do not send multiple large files all in one email.
   - **Smile!** You may have expanded or even sparked scientific interest in a student today!

**THANK YOU!** ...for your participation in our program this year.

We hope you will join us next year too. Planning of experiments and contests starts in late April. You don’t have to be a teacher or scientist to join our Planning Committee; all you need is a desire to share science with students. Development of ideas and refinement of experiments goes on throughout the summer (a couple of hours every other week), donation gathering and shopping is in late summer, and kit assembly (about 50 of them! needing a lot of volunteer hands) is on a Saturday in late September. It takes many, many volunteers to develop and put on all our programs. Even a little bit of help goes a long way. Contact us this year or next year if you (or a friend of yours) want to join in on the preparations!

Thanks again!!!

Bob Fowler ([fowler@en.com](mailto:fowler@en.com))
Natalie Zarlenga ([KARSTNK@kellyservices.com](mailto:KARSTNK@kellyservices.com))
Appendix

A. Material Safety Data Sheets

MSDS sheets for all materials used in this year’s program may be found on our web site at http://www.csuohio.edu/sciences/dept/cleveland_acs/NCW/ or from the sources listed below:

3M Scotchcast™ Plus synthetic Casting tape

All of these items are available at your local drug store or hardware/poet stores:

Activated Charcoal (for filtering water in fish tanks)

Calcium Chloride (used for melting ice)

Citric Acid (used for baking/candy making)

Epsom Salts (used for soothing baths)
http://www.flinnsci.com/Documents/MSDS/M/MagnesiumSulfate.pdf

B. Supply list for recreating these experiments including item substitutions

Material resources for reproducing the experiments for items not found in your local grocery/drug/hardware store:

Exp. 2: UV coloring changing beads www.teachersource.com

Exp. 6: 3M Scotchcast™ Plus Casting Tape: www.Mooremedical.com