

# **Having a Ball with Chemistry!** **A Hands-on Program**

**An Educational Demonstration Package**

Prepared by the  
**National Chemistry Week Committee**  
of the  
**Cleveland Section of the American Chemical Society**  
for  
**National Chemistry Week 2008**

## **Overview**

During this Olympic year, join us for our celebration of National Chemistry Week with an hour of hands-on experiments and demonstrations as we learn how chemistry affects sports. We'll learn about sports drinks, clean up some nasty grass stains, learn how to treat some of our injuries, make our own rubber ball, and more!

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## **Acknowledgments**

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 2008, the Cleveland Section volunteers will perform over fifty demonstrations at libraries, schools, and other public sites. Continuing our relationship that started in 2001, the Cleveland Section will also be providing hands-on training and (at least) 40 sets of 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.

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 are especially grateful for a fourth year in a row to the Martha Holden Jennings Foundation for a significant financial grant this year of \$3000. We also thank John Carroll University, the Cuyahoga County Public Libraries, NASA Glenn Research Center, and other anonymous sponsors for their numerous contributions and support.

Last and most important, we thank all the volunteers who donate 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 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, was overseen by the Cleveland Section's NCW coordinator for 2008 Bob Fowler. Committee members include Lois Kuhns, Marcia Schiele, Shermila Singham, Vince Opaskar, Kat Wollyung, and Mark Waner. Additional credit and thanks is given to the many GAK (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.

## 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 – You obviously do not need to cover all of this material with your students. Some is only for your 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.

1. Introduce experiment.
2. Do your demonstration piece.

*Note: Many 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 student's hands-on work are nearly simultaneous. You lead 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.

The NCW Committee offers a "Dress Rehearsal" to show the entire program to the demonstrators in advance of their own program performances; however attendance is not mandatory. 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 requires formal educational/teaching experience from all of its volunteers.

### **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, including where to obtain an MSDS.

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

### Demonstration Check-Off List

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

Activities To Do Well Before the Day of the Demonstration	Completed ?
Read through this packet to familiarize yourself with the experiments and verify that you have all the items as listed in the kit contents.	<input type="checkbox"/>
<i>Please check your kits upon receiving them.</i> Vials and bottles containing solutions may have shifted during storage and transportation. Check for leakage; correct situations. Store vials and bottles in an upright position as much as possible.	<input type="checkbox"/>
Please do not store kits in an overly warm area (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.	<input type="checkbox"/>
Contact us with any questions: Bob Fowler <a href="mailto:fowler@EN.com">fowler@EN.com</a> or Kat Wollyung <a href="mailto:katkat@neo.rr.com">katkat@neo.rr.com</a> .	<input type="checkbox"/>
Collect the materials you need to bring with you to the demonstration. The materials list is on page 9. The librarian may be able to provide some of the items, but you need to call to verify that – do <b>not</b> assume they have anything.	<input type="checkbox"/>
One of the experiments this year requires 2 cups of hot water. Water heated at home and stored in a thermos might be okay, however, it is better to ask your librarian if you can assist you by using their microwave to heat the water just prior to this experiment or assist you with heating the water in advance of your program for you to then store it in your thermos at that time.	<input type="checkbox"/>
If you wish to add other experiments or demonstrations into your program, you must contact the Head Student 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.	<input type="checkbox"/>
You may wish to ask a friend to be your assistant. 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.	<input type="checkbox"/>

**Demonstrator's Guide**

Read over the experiments a few times and become familiar with them. 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.	<input type="checkbox"/>
<p>Contact the librarian who is helping you to coordinate your program:</p> <ul style="list-style-type: none"> <li>* Verify that they limit registration to 30 students</li> <li>* Ask the room to be arranged with 6 student tables with 5 chairs each and an additional front table for the demonstrator</li> <li>* Ask for all the tables to be covered with newspapers and for extra paper towels for each table. Otherwise take newspaper and do this during setup.</li> <li>* Ask about availability of demonstration materials from list of page 9 (ex. paper towels, newspaper, extension cord, scissors)</li> <li>* Ask about the availability of a microwave for heating 2 cups of water for experiment #2 either just prior to the experiment or before your program prior to storage in your thermos.</li> <li>* Ask if the librarian is available at the start of the program to greet the students and help distribute goggles.</li> <li>* Make sure that the room is available before and after the program for set up and clean up. <b>Set-up may take up to an hour</b> on your own. Ask the librarian if someone is available to help with set-up to cut down this time.</li> <li>* Offer that a librarian is welcome and encouraged to stay for the entire program. (They might even offer to be an assistant if given the opportunity.)</li> </ul>	<input type="checkbox"/>

<b>Activity To Do AT LEAST ONE DAY BEFORE the Demonstration</b>	<b>Completed?</b>
Review the script in its entirety and be familiar with all the experiments.	<input type="checkbox"/>
Gather all the items needed for your presentation as provided in the materials list starting on page 9. Do NOT assume your librarian will supply any materials unless agreed upon in advance, and even then, call and verify they 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 filling bottles or cups easily.	<input type="checkbox"/>
Optional: You may find that you save a lot of library set-up time if you do the "activities to do one site prior to the demonstration" for experiment #2 at home before going to the library (see page 12). Note however, that you will need a good way to transport the filled vials to the library to prevent spillage.	<input type="checkbox"/>

## Demonstrator's Guide

If possible/desired, fill a sandwich bag with freshly cut grass or green leaves for Experiment 5.	<input type="checkbox"/>
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Activities To Do When You Get To The Library	Completed?
<b>NOTE: Arrive approximately 1 hour before demo time</b> to allow for set-up depending on how quickly you think you can perform the steps listed in the Experimental Setup section beginning on page 12. Do NOT assume that a librarian will be present to help you set up for the experiments.	<input type="checkbox"/>
Introduce yourself to the Students' librarian.	<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 9 if provided by library.	<input type="checkbox"/>
Complete Demonstration Set-Up for all demonstrations: see Experimental Set-Up: "Activities to Do On-Site Prior to Demonstration" starting on page 12. <i>Note: This set-up is estimated to take 45-60 minutes.</i>	<input type="checkbox"/>
<b>Set-up note!</b> 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, and distribute other items throughout the program	<input type="checkbox"/>
<b>Set-up note!</b> There are NO caustic or highly irritating materials in this year's program.	<input type="checkbox"/>
You may wish to set up an 'Entrance' area table to allow space for beginning-of-program activities: goggle distribution	<input type="checkbox"/>
You may wish to set up an 'Exit' area table to allow space for end-of-program activities: goggle return and literature distribution.	<input type="checkbox"/>

Activities To Do At the Start of The Demonstration	Timing
Hand out goggles and help adjust to the correct fit (if necessary).	4 min
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.	-

Activities To Do During The Demonstration	Timing
<b>Complete the Opening Session Introduction</b>	~5 min.
<b>Perform demonstrations</b>	
* Experiment 1: Make a Bouncing Ball	8 min.
* Experiment 2: Sports Drinks – How Sweet Are They?	8 min.
* Experiment 3: Why Are Plants Green? – Chromatography of Grass Extracts	10 min.
* Experiment 4: Lowering Surface Tension - Water and Surfactants	5 min.
* Experiment 5: Using Wet Water to Clean Clothes – Using Surfactants to Re-dissolve Chlorophyll	7-8 min.
* Experiment 6: Treatment of Sports Injuries - Soothing the Pain with Hot and Cold Compresses	5-6 min.
* Experiment 3: completion	1 min
<b>Complete the Closing Session information.</b>	1-2 min.
<b>Collect goggles &amp; hand out literature.</b>	1 min.
<b>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. <u>Plan ahead</u> to determine which experiment you might skip over or abbreviate.</b>	<i>Total Time: ~60 min</i>

Activities To Do Immediately After The Demonstration	Completed?
Clean up as indicated in the <b>Clean Up</b> section (page 38).	<input type="checkbox"/>
Complete the Feedback Form	<input type="checkbox"/>
Give the reusable items and the feedback form in the mailing envelope(s) along with the box of 32 goggles to the librarian for return to Julia Boxler via interlibrary mail. <i>(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.)</i> Please return all materials within two weeks of NCW.	<input type="checkbox"/>
Give any leftover literature to the librarian ( <i>CCPL library kits only</i> ).	<input type="checkbox"/>

**Demonstrator's Guide**

<b>Activities To Do Once You Get Home</b>	<b>Completed?</b>
Provide feedback about your program to Bob Fowler fowler@EN.com and Kat Wollyung at katkat@neo.rr.com with the following information: (1) attendance, (2) specific experiment comments/recommendations, (3) other comments as per the kit-enclosed feedback form. This information may be useful to other demonstrators who have not yet performed their 2008 presentation.	<input type="checkbox"/>
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 Demonstrator to Provide (or to request in advance from the librarian)

*newspaper for covering 7 long tables with a few layers of paper (if none at site)*

*1 roll paper towels (if none at site)*

*1 large garbage bag for solid waste collection*

*1 bucket for liquid waste collection (optional if sink is within the demo room)*

*1 measuring cup, small pitcher or other container with a spout for adding water to various cup/bottles in experiments*

*Approximately 1.5 gallons 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.*

*Microwave-safe 2-cup container and/or thermos with 2 cups of hot water) (Expt. 2)*

*1/2 cup measuring cup (Expt. 2)*

*2 cup measuring cup (Expt. 4)*

*1/2 teaspoon (Expt. 6)*

*1 tablespoon (Expt. 6)*

*Optional but also preferred:*

*A sandwich bag filled with freshly cut grass or green leaves*

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

- small quantity of household bleach
- wash bin or bucket
- old towels or cotton paper towels for drying (soft so as not to scratch the goggles)
- ...OR...
- individual sanitizer wipes (soft so as not to scratch the goggles)

**Items Provided in Each Demonstration Kit:**

*Note: Items needed for each demonstration that are to be provided by the demonstrator are listed in italics below the kit items for convenience/reference*

**General:**

- 1 box containing kit contents
- 30 copies *Celebrating Chemistry* newspapers (if available from ACS)
- 30 copies each of 'Book & Website List', "Experiments to do at Home" or other handouts
- 3 (or so) copies of a Photo Permission Form (*library kits only*)
- 1 Program Feedback Form (designed for either teacher programs or library programs)
- 1-2 envelopes for returning the Feedback Form and reusable supplies to the NCW via interlibrary mail (addressed to Julia Boxler - YTH) (*library kits only*)
- NOTE: Initially, the return envelope will contain much of the paperwork for your program. This was done to help prevent folding and wrinkling in storage/transport.*
- 1 box of goggles (30 student & 2 adult size, addressed for return to Julia Boxler - YTH) (*library kits only*)

**Experiment 1: Make a Bouncing Ball**

- 7 3-oz plastic cups marked 'R'
- 7 3-oz plastic cups marked 'C'
- 1 squeeze bottle containing 118 mL of Elmer's glue
- 1 50-mL centrifuge tube marked 'B' containing 20 mL of solution B (a boron catalyst)
- 1 50-mL capped centrifuge tube marked 'C' containing 40 mL of solution C (crosslinker – amino methyl propanol or AMPS)
- 7 wooden craft sticks
- 1 marked disposable pipet (marked at the 2mL line for reference)
- 6 unmarked disposable pipets
- 1 plastic teaspoon
- 7 pieces of cut up paper towels

**Experiment 2: Sports Drinks – How Sweet Are They?**

- 1 baggie marked "B" containing a vial of Benedict's solution and a beral pipet
- 1 baggie containing sugar equal to the sugar in one bottle of Gatorade (35 g).
- 7 blue-capped vials marked "W"
- 7 blue-capped vials marked "S"
- 7 blue-capped vials marked "F"
- 7 blue-capped vials marked "G"
- 1 baggie containing 2 large self-standing vials marked "S" and "F"
- 1 bottle of Gatorade
- 1 3-oz plastic cup marked "G"
- 1 3-oz plastic cup marked "W"
- 4 beral pipets

- 7 9-oz. Styrofoam cups
- 1 baggie containing 7 nutritional labels
- 1 metal alcohol thermometer
- 1/2 cup measuring cup*
- microwave safe 2+ cup container for microwaving and pouring hot water or thermos for storing hot water from home or library*

**Experiment 3: Why Are Plants Green? – Chromatography of Grass Extracts**

- 7 pieces of 1/2 x 4" chromatography paper
- 7 3-oz plastic cups marked "GE"
- 1 water bottle containing 80 ml of grass solution "concentrate" (made from alcohol and ground-up grass and/or leaves)
- 1 plastic spoon

**Experiment 4: Lowering Surface Tension – Water and Surfactants**

- 31 pennies
- 31 beral pipets
- 7 3-oz plastic cups marked "W"
- 7 3-oz cups marked "SW" (soapy water")
- 1 10ml blue capped vial with detergent.
- 31 paper towel pieces (1/4 large sheet or \_ of "select-a-size")
- 2 cup measuring cup*

**Experiment 5: Using Wet Water to Clean Clothes - Using Surfactants for Chlorophyll**

- 14 pieces of cloth, each 2" x 2".
- 7 50ml capped centrifuge tubes marked "D" containing detergent.
- 7 empty 50ml capped centrifuge tubes marked "W".
- 1 50ml capped centrifuge tube marked "G" containing an aqueous "grass concentrate"
- 1 empty sandwich bag.
- 7 paper towels

**Experiment 6: Treating Sports Injuries - Soothing the Pain with Hot and Cold Compresses**

- 14 zipper-top sandwich bags, empty, unmarked
- 7 zipper-top sandwich bags, empty, marked "C"
- 7 zipper-top sandwich bags, empty, marked "H"
- 7 small paper cups marked "A"
- 7 small paper cups marked "B"
- 7 small paper cups marked "C"
- 1 zipper-top sandwich bag marked "CaCl<sub>2</sub>", containing 3 1/2 teaspoons calcium chloride
- 1 zipper-top sandwich bag marked "citric", containing 3 1/2 teaspoons citric acid crystals
- 1 zipper-top sandwich bag marked "soda", containing 3 1/2 teaspoons baking soda
- 1/2 teaspoon*
- 1 Tablespoon*

## Activities to Do On-site Prior to Demonstration

### General:

- \* Verify room setup (6 student tables with 5 chairs each, one demonstrator table, all covered with newspaper, each with paper towels, etc.)
- \* Obtain any supplies requested from librarian (see page 9)
- \* Place Photo Permission Forms on the demonstrator table. IF photos are taken 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 photo permission form for each and every person in the photo. Do NOT take photos of anyone who requests else wise.

### Experiment 1: Make a Bouncing Ball

- Fill each of the cups marked “R” to the level indicated with Elmer’s glue from the squeeze bottle.
- Add 1 teaspoonfuls of solution C to each of the cups marked “C”. This is approximately 5 mL.
- Place the centrifuge tube marked “B” on the demonstrator’s table.
- Place the one marked disposable pipette on the demonstrator’s table with a paper towel segment next to it
- Place one unmarked pipette on each of the six students’ tables
- Place one wooden craft stick on each table including the demonstrator’s table

### Experiment 2: Sports Drinks – How Sweet Are They?

- Place the bag containing the amount of sugar found in one bottle of Gatorade on the demonstrator’s table.
- Mix the vial marked “S”(sugar) with enough tap water to reach the 50 ml mark. Securely close the cap and shake until dissolved.
- Place one beral pipet next to the “S” vial.
- Mix the vial marked “F” (fructose) with enough tap water to reach the 50 ml mark. Securely close the cap and shake until dissolved
- Place one beral pipet next to the “F” vial
- Pour Gatorade into the 3 oz plastic cup marked “G” until it’s approx half full
- Place one beral pipet in the cup marked “G”
- Place tap water into the 3 oz cup marked “W” until it’s approx half full
- Place one beral pipet in the cup marked “W”

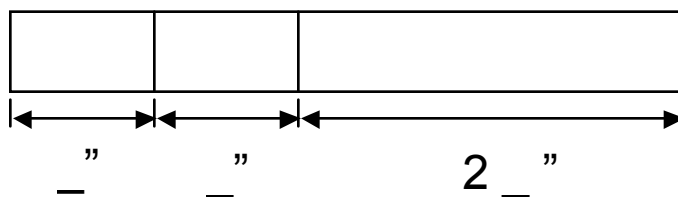
## Experimental Setup

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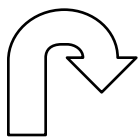
- Using the beral pipet in the baggie marked “B” add Benedict’s solution equally to all 28 of the blue-capped vials. This is approximately one squeeze-full of solution. ***You may do this earlier in the day if you wish to save time at the library.***
- Place 1 blue-capped vial marked “W”, “S”, “F” and “G” (each containing the Benedict’s solution) on each of the student tables and one on the demonstrator’s table.
- Fill a 2 cup microwave-safe container with tap water and ask the librarian (or parent/helper) to heat it in the microwave until very hot just as you begin the actual demonstration with the students.
- Remove the nutrition labels from the baggie but do not pass them out yet.

#### Experiment 3: Why Are Plants Green? – Chromatography of Grass Extracts

- Place one plastic cup marked “GE” at each table.
- Add two teaspoons of the “grass concentrate” (ethanol extract of food processor processed grass) from the water bottle into the plastic cup marked “GE”.
- Fold the seven pieces of chromatography paper *approximately* as follows:
  - Make one fold in the paper about 2.5” down its length. Then make a second fold about   ” inch from the first so that about   ” will remain. Note: the 2.5” length is approximate. What is important is that this length be long enough to extend into the solution without touching the sides of the cup.



- When folded it should look like a square upside down “J”.



- Leave the papers on the demonstrator’s table for distribution during the experiment.

#### Experiment 4: Lowering Surface Tension – Water and Surfactants

- Place 6 beral pipettes (one per student) on each of the students’ tables and one on the demonstrator’s table.
- Place 6 pennies (one per student) on each of the students’ tables and one on the demonstrator’s table.

## ***Experimental Setup***

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- Fill each cup marked “W” with about 1/4 cup tap water (about half full)
- Place one 3 oz cup marked “W” on each student table and one on the demonstrator’s table.
- Add the soap in the vial to 1 cup of tap water and stir. Distribute among the 7 3oz cups marked “SW”.
- Place one 3 oz. cup marked “SW” on each student table and one on the demonstrator’s table.

#### **Experiment 5: Using Wet Water to Clean Clothes - Using Surfactants for Chlorophyll**

- Fill all tubes marked “D” and “W” up to the 30 ml mark with tap water and then cap.
- On each students’ table and the demonstrator’s table place 2 pieces of cloth, one tube marked “D”, and one tube marked “W”.
- Place a paper towel at each student table, and put a small quantity of your grass or green leaves on it. (If you don’t have grass or leaves, put the 50 ml centrifuge tube marked “G” on the demonstrator’s table—you will use this as a source for “grass stains”. When it comes time to rub the grass into the fabric, simply pour some of this material onto the students’ cloths for them. Otherwise disregard this particular tube.)

#### **Experiment 6: Treating Sports Injuries – Soothing the Pain w/ Hot and Cold Compresses**

- Place 1 tablespoon of room-temperature water in each of the 14 unmarked zipper-top sandwich bags and seal.
- Distribute the  $\text{CaCl}_2$  evenly into the 7 cups marked “A” (approx. 1/2 teaspoon in each).
- Distribute the baking soda evenly into the 7 cups marked “B” (approx. 1/2 teaspoon in each).
- Distribute the citric acid evenly into the 7 cups marked “C” (approx. 1/2 teaspoon in each).
- Place 2 zipper-top bags containing water, 1 zipper-top bag marked “C”, 1 zipper-top bag marked ‘H’, 1 cup marked “A”, 1 cup marked “B”, and 1 cup marked “C” at each table.

#### **Closing Session**

- Set out the literature for students to pick up at the END of the program
  - Celebrating Chemistry activity newspapers
  - Multiple stacks of the various take-home sheets
- Set up an area for goggle drop-off

## **Opening Session**

### **Greet the Students (and Parents) Upon Their Arrival and Distribute Goggles**

*Do the following:*

- Hand out and adjust students' goggles (alternately, do this at the start of the program; however doing this before the program saves time).
- Ask each student to take a seat at a table (no more than 5 students per table) and to PLEASE not touch any of the materials before the program begins. Some experiments may be ruined if they do.

### **Opening Discussion**

*Do the following:*

- Introduce yourself as a chemist or chemist/science teacher (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.*)

*Continue:*

- Explain that chemistry involves the study of everything around them. That's why we celebrate it every year with programs like this.
- The theme of National Chemistry Week this year is "Having a Ball with Chemistry" to celebrate chemistry in sports.
- Ask "Why do you think we chose this theme for this year?" A: It's an Olympic year.
- Ask and discuss the following items:
  - "Did anyone watch the Olympics on TV in August? There were 7 people from the Cleveland/Northeast Ohio area who were in the Olympics! These including the gold medal winners LeBron James (the Cavs basketball player) and Matt LaPorta (from the Akron Aeros baseball team), who got hit in the ear by a pitch.
  - These athletes exercised and trained for years to make it to the Olympics. Just like them, chemists and engineers have been working for years trying to make athletic equipment better, lighter and stronger. They have worked on the materials used in balls, athletic clothing and running shoes, and the ingredients in sports drinks and nutritious energy bars.

- They have even worked on the Olympic torch (the one carried by the runners around the world), making it light enough to carry, and making the flame burn continuously, even in cold mountains, underwater, and in high wind.
- ***Science and technology have always been a part of sports! This year we're proud to say that chemists have helped our athletes go for the gold.***
- Before we start our experiments, we're going to play a little guessing game (with 3 questions). We're going to call it "The Chemistry Olympics"!

First question: How much did the Olympic torch weigh this year (the one carried by the runners)?

- 1) 16 pounds (like a heavy bowling ball)?
- 2) 8 pounds like a gallon of water or milk?
- 3) 2 pounds like a 10-day, newborn puppy?

The answer is 3). It weighed only 2 pounds (actually 2.2 pounds)! Can you guess what lightweight metals it's made of? .... magnesium and aluminum [you are familiar with aluminum foil, and aluminum bats?].

Are metals chemicals? YES!

Second question: What fuel did the Olympic torch burn?

- 1) gasoline, like in your car?
- 2) propane, like in a gas grill?
- 3) hydrogen, like in a rocket going to outer space?

The answer is 2). It's propane. Propane was picked for the torch because it would not freeze on Mt. Everest. [In the Sydney 2000 Games, a mixture of propane and butane was used; the torch could even burn underwater at the Great Barrier Reef in Australia!]

Is propane a chemical? YES!

Our third question is: For runners, Nike® designed a smooth, new unitard (running suit, like a leotard) that could help 100-meter runners take .02 seconds off their time. Do you think it's made from:

- 1) sheep wool?
- 2) recycled pop bottles?
- 3) coconut fibers?

The answer is 2). Recycled pop bottles! The pop bottles they used were made of polyester. Other recycled polyester clothes and fabrics were also used. Polyester is a man-made plastic (also called a polymer).

Speedo also made a new swimsuit called the LZR Racer using fabric made of spandex and nylon. It's very smooth, light, and tight. These are also man-made plastics or polymers. (We will make a ball out of plastic later today!)

Are polyester, nylon, and spandex chemicals? YES!

We talked about metals (like aluminum) a gas (propane), and plastics....but everything we can see, and touch, taste, and smell is a chemical.

So... welcome to our Olympic year National Chemistry Week program!

You did so well on this quiz that when you leave we'll give you a handout at the end of the program with pictures of 3 Olympic chemistry medals for you to cut out. There's also more Chemistry Olympics questions since you enjoyed these so much. 😊

### **Introduce the Items on the Tables and Distribute Goggles as needed**

*Do the following:*

- Tell the students that various items have been gathered for them on their table.
- Most of the items can be found around the house, but they 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 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 with our goggles. Put on a pair of the adult-sized goggles. If you have an assistant, ask them to do the same.
- Help the students put on their goggles. Adjust the straps as necessary. (Note: These goggles are sanitized each year and prior to each demonstration.)

### **Introduce Today's Presentation:**

*Tell the students the following:*

- As we said earlier, this year's theme for National Chemistry Week is "Having a Ball with Chemistry"
- While most of us will never go to the Olympics, many of us do play sports and games.
- Today, we will follow a story of my friends Milli and Avogadro who like to play a variety of sports. They were recently at a game and gave us the opportunity to show them just a few ways how chemistry was involved in their game day. Today I'll share this with all of you.

## Experiment 1: Make a Bouncing Ball

### Experiment Purpose & General Methodology

- Students will be informed of the meaning of cross-linked polymers and how they are formed.
- Students will make a bouncing ball by preparing a mixture which becomes a highly crosslinked polymer.
- The experiment will be done per table and should take a total of 8 minutes to complete.

### Introduce the Experiment

*Tell the students the following:*

- The city of Akron is often referred to as “the polymer capital of the United States”. There are many companies in our area that make polymers. Ask: Do you know what polymers are? (Discuss) A polymer is a big molecule that is made up of a lot of small molecules connected together.
- We play many sports with a ball. A pool or billiard ball is a very hard plastic. So is a lighter weight ping-pong ball. A rubber ball is a ‘softer’ polymer.
- In this experiment we will make a ball with the ability to bounce.

### Ask the students to perform the following:

- 1) Select about 20 students and divide them into two groups (if you have a small group, save at least 2-3 students for the next step). Have the two groups form two lines facing each other. Have them link arms (wrap arms so they link elbows – this does not involve the use of hands and is less threatening to any shy children). Tell them that each of them represents a atom in a molecule and their linked arms represent the chemical bonds that hold a molecule together.
- 2) Ask both lines to, on the count of three, take two steps to the left simultaneously. Two more to the left. Now two to the right. Two more to the right. Have fun as it may take the two lines to get it correct. Have them end so that they are lined up evenly again. Tell the students that it is easy for the two lines to move because there is nothing stopping the sideways movement.
- 3) Select additional students. Place them between the lines in a perpendicular fashion at about every third line-student. Have them link their elbows with the two students across from each other. Tell them that these additional students will act as what polymer chemists call ‘crosslinkers’. As cross-linkers they form links or bonds across the two original molecules. Tell them to hold tight! Now ask the two lines to take two steps to the left. They cannot move easily because the crosslinkers are preventing the sideways movement.
- 4) Have the students return to their seats.

## Experiment 1

### Demonstrator's Guide

- 5) Ask one student from each table to come to the demonstrator's table with the pipette and section of paper towel. Give each student 2 ml of solution from the tube marked "B". It is important to be very accurate here so use your pipet which is marked at the 2ml line as a reference. Tell the student to wrap the paper towel segment around the pipette and return to his/her table holding the pipette upside down (i.e., bulb side down) so the contents don't run out.
- 6) Pour the contents of the cup marked "C" into the cup marked "R".
- 7) Mix the contents of the cup marked "R" well with the wooden craft stick.
- 8) After about 10 seconds of mixing, add the contents of the pipette to the cup marked "R". Continue stirring until no more lumping takes place.
- 9) Hold the crude rubber ball up and tell one of the students to take it off the wooden craft stick and roll it in his/her hands to shape it into a round ball shape.
- 10) Once the ball has its shape drop it on the table and see how it bounces.

#### **If there is time, perform the following demonstration for the students:**

- 1) Using the materials at your demonstrator's table, pour the contents of the cup marked "B" into the cup marked "R". Do **NOT** add the crosslinker C.
- 2) Mix thoroughly with your wooden craft stick.
- 3) Pour the contents of the cup onto a paper towel on the table. It will form a "pancake".
- 4) Now take the pancake, reform it into a ball, and lie it back down on the table.
- 5) Watch as the material spreads out on the table and the "pancake" reappears.
- 6) Ask the students why your ball formed a pancake and theirs formed a bouncing ball. [They should be able to relate to the principle of crosslinking based on the two-lines-of-students demo.]

#### **Conclusions**

*Tell the students the following:*

- The chemicals that were mixed together turned a "monomer" (with small molecules) into a polymer with large molecules.
- The crosslinker chemical "C" served the same function as the student placed between the lines of students. The crosslinker prevents the molecules from sliding over one another and makes the compound rubbery and bouncy. Without it the material would be form a pancake if placed on the table.
- Chemicals can react very fast. This polymer formed in seconds! The mixing tries to get all three parts (molecules) close to each other in order to get the best rubbery ball possible.

#### **Additional Information If Needed: Technical Background**

- None

## Experiment 2: Sports Drinks – How Sweet Are They?

### Experiment Purpose & General Methodology

- Students will be able to learn about the components and purpose of sport drinks.
- Students will experiment to determine the chemical reactions of various sugars in sport drinks comparing the results to a control and standards.
- Students will be able to determine one of the sugars in a sample of Gatorade.
- Students will see the amount of sugar in one bottle of Gatorade.
- This experiment is performed at each table and will run ~8 minutes.

### Introduce the Experiment

*Tell the students the following:*

- ***[Ask the librarian/parent or helper to microwave the water now. Take the thermometer to test the final temperature (at least 150 °F / 66 °C). DO NOT PLACE THE METAL THERMOMETER IN THE MICROWAVE WHEN HEATING THE WATER.]***
- ***[Have the helper pour about \_ cup of hot water into each of the seven Styrofoam cups and place one on each student table and one on the demonstrator's table as you proceed with the experiment]***
- How many of you have ever had a sport drink?
- Ask those who responded why they drank this? (Answers will vary.)
- Ask the students if they know what the ingredients are in a sport drink? (Answers will vary but should include sugar and flavoring.)
- Ask the students why sport drinks are so popular with athletes? (Answers will vary.)
- Tell the students that they will now do some testing on a popular sport drink to learn some of their interesting chemistry.

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

*Do the following:*

- 1) Have the students locate the blue-capped vials marked “W”, “S”, “F” and “G.”
- 2) Have four of the students at each table hold one of these vials.
- 3) Demonstrate the technique you wish them to use when you call them to the demonstrator's table. Squeeze out the air of the beral pipet, put it completely into the solution, let go as the

## Experiment 2

### Demonstrator's Guide

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pipet fills and then empty it into their vial. Return to their seat and wait until everyone has obtained their solutions.

- 4) Have the students holding the “W” vials form a line at the cup marked “W” at the demonstrator’s table and ask them to add one beral pipet full of the liquid to their vial returning to their seats when finished as you just demonstrated to them.
- 5) Do the same with the “S”, “F” and “G” vials. *If you have helpers you may do more than one line simultaneously to save time.*
- 6) **[The Styrofoam cup of hot water should be on the student tables and your table at this time.]**
- 7) Ask the students to describe the colors of all the solutions before they place them in the hot water cup. Answer: *Clear blue.*
- 8) Tell the students that there is a cup of very hot water on the table and to carefully put their vials into the cup without spilling it. Ask one student to hold the cup steady to prevent spilling while the reaction occurs.
- 9) *[You will be able to judge when the reaction has occurred (reaction turns cloudy and changes color in two of the vials (“F” and “G”). The hotter the water the faster the reaction.)*
- 10) Ask the students to name a sport drink. (Hopefully one will say “Gatorade.”)
- 11) Tell the students that back in 1965 the University of Florida “Gators” were wilting on the football field being very affected by the heat and heat related illnesses. University physicians asked to help the coach found that the fluids and electrolytes the players lost through sweat were not being replaced, and the large amounts of carbohydrates the players’ bodies used for energy were not being replenished. The researchers went to work and came up with a beverage that would adequately replace the key components lost by Gator players through sweating and exercise. They called their concoction ‘Gatorade’.
- 12) Back to our experiment! While the reaction occurs ask the students how a scientist knows whether or not an experiment has produced real results? (Answers will vary but use any answer that hints at the use of controls and standards and reaction indicators—color changes, etc.)
- 13) Tell the students that today the “W” vial is their control sample and contains only water and “Benedict’s Solution” which is used to test for the presence of certain sugars. The student who added liquid to their vial was adding water only.
- 14) Tell the students that those who added the “S” solution they were adding table sugar also known as sucrose. Sucrose is a sugar (a disaccharide) that contains 2 simple sugars (glucose and fructose) chemically bound together but not able to react with the Benedict’s solution.

- 15) Tell the students that those who added the “F” solution were adding “fructose” also known as fruit sugar to their vials. Fructose is a simple sugar (a monosaccharide) that does react with the Benedict’s Solution.
- 16) Let the students know that the “S” (sucrose) and “F” (fructose) vials contain what are called standards. We will be comparing our sports drink “G” with the control and the standards.
- 17) Have the students remove the “W” vial—the control. It should be a clear blue—no change having occurred. No reaction was expected here
- 18) Have the students remove the “S” vial—the sucrose standard. Again there is no reaction and the color is the same as that of the water/Benedict’s solution.
- 19) Have the students remove the “F” vial—the fructose standard. The color here will be different from that of the water/Benedict’s solution. It will be cloudy and the color from green to reddish brown. (*Completeness of the reaction depends on the temperature of the water with such a short time frame as experienced here*).
- 20) Now have the students remove the vial marked “G” our real sport drink—Gatorade.
- 21) Can the students determine which sugar was present in the sports drink? *Answer: Yes—fructose! The color is the same as that of the fructose solution.*
- 22) Ask if the students can determine if the sucrose was present? *Answer: NO! No visible reaction occurs. You would need a more complicated test to determine this.*

### Conclusions

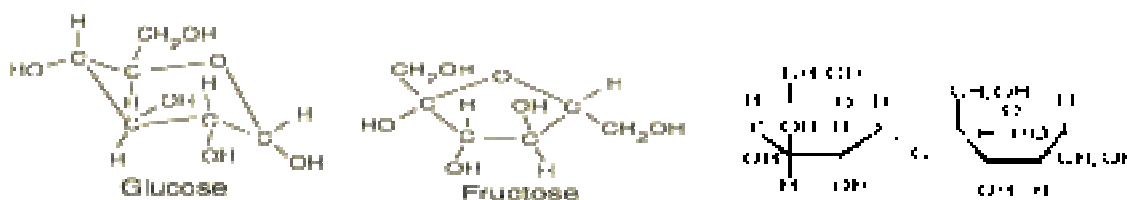
*Tell the students the following:*

- Pass out a copy of the nutrition label and have them read the ingredients—water, sucrose and fructose, etc.
- The sugar and fructose you tested for earlier are the main ingredients after water.
- Sugars give an athlete quick energy.
- The salts (sodium and potassium (in the form of monopotassium phosphate)) are there to help replace the salts the body loses during heavy exercise. The more intense your exercise the more you sweat which helps to cool the body but causes you to lose water and salt.
- If you lose too much water you “dehydrate” or “become dehydrated”. Sports drinks help reverse that process by “re-hydrating.” your body.
- It is necessary to **re-hydrate** the body for an athlete to perform at his or her peak. Even a little **dehydration** can affect their performance.

- Ask the students to read the nutrition label to determine the grams of sugar in the entire bottle of Gatorade (check label as there may be more than one serving probably 2.5 servings. There are 14g per 8 oz. serving.)
- Ask the students if they know how much sugar this really is.
- Show the bag of sugar that has an amount equal to what is in the Gatorade bottle.

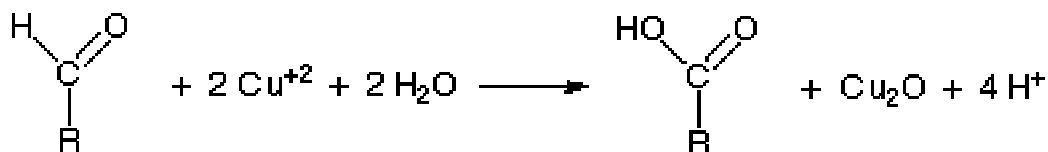
#### Additional Information if Needed: Technical Information.

- Chemical structures of glucose and fructose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> isomers), and of sucrose



#### Sucrose

- Most mono- and disaccharides are reducing sugars (sugars with a free aldehyde or ketone group) which will test positive with Benedict's reagent. Sugar is one of the few disaccharides that is not a reducing sugar and does not react.
- Benedict's solution is a mixture containing copper (II) sulfate which gives it the characteristic blue color. Carbohydrates that contain aldehydes or α-hydroxymethyl ketones can be oxidized by Cu(II) ion and are classified as reducing sugars. They reduce the Cu(II) ion to Cu(I) as shown here:



- The final color of the solution following the Benedict's test depends upon how much of the Cu<sub>2</sub>O precipitate was formed, and therefore the color gives an indication of how much reducing sugar was present. With increasing amounts of reducing sugar the result will be:

Blue (none)—green—yellow—orange—red (most)

- <http://gatorade.com>
- Dehydration impairs athletic performance whenever body fluid level falls below 98% of normal. The primary cause of dehydration is sweat loss, an essential body process which facilitates the release of body heat into the environment. When athletes don't replace what they lose in sweat, the physiological function of the body's heat management system is compromised, placing both the athletes' performance and physical well-being at risk.

- **Dehydration's Warning Signs**

Sweat loss reduces blood volume and increases the concentration of sodium in the blood. This stresses the cardiovascular system and contributes to a faster increase in body temperature. Dehydration results in a number of symptoms that are important to remember.

<b>Noticeable thirst</b>	<b>Muscle Cramps</b>	<b>Weakness</b>	<b>Decreased performance</b>
<b>Difficulty paying attention</b>		<b>Light-headed feeling or dizziness</b>	
<b>Nausea</b>	<b>Fatigue</b>	<b>Headache</b>	

- Other additives and their purpose in sport drinks in general.  
<http://www.ca.uky.edu/hes/fcs/factshts/FN-SSB.144.PDF>

<b><u>ADDITIVE</u></b>	<b><u>PURPOSE</u></b>
Salt (NaCl)	flavoring
Citric acid and sodium citrate	controls acidity, antioxidant and flavoring
Monopotassium phosphate and Phosphoric acid	acidifier, emulsifier, nutrient, stabilizer, flavoring
Flavorings	taste
Food dyes	coloring
Sugar, corn syrups	sweetener

**Experiment 3: Why Are Plants Green?****– Chromatography of Grass Extracts****Experiment Purpose & General Methodology**

- The experiment will show the students why grass is green.
- Chlorophyll is extracted from a grass blade or leaf onto a filter paper and eluted with ethanol to show the two types of chlorophyll (yellow and green).
- The experiment will take ~10 minutes and be performed at each table.

**Introduce the Experiment**

*Tell the students the following:*

- We play many sports on natural grass. While having fun we often get grass stains on our clothes when playing sports outside on the grass. What makes grass or leaves green? It is a chemical called Chlorophyll. The chlorophyll takes part in the growth of a leaf or stem of grass by changing carbon dioxide from the air along with water and other material from the soil into solid sugars and starches which make up the plant material. A waste product of this process is oxygen. Thus, plants help to make the oxygen gas which we breathe. In this experiment we will take some of the chlorophyll out of a green blade of grass or leaf and show that we actually get at least two materials from the grass or leaf by a process of separation called chromatography.

**Perform Experiment as a Demonstration, then simultaneously with the students**

*Do the following, leading the students:*

- 1) Have the students locate the cup marked “GE”. Tell them that this is our ‘grass extract’ made from crushing up grass and green plant leaves in alcohol.
- 2) Distribute the chromatography papers. Tell them that this paper is going to extract or ‘pull out’ the chlorophyll for us to see, but we have to give it some time to work.
- 3) Have the students be very careful in how they place the paper into the cup loaded with the “grass concentrate”. The hook holds the paper upright and touches the solution on the bottom; however, the paper should NOT touch the side of the cup.
- 4) Have the students carefully set the experiment aside until completion of Experiment 6 or until the solvent front (wet leading edge) nears the top of the paper standing in the cup (or does not rise any further).

When Experiment 6 is completed, return to this experiment. At this point two bands of color will be visible: blue-green band (lower chlorophyll a) and a yellow-green band (upper-chlorophyll b). These are the alpha and beta forms of chlorophyll.

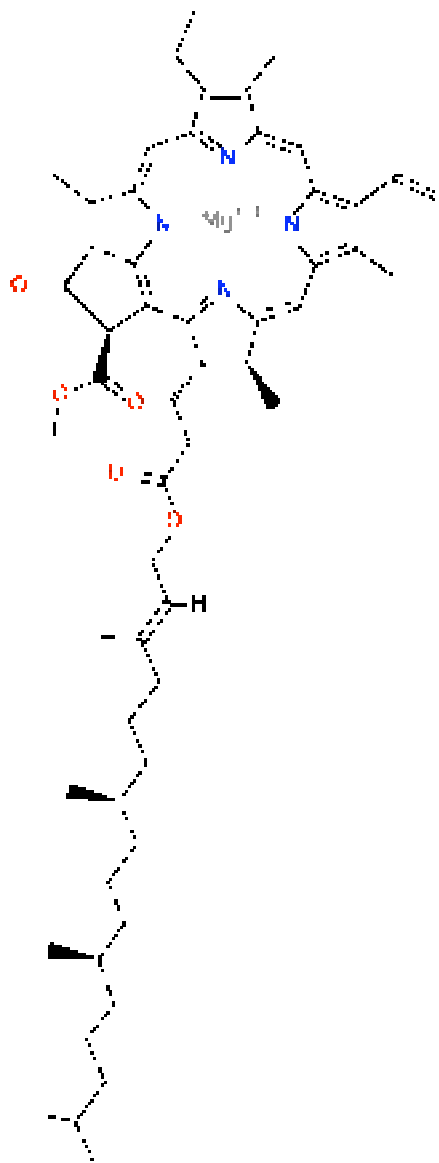
#### Conclusions

*Tell the students the following:*

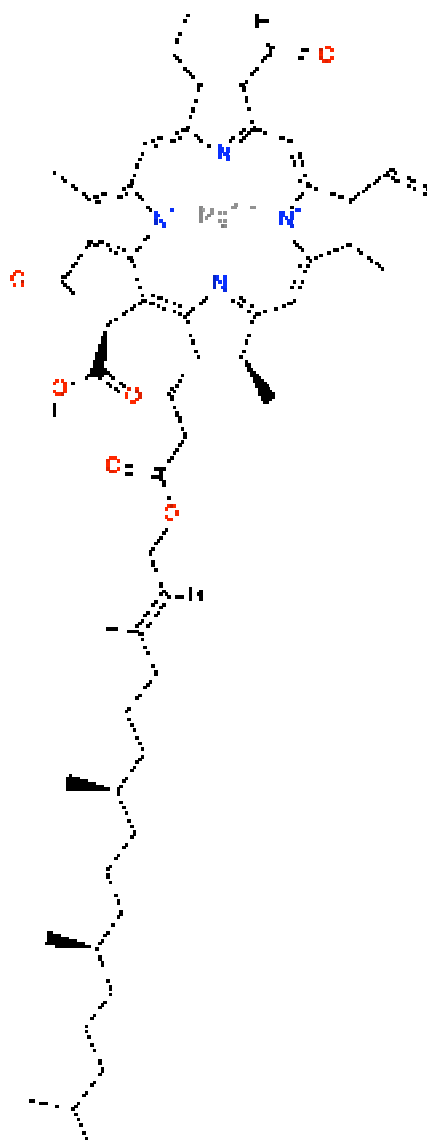
- 1) Many simple things are made of many parts. Grass has many chemicals inside it, and it actually has two colors – a familiar green part and a yellow part which is hidden by the green. In the Fall (Autumn) leaves and grass actually turn yellow in some instances because the green part falls apart and leaves the yellow color behind. This separation experiment is similar to that done in hospitals that analyze blood when people get sick. The blood tests can identify illnesses. Doctors can then write medicine prescriptions to make people healthy.

#### Additional Information If Needed: Technical Background

- There are the alpha and beta forms of chlorophyll.
- Water will not get the chlorophyll to move in the paper. Because the chlorophyll is a complicated molecule, it requires a different liquid (ethanol) to move up the paper.
- **Chlorophyll** is a green pigment found in most plants, algae, and cyanobacteria. Its name is derived from Greek: (*chloros* , "green") and (*phyllon* , "leaf"). Chlorophyll absorbs light most strongly in the blue and red but poorly in the green portions of the electromagnetic spectrum, hence the green color of chlorophyll-containing tissues like plant leaves.
- Chlorophyll is a chlorin pigment, which is structurally similar to and produced through the same metabolic pathway as other porphyrin pigments such as heme. At the center of the chlorin ring is a magnesium ion. The chlorin ring can have several different side chains, usually including a long phytyl chain. There are a few different forms that occur naturally, but the most widely distributed form in terrestrial plants is chlorophyll *a*.



Chlorophyll a



Chlorophyll b

**Experiment 4: Lowering Surface Tension – Water and Surfactants****Experiment Purpose & General Methodology**

- Students will explore the concept of surface tension.
- Students will learn the effect of a surfactant (soap) on surface tension.
- Each student will have their own experimental setup. This experiment will take 5 minutes.

**Introduce the Experiment**

*Tell the students the following:*

- Ask the students to raise their hand if they ever got a grass stain on their clothing (most should raise their hands).
- Ask the students how they might remove a grass stain from their clothing {answers will vary}.
- Tell them we'll be exploring the properties of water and soapy water before they can really answer these questions.
- Now ask the students if they've ever seen a movie in which a small insect with long legs walks on water. Or if they've floated a toothpick on water. If they have, these things were possible because of the "skin" on water called surface tension. This same skin makes it difficult for water to penetrate thoroughly into fabrics.
- We're going to investigate this surface tension and find out how detergents (something called surface active agents or surfactants by chemists) can lower it.

**Perform the Experiment Simultaneously with the Students**

*Do the following, leading the students:*

- 1) Ask each student to place take one of the pennies and place it in front of them. Be sure it is dry. If not use the piece of paper towel to dry it before continuing.
- 2) Ask each student to fill a pipette with the water from the cup marked "W".
- 3) Tell the students to carefully place drops of water on the penny. Tell them to count the number of drops of water they can drip onto a penny before it spills [it should take about 25-50 drops].
- 4) Have them dry the penny with a paper towel and repeat the experiment using the soap solution in the cup marked "SW" [it should take less than 5-20 drops].

**Conclusions**

*Tell the students the following:*

- Ask the students if the soapy 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.
- When soap is added to the water, it weakens the “skin” (or lowers the surface tension), so less drops of water can be piled on the penny.
- What effect do you think this surfactant would have on a grass stain? (Answer: It might help remove it!) In the next experiment we'll see how surfactants assist mom in removing those grass stains that you got on your clothes while you were playing your favorite sport.

#### **Additional Information If Needed: Technical Background**

- See Expt. 5.

## **Experiment 5: Using Wet Water to Clean Clothes - Using Surfactants to Re-dissolve Chlorophyll**

### **Experiment Purpose & General Methodology**

- Two pieces of cloth are stained with grass. The control is placed in a test tube of water and the other piece is placed into a test tube with water loaded with detergent. The test tubes are capped, shaken and after a minute of “soaking”, removed and compared. The sample from the wetted/detergent solution will remove most of the grass stains from the cloth.
- The experiment should take 7-8 minutes to complete and is done per table.

### **Introduce the Experiment**

*Tell the students the following:*

- We play many sports on natural grass, and we often get grass stains on our clothes when playing like this. Our dirty clothes are cleaned in a washing machine by adding detergents. How do these detergents work?
- Have you ever noticed your mom's sink before she adds the dish detergent? Often there are oily “spots” from the greasy dishes which float on the water. When mom adds the detergent, these oily spots disappear! What happened to them?
- Surfactants are molecules that have one end which “likes” water and another end which “likes” oily materials. When the detergent is added to oily water one end mixes with the water and the other mixes with the oily material so that the oily material appears to dissolve. In the same way detergents make water act “wetter” to help remove stains from clothes. When it's wetter, water gets “closer” to the dirt or stain and dissolves it.

### **Perform Experiment as a Simultaneously with the Students**

*Do the following:*

- 1) Tell the students to place the two pieces of cloth in front of them. Rub grass or the green leaves on each piece of cloth until each is well stained. This may take some extra elbow grease from the students. Rubbing the blades of grass between the two cloths or using the blunt end of a wooden craft stick or ball point pen or fingernail will “smoosh” some chlorophyll onto the cloth. To do this, the cells inside the leaves are being broken thereby releasing the chlorophyll from inside the cells.
- 2) Locate the tube marked “D” and shake it to dissolve the detergent.

- 3) Place one “dirty” cloth into the test tube marked “W” which contains only tap water. Shake the capped test tube like a washing machine for one minute.
- 4) Repeat this step with the second piece of cloth using the test tube marked “D”.
- 5) Open the test tubes and carefully remove the cloths. Ask: Which one is cleaner? What are the colors of the washing solutions? *Answer: the cloth “washed” in the detergent solution is cleaner, and the soapy solution should be greener than the water.*

#### Conclusions

*Tell the students the following:*

- The addition of a detergent causes water to be wetter than plain water. (Remember the previous experiment with the penny?)
- The “wetter” water removed more dirt. It is not perfect in this experiment because of the short wash cycle and because the agitation was limited. The wetter water gets “closer” to the dirt and can lift the dirt away from the cloth fibers. The greenish color of the wash water with the detergent in it shows how the wetter water removes grass stains.

#### Additional Information If Needed: Technical Background

- Detergents contain wetting agents for surface tension reduction, enzymes for biologically removing stains, emulsifiers for keeping the dirt in suspension and not allowing the dirt to resettle on the cleaned clothes. There is a lot of chemistry in “soap”.
- Our limited experience with the “grass concentrate” solution is that its shelf life (when kept in the dark at room temperature) should be at least a month or so.

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**Experiment 6: Treating Sports Injuries –  
Soothing the Pain with Hot and Cold Compresses****Experiment Purpose & General Methodology**

- The students will be informed why we put hot and cold compresses on specific injuries.
- Students will have the opportunity to create both a hot and a cold compress.
- Students will get an introduction to different types of reactions: a chemical exothermic reaction and a physical endothermic reaction
- This experiment will be done by each table and should take 5-6 minutes to complete.

**Storyline transition and experiment introduction**

- We all know that in sports, injuries often occur. Does anyone know what injury occurred to one of our Ohio Olympians? Hint: I heard it happened to Akron Aeros baseball player Matt LaPorta. He had his ear injured by a pitch. Ouch!
- Unfortunately, while Millie and Avogadro had a fun time at their game, with all their running around they unfortunately had some minor aches and pains too! Too bad! We'll see in a moment two ways that chemistry can help heal some injuries.
- Ask: What types of injuries have you seen which are common and how have you/they been treated? (Allow a few responses.)

**Part 1: Endothermic Reaction - Cold Pack****Introduce the Experiment**

- Discuss: Poor Millie collided with a teammate and may have sprained her wrist. Ask the students: What is one of the first things that you might do when you have a minor injury like a sprained ankle or other dark bruise? (Put something cold like ice on it.) Why? (To reduce swelling after sharp and sudden injuries (such as after a fall, sprain, or collision) where swelling is a problem.)
- Tell the students that we will create our own cold pack and observe an endothermic reaction.

**Perform the Experiment Simultaneously with the Students**

*Do the following, leading the students:*

- Have each table locate one of the zippered bags containing water and have the students feel and describe the temperature of the water – it should be room-temperature or lukewarm. Remind the students that 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.

- Have one student carefully open the bag and hold it open.
- Have a second student locate the cup marked “C” (containing citric acid) and pour the contents into the water in the open bag. Agitate **gently** (remember, the bag is open at this point!) to dissolve and disperse the citric acid.
- WARN the students not to get startled during the next step. Hold the bag steady. Have a third student locate the cup marked “B” (containing baking soda) and pour the contents into the citric acid solution in the open bag.
- Ask the students “What’s happening? (Answer: It bubbles.) Ask: What does that mean? (Answer: A reaction is occurring that produces a gas.)
- Tell the students to 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.
- Next, have the students pass the bag around the table so that everyone can feel the temperature of the bag. Note: Use the back of the hand or inside of the wrist like before.
- Ask the students “Do you notice any change? (Answer: the water in the bag has gotten cooler!)

#### Conclusions for Endothermic Chemical Reaction - Cold Pack

- Inform the students: What we have just demonstrated is a common reaction called an acid-base reaction.
- Discuss with the students: Chemists like to put our experiments and reactions into categories to help us describe them to each other. Two categories are called ‘Physical Reactions’ and ‘Chemical Reactions’. In a physical reaction, the chemicals involved do not change. For example, you can freeze water but it’s still water, or you can cut up paper but it’s still paper. In a chemical reaction, you start with one set of chemicals and produce an entirely new chemical or chemicals. Do you think what our experiment was an example of a physical or a chemical reaction? (Answer: chemical) Why? (Answer: We didn’t add a gas but gas bubbles were formed.)
- Inform the students: It is very common in chemistry that when we add an acid and a base together (citric acid and baking soda here) that a gas and a salt are formed. We cannot see the sodium citrate as it is dissolved in the water, but we can see evidence of the reaction and of the gas produced – the bubbles! Our gas is  $\text{CO}_2$  or carbon dioxide, the same gas we breathe out all day long.
- Discuss with the students: When a chemical reaction or physical process absorbs heat from its surroundings, chemists call that an “endothermic reaction”. Ask: What do you think “endothermic” means? (Accept a few responses and then continue leading.) Say: The second syllable ‘thermic’ sounds like another word we all know. Ask: What changes did we notice in

our reaction? (Answer: bubbling and temperature change?) Ask: What do we use to measure temperature? (Answer: a thermometer.) Yes, a THERM-ometer measures temperature, and our endo-THERM-ic reaction showed a decrease in temperature. An endo-thermic reaction needs to absorb heat to occur. Endo means “to take in”. Thus, this reaction takes in heat. Since it takes this heat from the water, the water in turn gets colder.

- 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!

### Part II – Exothermic Physical Reaction - Hot Pack

#### Introduce the experiment:

- 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. Or sometimes you simply get sore from performing an activity over and over which causes minor injuries, and heat can help these too.
- Ask: How do you put heat on an injury? (Gather some answers). You could use an electric heating pad or a hot water bottle, or even a hot tub, but those require access to electricity or hot water. Again, chemistry can provide another solution in the form of portable heating packs!
- Later on, when Avogadro gets home, his legs are sore from so much running; this happens to him often, so he may want to use a heating pack on his calf muscles to help the aches and pain subside. While we cannot make one here as good as the ones we can buy at the pharmacy store, we will use other items to create our own hot pack.

#### Perform the Experiment Simultaneously with the Students

*Do the following, leading the students*

- 1) Discuss: What about after you play a long, tiring game and your muscles are all sore. Does anyone know how to help them? (Put something warm on them.) Why? (Heat treatments are used for chronic (slowly developing) conditions which cause dull pain and soreness, typically from overuse of muscles, and do not have swelling. We use heat to help relax tissues such as muscles and also to increase blood flow to the area to get nutrients and other items to the muscles faster to help them heal sooner.

- 2) Locate the other zippered bag containing water and have the students feel and describe the temperature of the water – it should be room-temperature or lukewarm.
- 3) As in the previous experiment, have a student carefully open the bag.
- 4) Have a second student locate the cup marked “A” (containing calcium chloride) and pour the contents into the water in the open bag.
- 5) Carefully seal the bag and place it in the empty bag marked “H” to help guard against leaks. Gently agitate the bag to disperse the calcium chloride pellets.
- 6) Have the students pass the bag around the table so that everyone can feel that the water in the bag has gotten warmer! **Note: The calcium chloride pellets can get very warm! Do not** let students squeeze the pellets that have not fully dissolved.

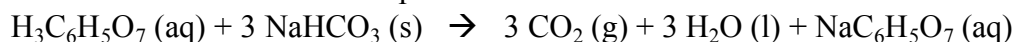
### Conclusions for Endothermic Reaction/Cold Pack

*Tell the students the following:*

- Discuss: We already discussed that physical reactions do not change the chemicals involved, but chemical reactions do. Ask: What type of reaction do you think happened here? (Obtain observations.) Lead the students: Do we see any gases given off? No. Do we see any solids that are new? No. We didn't see any solids last time either though. Is there a color change? No. Hmm. How do we even know that a reaction occurred? It gave off heat!
- If we were back in my laboratory we could run other tests to see if any new chemicals were produced by our reaction. I can tell you that I do know that if I let the water evaporate from the bag, I would be left with my original calcium chloride. So now that you know that, was this a physical or chemical reaction? (Answer: physical). Yes, a physical reaction occurred. In our hot pack, the calcium chloride gives off heat as it dissolves in the water. Dissolving is a physical process, not a chemical reaction. If you go into your kitchen and dissolve table salt, you can then evaporate of the water and get the salt back out unchanged – However, hat particular salt does not give off nearly as much heat as calcium chloride when dissolving.
- A chemical reaction or a physical process that gives off energy to its surroundings is called exothermic. Remember THERM-ic means temperature or heat. Endo meant to “take in”, so “Exo” means to.... “give off”... Yes, an exothermic reaction gives off heat. That's why the solution in the bag gets warmer. The calcium chloride molecules have chemical bonds which use energy to hold them together, when they dissolve, this energy is given off as heat.
- 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.

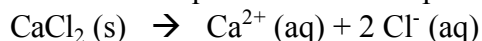
#### Additional Information If Needed: Technical Background

- The chemical reaction for our cold pack is:



Citric acid plus baking soda yields carbon dioxide, water, and sodium citrate salt

- The dissolution equation of our hot pack is:



Calcium chloride dissolves to produce calcium ions and chloride ions.

Each gram of  $\text{CaCl}_2$  that dissolves releases 160 cal into the water.

#### From WebMD.com:

- Cold treatment is used to reduce swelling after sharp and sudden injuries (such as after a fall, sprain, or collision) where swelling is a problem. Decreasing swelling around an injury will help control the pain too. The cold causes blood vessels to constrict (get more narrow) and limits internal bleeding at the injury site. Cold therapy is also helpful in treating some overuse injuries such as a runner with chronic knee pain; a runner may ice the injured area after each run to reduce or prevent swelling and inflammation. (Note: icing a chronic injury before exercise is NOT helpful.)
- Heat treatments are used for chronic (slowly developing) conditions which cause dull pain and soreness, typically from overuse of muscles, and do not have inflammation or swelling. We use heat to help relax and loosen tissues and to stimulate blood flow to the area. Heat treatments are used either long after the activity when you are still sore, and more commonly before participating in activities to help prepare tissues for the activity. You should NOT typically apply heat directly after exercise for chronic injuries. Heat can increase the elasticity (stretch ability) of muscles and joint connective tissues. Your muscles are sometimes sore because they are slightly damaged and also contain waste chemicals from using stored sugar, carbohydrates and fat to produce energy. Heat increases blood flow and allows more nutrients to gather and flush wastes away to repair your damaged muscles.

**When Experiment 6 is finished, complete Experiment #3:**

**The final experimental information has been copied here for convenience.**

### **Conclusions**

*Tell the students the following:*

- Many simple things are made of many parts. Grass has many chemicals inside it, and it actually has two colors – a familiar green part and a yellow part which is hidden by the green. In the Fall (Autumn) leaves and grass actually turn yellow in some instances because the green part falls apart and leaves the yellow color behind.
- At this point two bands of color are visible. A blue-green band (lower chlorophyll a) and a yellow-green band (upper-chlorophyll b). These are the alpha and beta forms of chlorophyll. They have slightly different chemical structures.
- We all know what a rainbow looks like. What makes all the colors? All those colored bands are caused by the reflection of light off water droplets in the air. The light is reflected at different angles through the sky and we see this as different colors. The two types of chlorophyll have different shapes to their molecules. These different shapes also reflect light at different angles so we see them as different colors once we have separated them.
- But why do the two types of chlorophyll separate on the paper? We all have seen that when you blot up spilled water with a paper towel that the water is pulled into the paper towel. Here our alcohol is pulled up into our paper. The alcohol carries the two types of chlorophyll with it, however one type of chlorophyll molecule gets is more attracted to the paper molecules more, so it doesn't flow up as well into the paper. The second type of chlorophyll is less attracted to the paper and it is carried along up higher as the alcohol flows up into the paper.
- This separation experiment is similar to that done in hospitals that analyze blood when people get sick. The blood tests can identify illnesses. Doctors can then write medicine prescriptions to make people healthy.

### **Additional Information If Needed: Technical Background**

- There are the alpha and beta forms of chlorophyll.
- Water will not get the chlorophyll to move in the paper. Because the chlorophyll is a complicated molecule, it requires a different liquid (ethanol) to move up the paper.
- **Chlorophyll** is a green pigment found in most plants, algae, and cyanobacteria. Its name is derived from Greek: (*chloros* , "green") and (*phyllon* , "leaf"). Chlorophyll absorbs light most

strongly in the blue and red but poorly in the green portions of the electromagnetic spectrum, hence the green color of chlorophyll-containing tissues like plant leaves.

- Chlorophyll is a chlorin pigment, which is structurally similar to and produced through the same metabolic pathway as other porphyrin pigments such as heme. At the center of the chlorin ring is a magnesium ion. The chlorin ring can have several different side chains, usually including a long phytol chain. There are a few different forms that occur naturally, but the most widely distributed form in terrestrial plants is chlorophyll *a*.

## Closing Session

### Close Demonstration

- Remind the students to share our experiments with their family and friends.
- 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 prizes. They should also be able to find us by searching for the Cleveland American Chemical Society. Our website address is [http://www.csuohio.edu/sciences/dept/cleveland\\_acs/NCW/index.htm](http://www.csuohio.edu/sciences/dept/cleveland_acs/NCW/index.htm)
- Thank the students and parents for coming to this year's demonstration and learning about science and chemistry.
- Have students come up to the closing area to turn in their goggles, and pick up their take-home sheets & *Celebrating Chemistry* newspapers.

## Clean up

### After the students leave, clean up the room

- Empty the vials and rinse them well with water, shake off as much water as possible, then place them on paper towels to start to dry while you clean up the rest of the room.
- Return items borrowed from the library. Give any leftover literature to the librarian. (You may save a copy for yourself though!)
- Combine the rest of the water and other liquid-waste in a gallon jug or bucket. This liquid waste can be put down the sink safely with running water.
- Complete the Feedback Form.
- Collect items into plastic bags and place into the mailing envelope(s) marked "Julia Boxler - YTH" to be returned to the NCW Committee for future programs via CCPL interlibrary mail. These include:
  - Completed Feedback Form,
  - dry (or damp) vials in a zip lock bag (air pushed out and zipped closed), and
  - Do not save extra paper and plastic cups. They are crushed in interlibrary mail.
- All solid waste can be collected in the large garbage bag and thrown into the regular trash. BUT PLEASE RECYCLE any of the CLEAN soda/water bottles.
- 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.)
- Give the mailing envelope (containing saved supplies and feedback form) as well as the box of goggles to the students' 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).

#### **At home:**

E-mail Bob Fowler [fowler@EN.com](mailto:fowler@EN.com) and Kat Wollyung at [Katk@neo.rr.com](mailto:Katk@neo.rr.com) with feedback form info:

1. The number of students and adults at your program
2. Any comments you have to improve our programs in the future.

We need this information to write the reports required by ACS National and industrial donators of supplies.

#### **Finally:**

**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 committee; all you need is a desire to share science with students. Development of ideas and refinement of experiments goes on throughout the summer, donation gathering and shopping is in late summer, and kit assembly (over 100 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!

Contact Bob, Cleveland section ACS, NCW Chair 2008 [fowler@EN.com](mailto:fowler@EN.com)

More info on our website:

[http://www.csuohio.edu/sciences/dept/cleveland\\_acs/NCW/index.htm](http://www.csuohio.edu/sciences/dept/cleveland_acs/NCW/index.htm)

## Appendix

### **A. Material Safety Data Sheets**

- An MSDS for AMPS can be found at Sigma Aldrich's website:  
<http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do>
- You can obtain an MSDS from the ACS Cleveland section NCW Committee by going to our website at [http://www.csuohio.edu/sciences/dept/cleveland\\_acs/NCW/index.htm](http://www.csuohio.edu/sciences/dept/cleveland_acs/NCW/index.htm) or contacting Kat Wollyung at [katkat@neo.rr.com](mailto:katkat@neo.rr.com)

### **B. Supply list for recreating these demos including item substitutions**

Most of the materials in our script can be purchased from local General/Grocery, Craft (Pat Catans, Michaels), Outdoor/Building Supplies (Lowe's, Home Depot), and Hardware stores.

Items required for each demonstration are listed in the "Required Supplies" section of this script, starting on Page 9. "Special" harder to find items are listed below.

Often the type and size of cups can be varied, but pay attention to if the cup needs to be clear (see-through not opaque) or needs to be sturdy (plastic not paper).

If you plan to scale-up or scale-down the experiment you may need to test the new procedure.

The few special items and their suppliers are listed here. For some experiments, alternative items are listed for some of the supplies. Using alternate items for acids and bases, or other changes to experiments, should also be tested for obtaining the desired result and for safety.

#### Experiment 1 –

- AMPS is amino methyl propanol. Approximately \$45/Liter from Sigma Aldrich #08581
- Our NCW programs in past years have made other polymers too from other ingredients, sometimes all household ingredients. See our website or ask to see our Cuyahoga County Public Library archives (located at Solon and the main branch in Parma) for more 'recipes'.

#### Experiment 2 –

- Benedict's solution is available at many chemical supply houses or check with your high school chemistry or biology departments.
- Parafilm is available at many chemical supply houses or check with your high school chemistry or biology departments.
- Powdered fructose is available at health food stores such as Wild Oats Market in Solon or possibly cake decorating stores. Glucose (dextrose) can be substituted as it is also a component of some sport drinks. Glucose gives a positive Benedict's test.

- Hot plates and 250 ml beakers may be more convenient in the school laboratory setting to speed the reaction. Fill a 250 ml beaker half full of water and heat to boiling. Add the capped vials. Remove within about 3 minutes using test tube holders.

Experiment 3 –

- Chromatography paper is available at chemical supply houses. A study coffee filter will also work.
- Ethanol (ethyl alcohol) is available at hardware or home supply stores as “denatured.”
- [http://biologyjunction.com/chromatography\\_plant\\_pigments.htm](http://biologyjunction.com/chromatography_plant_pigments.htm) for separation of plant pigments in leaves before and after they turn color in the autumn.

Experiment 4 –

No special information

Experiment 5 –

No special information

Experiment 6 –

- Calcium carbonate can be found as the product Damp Rid® (moisture-absorbing product for closets, basements, etc.) available at grocery and general merchandise stores. If you use Damp Rid use a heaping \_ teaspoon measure to compensate for other components in the product.
- Citric acid can be purchased as Sour Salt, available with other spices, at grocery stores.
- Baking soda (sodium bicarbonate) can be found at all grocery stores.