Session 1: Cabbage Juice Tests

Introduction

Students mix red cabbage juice with each of a variety of household liquids and record the color of the resulting mixtures. After conducting these tests, they classify household chemicals by the color they produce with cabbage juice. Students organize the liquids into as many or as few groups as they wish and choose a name for each group.

If you have time after you complete this session, plan to go directly to Session 2. Teachers have found that presenting these two lessons back-to-back builds on student momentum and eliminates some of the logistical problems of separating the two sessions (see the note on Session 2 on page 4). The following instructions, however, are written for those who must present these two sessions on different days.

What You Need

For the class:

You will need three household neutrals, three acids, and three bases. You may substitute other household acids, bases, and neutrals for the ones we suggest if it is more convenient, but make sure you include drain cleaner (a base), vinegar (an acid), and water (a neutral).

**Neutrals:** (Cabbage juice mixed with a neutral remains purple.)

- □ 32 oz. (1 liter) rubbing alcohol (isopropyl)
- □ three teaspoonfuls of table salt (25 g)
- □ 32 oz. (1 liter) water

**Bases:** (Bases cause cabbage juice to become green.)

- □ ½ tsp. (3 g) dry drain cleaner
- □ 30 tsp. (160 g) baking soda
- □ 40 antacid tablets

**Acids:** (Acids cause cabbage juice to become pink.)

- □ 16 oz. (500 ml) white vinegar
- □ 40 aspirin tablets
- □ 32 oz. (1 liter) lemon juice
Baby food jars with screw top lids are a convenient way to contain the test solutions, especially if you plan to present this activity several times.

Some teachers have chosen to use a bucket rinse station in addition to the sink in their classroom to alleviate student traffic around the sink. A bucket rinse station is mandatory for classrooms without sinks.

We suggest obtaining enough egg cartons so students may conduct their own tests. This is most important with younger students who derive great benefit from doing things themselves. This assists them in remembering what chemical was added and what color the mixture became. This arrangement also sidesteps competition over who gets to do what. Older students generally work well in groups of two or three. If you have older students and decide to have them work in groups, you will not need as many egg cartons.

If the prospect of acquiring so many medicine droppers seems unrealistic in your situation, consider making homemade droppers with drinking straws and tape using the following procedure. Cut a drinking straw in half. Fold over the top third of the straw and use clear tape to anchor the end of the straw. Squeeze the folded part as you would the rubber bulb of a medicine dropper. Keep in mind that making homemade droppers will significantly increase the amount of preparation time needed and that the homemade droppers are harder to rinse.

For making cabbage juice:

- 1 red cabbage
- 1 knife
- 1 non-aluminum pot, 1 gallon (4 liter) or larger
- 1 plastic container with a lid, 1 gallon (4 liter) (for storing cabbage juice)
- a large funnel
- 1 strainer
- stove or hot plate (need not be in classroom)
- 7 containers with screw tops, 2 quart (2 liter) or larger, such as plastic milk containers or vinegar jugs (for mixing solutions of household chemicals)
- a set of measuring spoons (or a metric balance)
- 1 measuring cup (1 cup or larger)
- a roll of masking tape or mailing labels
- a permanent marker
- sponges
- paper towels
- access to a sink or 1 or 2 buckets and 2 large squirt bottles of water for rinsing hands (A dishwashing liquid bottle, thoroughly rinsed to remove all soap residue, makes a good squirt bottle.)

For each group of 4–6 students:

- 1 cafeteria tray
- 12 clear plastic wide-mouthed cups
- 12 medicine droppers
- crayons or colored pencils (including at least pink, green, purple, and blue)

For each student:

- 1 white styrofoam egg carton (white plastic paint trays with at least 6 depressions can be used as an alternative to egg cartons)
- 1 “Telltale Colors” data sheet (master included on page 18.)
- 1 pencil
- 1 pair of safety goggles (Optional—see Safety Considerations on page 6.)

If styrofoam egg cartons are not available, you could also use white plastic paint trays from an art store.
Getting Ready

Several Weeks Before Beginning this Unit:

Start collecting white styrofoam egg cartons for use as mixing trays. You can ask students to bring in cartons from home or contact restaurants that serve lots of breakfasts (fast food chain restaurants go through dozens of egg cartons per day).

Before the Day of the Activity:

1. Prepare the Cabbage Juice:

   a. Cut a red cabbage into 8 parts.
   b. Put the cabbage pieces in a non-aluminum pot.
   c. Add enough water to cover the cabbage.
   d. Boil for 10–15 minutes.
   e. Pour the contents of the pot through a strainer into a container.
   f. Discard the cabbage leaves.
   g. Cool the cabbage juice and store it in a covered container in the refrigerator.
      Freeze the cabbage juice if you plan to store it for longer than several days.

   If the water in your area of the country is very alkaline, it will cause the cabbage juice to turn blue-green when you first make it. If this is the case, discard and make a new batch using bottled water. If you find that your tap water is very alkaline, use bottled water to make all acid and neutral solutions as well.

   Sometimes cabbage juice will take on a bluish tint after you have used it for awhile. This slight color change will not interfere with its indicator properties. However, your students will probably insist on calling it “blue” rather than “purple.” If your cabbage juice becomes greenish or slightly pink, it has most likely been contaminated. If this happens, you can add a little acid to remove the green tint, a little base to remove the pink tint, or discard the cabbage juice and make a new batch.

IMPORTANT NOTE:
Since this guide was first published, Lawrence Hall of Science staff and many teachers have learned that it is not necessary to cook the cabbage juice. Wedges of cabbage can be put in a blender, and the juice strained through a metal strainer lined with a paper towel or coffee filter (or using cheesecloth). This juice can then be used in these activities. This obviously saves some preparation, greatly lessens the odor, and does not require heat. Some teachers say that the brightness of the color can be somewhat affected, but it still clearly distinguishes and works well for these activities. It is also worth noting that cabbage juice can be frozen over longer periods for later classroom use.
Students will comment on the way the cabbage juice "stinks" so you may want to prepare them for this or make light of the odor in one way or another.

2. Prepare Solutions of Household Chemicals:

The following instructions describe how to make 2 quarts (2 liters) of solution at the proper concentration.

**Neutrals**

* Alcohol: Use full-strength rubbing alcohol.

* Water: Use tap water unless your local water is very alkaline. If that is the case, use bottled water.

* Salt Water: Dissolve several teaspoonfuls of table salt in 2 quarts of tap water or bottled water.

**Bases**

* Drain Cleaner: Dissolve ½ teaspoon of dry drain cleaner in 2 quarts of tap water. (Caution: pure drain cleaner is extremely caustic. Avoid contact with your skin.)

* Baking Soda: Dissolve 30 teaspoons of baking soda in 2 quarts of tap water.

* Antacid: Dissolve 40 antacid tablets in 2 quarts of tap water. (Crush the tablets to hasten dissolving. The stabilizer in the antacid tablets will not dissolve, nor will it interfere with the test.)
Acids

Vinegar: Combine 16 ounces (500 ml) of household vinegar with 16 ounces (500 ml) of tap or bottled water.

Aspirin: Dissolve 40 aspirin tablets in 2 quarts of tap or bottled water. (Crush the tablets to hasten dissolving.)

Lemon Juice: Use full strength.

3. Test the solutions with cabbage juice. Following the test procedure described on page 15, mix each of the acid and base solutions with cabbage juice to make sure the acids turn cabbage juice pink, the bases turn cabbage juice green or greenish-blue, and the neutrals don’t change the color of the cabbage juice. The recipes provided in this guide have been carefully tested, but depending on your particular brand of antacid or vinegar, or a number of other variables, it’s possible that a solution might need to be made stronger. Acid and base solutions can be made stronger by adding more base or more acid. Neutral solutions can be remade using distilled water. It’s also worth noting that some antacid and aspirin products are coated with a chemical to make them time-release capsules. If this is the case, you may have to wait a few minutes to observe the complete color change in these solutions.

4. Label Containers

- Duplicate labels onto blank sheets of self-adhesive mailing labels using the master label sheets located at the back of this guide, or, use a permanent marker and masking tape to make your own labels. Label plastic cups with the name of each solution. You’ll need to label one cup for each group of 4–6 students. To make masking tape labels quickly: stick a length of masking tape several feet long to a flat, smooth, surface; write the name of the solution 4–6 times along the strip; remove the tape from the table, segment by segment; and stick the labels on the containers.
2. Emphasize the need for good safety practices.

   a. Point out to your students that some of the solutions can be harmful to their skin or in their mouth or eyes. If you are using safety goggles, mention their importance at this point. Even if you have decided not to have your students wear eye protection, discuss the danger of splashing chemicals and the fact that chemists often wear safety goggles.

   b. Spills should be wiped up with a sponge immediately. If a student spills solution on her skin, she should first tell you and then calmly walk to the sink and rinse it off (or if you have no sink, use the rinse bottle to rinse the skin over the bucket). Tell students not to rub their eyes with their hands.

3. Demonstrate the test procedure:

   a. Put a half medicine dropper of cabbage juice into the first compartment of the egg carton.

   b. Add the same amount of one of the household test solutions to the same compartment and gently jiggle the egg carton to mix the two solutions.

   c. Select the crayon or colored pencil that most closely matches the color of the mixture and record the color on the “Telltale Colors” data sheet. If students cannot find a crayon that will record the precise color of the solution, they can mix two colors together to make a color that is about right. Tell them it need not be exact.

If you are working with older students, you might want to have them measure equal amounts, or count an equal number of drops of cabbage juice and test solution. However, while encouraging precision and measurement is a worthwhile emphasis, it is not necessary for the test itself.
Students conduct their tests at different rates. If you do not have something for them to do as soon as they finish, they may be tempted to start mixing solutions randomly. This is why the entire procedure for what to do when finished is presented now and not later. Some students will need you to remind them how to “group” their chemicals.

You may also want to suggest ways in which your students can keep track of which chemical is in which compartment. Some students have tested the chemicals in the same order in which they are listed on the data sheet, other students have numbered or labeled the compartments using masking tape or writing directly on the styrofoam.

4. Point out that when they finish testing all chemicals, they should do the following: (List on the board.)

   a. Don’t empty your egg carton when you finish. (They will need the different colored solutions for the next activity.)

   b. Go on to Step 2 on your data sheet. (They will need to group the solutions according to color produced when mixed with cabbage juice. For instance, if several solutions turn pink, they’d be in one group called the “P” group, the “Pink Panthers,” or some other name. The students should write the name for that group in the column labeled “Group Name.”)

**Conducting the Cabbage Juice Tests**

1. Have your students get out crayons or colored pencils and come to the equipment table to get an egg carton, goggles, and a “Telltale Colors” data sheet.

2. Distribute one tray of solutions to each group of 4–6 students.
3. Have the students start testing their solutions.

4. Circulate around the room, asking and answering questions. Remind students not to dump the contents of their egg cartons when they finish.

5. Answer questions your students have about grouping and naming groups of chemicals. If a student has difficulty understanding what you mean by grouping or classifying, you might want to suggest that he divide the results into "families" of colors—colors that appear related.

6. Have the students close their cartons with the solutions still inside and use masking tape to label the lids. Have them close the lids and set the egg cartons in a location that you designate.

7. Collect all data sheets.

Cleanup

1. If you will be presenting the next session in the next day or so, the solutions can be left in the cups. Some teachers stack the trays, still holding all of the cups, in the corner of the classroom. Otherwise, pour the remaining liquids back to the proper gallon containers. If a solution looks contaminated, pour it down the drain. This is an acceptable way to dispose of these particular dilute solutions, but in general it is not a safe method for disposing of chemicals.

2. Store the cabbage juice in the refrigerator.

If your students are slow in testing, you might ask a student who has developed a system for testing to tell the other students how she does it.
# Telltale Colors

1. Mix each chemical with cabbage juice. (What color does it become?)

2. After you test all of the chemicals, group those test chemicals that look the same when mixed with cabbage juice. Make as many groups as you need and think of a name for each group.

<table>
<thead>
<tr>
<th>Name of test chemical</th>
<th>Color it turns cabbage juice</th>
<th>Group name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinegar</td>
<td></td>
<td></td>
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<tr>
<td>Baking soda</td>
<td></td>
<td></td>
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<tr>
<td>Water</td>
<td></td>
<td></td>
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<tr>
<td>Lemon juice</td>
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<tr>
<td>Salt water</td>
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<tr>
<td>Drain cleaner</td>
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<tr>
<td>Aspirin</td>
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<tr>
<td>Tummy tablets</td>
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<tr>
<td>Alcohol</td>
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