tried & true
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Every rock band has its signature songs, every restaurant has its specialties, and every magician has a famous trick. So it is with science teachers. We each have our own special activities and demonstrations, and we improve upon them every year. We may not remember where we originally found the lessons—perhaps from a former teacher, a mentor, a textbook, or a workshop—but they have become an integral part of our classroom instruction.

Every year, some of our incoming students know they will do certain labs or see particular demonstrations in our classrooms. Word is passed down from sibling to sibling, and some students start asking for these activities on the very first day of school. Older students who come back to visit us often recall these activities and vividly describe their favorites.

It is these kinds of activities that Science Scope hoped to capture when the editors introduced the “Tried and True” column in February 2003. We did not solicit or recruit a specific writer, as we do for other columns, because we wanted submissions from as many of our readers as possible. We wanted as full a representation of the nature and variety of classic science activities as we could get. So our call for papers has remained more or less the same over the intervening years:

Do you have an activity that has withstood the test of time, one that deserves a place in any collection of lab classics? Perhaps you have been doing it so long that you have forgotten where you originally found it, or you have changed it so much that it hardly resembles the original. Tell us what makes the activity worth keeping. Is it the never-fail excitement it generates with students? Is it the clarity with which it teaches a concept? Is it the ease with which it develops valued lab or process skills? What special ingredients or twists do you add to make the classic version even better?

Many of these activities originated before computers and calculators were used in classrooms, but they are timeless and most can easily be refitted to incorporate today’s technology—including probes, gauges, sensors, computers, and other interactive media devices.

Every teacher has his or her own special reason for using a Tried and True activity, but the multipurpose, flexible nature of these classics is part of what makes them so enduring and so endearing. What serves as a springboard introductory activity for one teacher can be a unit capstone for another; what is a formative assessment in one class can be part of a summative assessment in another. For example, if the “Egg-in-the-Bottle Demonstration” is done at the start of a unit on heat and air pressure, as the author suggests, it will reveal students’ prior knowledge of the topic and any preconceptions they might have. However, the same activity would work equally well as a summative assessment at the end of an air pressure unit to let the teacher know whether the students had understood the concepts taught. In the same way,
assigning the writing task described in “Peanut Butter and Jelly Science” before reviewing procedure writing will let the teacher know how much practice students need with the process. That same exercise, on the other hand, could be turned into an excellent essay question at the end of a review unit on direction writing.

Organization of This Book
The volume in your hands contains a varied and useful collection of “Tried and True” columns from the past seven years. They are organized by instructional strategies and the core science disciplines—life science, Earth and space science, physics, and chemistry.

Activities that can be used as stand-alone lessons to develop particular science skills appear first in the book, under the heading “Developing Inquiry Skills.” However, applicable content can be easily incorporated into any of these lessons to teach science skills in tandem with other topics of study. Similarly, many of the content-specific lessons listed in core areas of science can be turned into stand-alone science skills activities.

Some of the activities in this collection fit more than one science content area. “Soil Is More Than Just Dirt,” for example, is listed as a life science activity, but it could easily be crafted into an Earth science activity as well. Similarly, “Evaporating Is Cool,” which falls under chemistry here, would make an excellent weather or water cycle–related Earth science activity.

You can also use the lesson formats of these activities as templates for designing or restructuring your own investigations and demonstrations. “Tried and True” activities can be enhanced with the use of higher-level critical-thinking questions or extended into more open-ended inquiry investigations. With additions, many of these activities can easily become 5E inquiry lessons, and those which are more teacher-centered can be made more student-centered by giving fewer directions and less information to students.

Veteran teachers will find new activities within this collection, or new twists to activities they are already doing, but this collection will be especially useful to new teachers who are just developing their own signature lessons. Will students start to know you as the teacher who shuffles cards? Or perhaps as the one who asks her students to write advertisements for cell organelle jobs? Only time will tell.

Safety Note
These activities do contain safety precautions. However, before attempting any activity with students, work through it step-by-step on your own so you know what to expect. Then add whatever supplemental safety instructions or warnings you feel are necessary.
One of the “good old” standard activities middle school students seem to enjoy is paper chromatography. The procedures and materials needed are relatively simple and the results can be colorful. All too often, however, the activity ends just after these colorful results are obtained, cutting short the potential it holds for some further inquiry. With some ingenuity and forethought, teachers can easily modify this activity to promote more inquiry by their students and address levels 5–8 of the National Science Education Standards for inquiry and physical science, which focus on the properties and changes in matter (NRC 1996). Appropriate modifications can also provide students with additional practice in measuring, collecting, and analyzing data and generating additional questions to investigate.

Chromatography is a technique used in separating mixtures to identify their components. There are many variations of the technique, but in each of them a substance, usually a mixture, is placed onto or into a medium (such as a filter paper strip in the case of paper chromatography) and a solvent is allowed to pass through the medium. The mixture moves through the medium with the solvent (i.e., dissolves in it). Different types of molecules are moved different distances by solvents, generally due to the ease with which each particular molecule is dissolved in and can remain dissolved in the solvent. Those components that can remain dissolved the longest are moved farthest by the moving solvent, while those less soluble are left behind. This causes the components of the mixture to separate, making analysis of the original mixture easier. The result is called a chromatogram. Among other things, chromatography is used in crime labs to separate the components of “clue” substances, such as ink or blood. The chromatograms created by this technique from laboratory “knowns” are compared to chromatograms made from samples of materials obtained from suspected sources.

**The Classic Paper Chromatography Activity**

In the classic paper chromatography activity (see Figure 1), students are asked to take a black water-soluble marker and make a large dot about a centimeter from the end of a strip of filter paper approximately 2–8 cm in size. A pencil or craft stick is then placed across the top of a clear plastic
cup, and the paper strip is folded so that the end with the marker dot extends down into the cup and the other end makes a 90-degree angle and rests on the stick. Water is then carefully poured into the cup until it just reaches the lower end of the paper strip. The water moves up through the paper wick and begins to dissolve the ink in the dot. As the water continues to move up the paper strip, the colors used to make the black ink begin to separate and become visible on the paper. By using two or more different black inks, each on a different paper, students compare the different chromatograms. They can repeat this procedure using ink samples from two red pens, or any other color, to see how the pigment blends vary.

Some versions of the activity ask students to consider what would happen if one of the black inks was not water soluble but could be dissolved in alcohol. If this was the case, should alcohol also be used on the other black inks, too? After some student analysis of their chromatogram results and discussion of these questions, the activity is typically brought to an end. At this point, some inquiry about the inks certainly has occurred, but much more is possible. Safety note: Students should wear chemical-splash goggles during all chromatography activities.

Extending the Inquiry
Some science curricula (e.g., GEMS 1985) suggest extending this paper chromatography inquiry further by asking students to try the technique with different colors of ink or with substances other than ink, such as vegetable matter or juice (e.g., spinach, carrots, purple cabbage, flower petals). These extensions can certainly further the inquiry students do with paper chromatography. However, other extensions can provide even more opportunities for students to collect, record, graph, and analyze quantitative data and begin drawing some

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**Figure 2**
Order of appearance of colors on filter paper strips

**Directions:** For each pen/ink sample, write “1” in the space on the table for the color that first appears, write “2” in the space for the second color to appear, etc.

<table>
<thead>
<tr>
<th>Pen/ink sample</th>
<th>Pink</th>
<th>Red</th>
<th>Orange</th>
<th>Yellow</th>
<th>Green</th>
<th>Blue</th>
<th>Indigo/purple</th>
<th>Other</th>
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**Figure 3**
Histogram for order of color appearance

**Directions:** For each pen/ink sample, color in the first color to appear in the lowest box on the histogram. For the second color, color in the second box. Continue with each box on the histogram until all colors for each pen are graphed.

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conclusions. Consider the following extensions to further investigate the chromatographic process. In each case, the data obtained should be recorded in a data table and then plotted on a histogram to facilitate later analysis.

A. Record the order in which colors appear from each of the black inks. List the colors in order from the one that appeared first to the one that appeared last (see Figures 2 and 3). Have students compare each of the filter paper strips and discuss whether similar colors (e.g., yellow) appeared in the same or different orders in relation to the other colors. Have students explain their results.

B. Record the time (in minutes) required for the colors to move up the filter paper strip (see Figures 4 and 5). Begin timing at the moment water is added to the container and the black ink dot becomes wet. For each color, record the time when the color is clearly present. As students analyze the data, ask them to determine if each similar color (e.g., yellow) on each paper strip appeared after the same amount of time. Again, have students try to explain their results.

C. Once all the colors have finished moving, remove the filter paper strip and measure the thickness (from bottom to top) of each band of color. Teachers should note that measuring the thickness of color bands could prove difficult for students because the color bands tend to blend together at their
edges and do not appear in distinct and separate bands. Students need to make judgments as to where one color ends and the other begins. Then have students compare the thickness of the bands from one filter paper strip to those on the other strips. Ask students to determine whether the thickness of all similar colors (e.g., all the yellows) is the same on all the strips and try to explain the results.

D. When the color movement has stopped, take the filter paper strip from the cup and measure the distance of each color from the top of the original black ink spot. Measure the distance in millimeters from the top of the original black dot to the bottom of each color. Again, because the color bands blend together at their edges, teachers may prefer to have their students determine the center points of each color band and measure from the top of the ink dot to these mid-band points. Have students compare the distance each color moved from the top of the black dot to the point at which it first appeared (or to the center of the color band, depending on the procedures followed). Have students determine whether the distances for all the yellows, for example, were the same. Again, ask students to try to explain these results.

Other Questions
Once students have collected, graphed, and analyzed all the data, have them reflect on questions that require them to consider the data as a whole. For example, based on all the different comparisons, are all the similar colors on all the filter paper strips the same (e.g., do you think all the yellows are the same yellow ink)? Students should be asked to explain their reasoning. Students could also consider a black ink that did not produce any colors on its filter paper strip. They could offer explanations for why it didn’t produce any colors and then design an investigation to find out why.

Last Drop
Although the number of good inquiry-oriented science activities has grown over the past decade, there are many still circulating that could be improved and strengthened through relatively simple modifications to better address the National Science Education Standards. The activity and modifications of paper chromatography described here are but a few examples of what teachers can do in this regard, and are an example of what Colburn (2000) described as “structured inquiry,” in which the teacher provides the question or problem to be investigated, the materials, and some or all of the procedures. Further modifications could easily change this to a guided inquiry, where the teacher provides the materials and question(s) to investigate and students come up with the procedures, particularly if the “classic” paper chromatography activity is the beginning point (in which students learn the basic procedure). Still further modifications could result in more of an open-inquiry approach in which students begin to formulate their own questions to ask and then proceed to devise their own investigations. For example, students may become curious about whether changes in the medium (in this case, the type of paper used) or the solvent (in this case, water) might produce different outcomes.

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