Exploring Plant Dyes

Overview: Nature presents an incredible visual rainbow. For centuries, people have captured these natural hues for decorating animal skins, fabrics, crafts, hair, and bodies. Dyeing with plants can provide an intriguing lens for exploring the local environment, learning science concepts, conducting experiments, learning about history and other cultures, and creating compelling crafts.

Grade Level/Range: K- 8th

Objective: Students will investigate the use of plants to create natural dyes, experimenting with different dyeing methods and a variety of plant materials.

Time: 1 hour to 4 days

Materials:

- **Pounded Flower Prints:** fresh flowers and leaves, rubber mallet, white or light-colored cotton fabric, safety goggles, wax paper, newspaper
- **Sun-Brewed Dye Bath:** Distilled water or pre-measured tap water that has been allowed to sit uncovered for a day or two to allow chlorine to evaporate; various fibers (wool, cotton, silk, linen; fabric or yarn); glass pint jars with lids; alum* (aluminum potassium sulfate from a pharmacy, craft store, or spices section of grocery store); plastic wrap; paper towels; plastic or wooden spoons
- **Stovetop Dye Bath:** Various plant materials, large enamel pot, hotplate or stovetop, large wooden spoon or spatula, alum*, cream of tartar* (available in spices section of grocery store), fabric or yarn, cheesecloth or nylon stockings

  ***Note:** Alum and cream of tartar are used as mordants. These are substances that act as fixatives to chemically attach or "set" the dye to the material being colored.

Background Information:

Since prehistoric times, humans from across the globe have used plant pigments to enrich their lives. Historians and scientists believe that prehistoric animal skins and cave paintings dating back to 15,000 B.C. were dyed with plant pigments. They've discovered examples of early dyed fibers in Egypt dating to around 2000 B.C., and Chinese records revealing even earlier use of plants as fabric dyes. Ancient Britons, called Picts, used a plant called woad to dye their bodies blue and frighten enemies in battle, while the British "red coats" who marched against the Americans in Revolutionary War times wore uniforms colored with dye made from the roots of the madder plant.

Most plant parts have a mixture of pigments, which is why dyes made from plants tend to appear more subtle and muted—less "pure"—than the synthetic dyes that are now used to color our world. However, the "earth tones" of plant dyes continue to intrigue many hobby and craft dyers because the rich hues of Mother Nature all seem to "go together."

Laying the Groundwork:

Invite your students to consider the following: *Why do plants have so many different colors? What purpose might they serve for the plant?* The green in most leaves is surely the most ubiquitous plant color. The green pigment chlorophyll in the leaves helps capture the sun's energy and convert it to chemical energy, which is then stored and used as food for the plant. Colors in flowers are adaptations that attract insects and other animals that, in turn, pollinate and help plants reproduce. Some plants have colorful fruits that attract animals to eat them, inadvertently spreading the plant's seeds as they do so. Scientists believe that other pigments may help protect plants from disease. Despite what we know about the role of a few of the thousands of plant pigments, the role of most colors in plants remains a mystery to scientists!

Exploration:

There are a number of different methods for extracting the pigments from plants to use as a natural dye. Try one or more of following techniques to demonstrate the process for your students (a list of suggested plants to use is listed below):

Pounded Flower Prints

1. A first step in exploring the mystery of plant pigments is to transfer them directly to fabric, creating decorative patterns to adorn napkins, pillowcases, or to make prints for framing. Have kids predict what colors their prints will be, explain their thinking, and then compare and discuss the results.
2. If using new napkins or pillowcases, wash them first to remove sizing. If students are making a print to be framed, cut fabric 1 inch larger than frame size so they can wrap the fabric around a piece of cardboard in the frame.
3. Cut flowers from stems, leaving a little bit of stem attached.
4. Choose a workspace that can be safely pounded with a hammer, such as the floor or a sturdy worktable. Cover the surface with thick protective layer of newspaper, and place wax paper on top to keep the newsprint from being transferred to the fabric. Lay fabric on top of the wax paper. Have kids practice on scrap fabric first to see the effects of different flowers.
5. Invite students to experiment with designs. They should place flowers and leaves face down on the fabric and place sheet of wax paper over the entire design.
6. With safety goggles on, students can hammer through the wax paper to transfer the flower pigment onto the fabric. Make sure they pound along the margins to define the shape. Thick flowers require more pounding.
7. Remove wax paper and check the fabric. Students may want to add more flowers and continue the process until they are pleased with the results. For a print to be framed, leave the small flower pieces that adhere to the fabric. For napkins and pillowcases, remove the residue.
8. Wash napkins and pillowcases in cold water and iron them. (Flower prints may fade when washed in hot water.) For a framed print, iron the fabric, then wrap the border of the fabric around the thin piece of cardboard that comes with the frame (or provide your own). Tape fabric to cardboard and place it in the frame.

Sun-Brewed Dye Bath

1. This is a simple dyeing method used by Native Americans that takes advantage of the sun as a heat source. It offers lots of variables for experimentation. Consider the following to get your juices flowing: Vary amounts of fabric or yarn. Use different kinds of fabric or yarn. Vary how long you steep plant parts and/or fabric.
2. Collect plant parts noted in the chart below. Crush berries and chop other plant parts, place them in the jars, and add water to within an inch of the brim. Cap the jars. (Note: If jar lids contain metal, cover the mouth first with plastic wrap to prevent the metal from reacting with the dye.)
3. Place the jar in a warm, sunny place for several days and then strain the liquid through cheesecloth or a strainer. Place the plant material in the compost pile or worm bin.
4. To each pint jar, add 1/4 teaspoon of alum and stir with a wooden or plastic spoon. Place moistened material or yarn in each jar, distribute it evenly, and replace the lids. Return jars to a sunny spot for 1 to 4 days.
5. Remove material and rinse it gently in cool, clear water. Place it on paper towels to dry.

Stovetop Dye Bath

Prepared to take your dyeing project to the next step? This activity requires more equipment, time, and materials, and will reward students with more colored fabric for their efforts. Students may want to experiment by leaving the fabric in the dye bath for different amounts of time, even overnight. Or they might want to do some "tie dyeing" to see what patterns emerge when they tie knots, gather fabric into clumps with rubber bands, or otherwise prevent the dye from penetrating throughout the fabric.

1. Get the color out. Prepare plant materials as in the Sun-Brewed Dye Bath activity (above). In an enamel pot, cover the plant materials with water and then simmer them for about an hour until the water is colored and the plant tissues look bleached. Strain the dye bath through cheesecloth or an old stocking to get rid of plant material. (Some dyers do simultaneous dyeing in which the plant materials are left in when the fabric is dyed. If you decide to do this, place the plants or the fabric in an old stocking or net bag to protect the material from direct contact.)
2. Treat the material to be dyed. Wash material with soap to remove dirt and oils that could prevent the dye from binding to the fabric. If you're using a skein of yarn, tie it loosely so the mordant and dye can penetrate well.
3. Treat with mordant. If you're just getting started, you may choose not to use a mordant to "fix" the dye. Some plants will yield colorfast dyes without a mordant (e.g. turmeric and black walnut hulls), and others may yield color without a mordant, but it may wear out with washing and sunlight (e.g. purple cabbage).

   If you're using the mordant alum to help the dye bind better to the fabric, you can either pretreat the yarn or fabric (as is typically done) or try adding the mordant directly to the dye bath. To pretreat the yarn or fabric, measure 3/4 teaspoon alum plus 1/4 teaspoon cream of tartar per each quart of water in your dye bath. Dissolve this in a cup of hot water, then add it to a pot of water (1 quart of water per each ounce of fabric). Wet the fabric to ensure penetration, then add it to the mordant solution. Heat slowly at a simmer for one hour. (Wool, in particular, doesn't respond well to rapid temperature changes.) Remove the pot from the heat; cool and rinse the fabric before adding it to the dye bath.
4. Begin dyeing. Simmer for 30 to 60 minutes, turning the material gently. Stir and check the color every 10 minutes or so. Rinse dyed materials with progressively cooler water and hang them to dry.

Here are some ideas for plants to grow and/or collect for dyeing. Note that plants are listed with corresponding colors, but your results may vary depending on the amount of the plant used, stage of maturity, soil fertility, and other environmental and procedural factors. *(*Never pick a flower that seems to be in short supply in an area or that you know to be endangered.)*

Color	Plant
Blue	Leaves: red cabbage Fruit: elderberries Leaves & stems: tomato plants
Yellow	Leaves: alder, mint, parsley, birch Flowers: aster, calendula, chamomile, dandelion, golden marguerite, marigolds, zinnias Leaves & stems: bindweed, mullein, wild mustard
Green	Leaves: carrots, golden marguerite Flowers: black-eyed Susan Leaves & stems: spinach
Orange	Flowers: dyer's coreopsis Other: turmeric
Gold/Brass	Flowers: sunflower Leaves & stems: cocklebur, dock, goldenrod, redroot pigweed Seeds: sunflower
Tan/Brown	Leaves: birch Fruit: hawthorn Other: coffee grounds
Magenta	Roots: dandelion
Pink	Leaves: red cabbage
Purple	Fruit: wild grapes, mulberries
Red	Roots: madder
Black	Black walnut hulls

Making Connections:

Evaluate the results of your dyeing experiments and ask students,

- *Did the plants produce the colors you were expecting?*
- *How do the colors from these natural dyes compared to those obtained by synthetic dyes?*
- *Which colors do you prefer and why? Why is color so important? What does it add to our lives?*

Branching Out:

Science: Continue experimenting with natural dyes. It's generally easier to dye animal fibers like wool and silk than plant-based fibers like cotton or linen. The scale-like protein molecules in wool fibers provide a lot of active "sites" to which pigment molecules can attach. Cotton, flax, and other plant fibers, on the other hand, are made mostly of smoother cellulose, which has few sites available to combine with color molecules. Invite your students to carefully observe different types of fibers and fabrics under magnifying lenses. (You may want to include synthetic fabrics as well. Pigments will bind differently to each type of fiber.) Consider numbering each sample and have students, notebooks in hand, describe and/or draw each specimen and compare it with others. (You may want to reveal the origin of each type of fiber.) Which do they predict will more readily "take" a dye and hang onto it? Have them explain their responses and then give them an opportunity to test their assumptions.

History: Ask students to imagine and discuss how they think early humans might have discovered that they could use plant pigments to color their bodies, hair, crafts, animal skins, and fabrics. Encourage exploration through library and Internet research. You may want to ask a local experienced craft dyer or folk life educator to speak to your class.

Nutrition: Color makes things more appealing, including foods. A quick survey of ingredient labels shows that everything from breakfast cereal to hot dogs has some hue included to make it more appealing. Before synthetic food colors were available, most food color additives were derived from edible berries, flowers, and even medicinal lichens. Although synthetic food color is widespread, there has been past and present speculation about the safety of its use. Explore food coloring with students. Investigate ingredient labels to find the use of natural ingredients to add color (many of which have been used throughout history) such as annato, saffron, turmeric, extracts of carrots (beta-carotene), beet powder, fruit juices, paprika, and hibiscus flowers. Older students may want to research and debate the use of synthetic food color versus natural additives.