



Science Unit: *Plants*

Lesson 8: *Using Plant Pigments as Natural Dyes*

School year: 2004/2005

Developed for: Queen Alexandra Elementary School, Vancouver School District

Developed by: Paige Axelrod (scientist) and Janet Vesterback (teacher)

Grade level: Presented to grade 3; appropriate for grades 1 – 7 with age appropriate modifications.

Duration of lesson: 1 hour and 20 minutes for initial lesson, and continued as necessary in further lessons to achieve final product.

Notes: This lesson is based on the Natural Dye Lesson Plan by Beth Calder, Ph.D., University of Maine. See reference 1.

Objectives

1. To identify major pigments occurring naturally in plants: chlorophyll (green), carotenoids (yellow, orange and red), and anthocyanins (red, purple and blue).
2. To use the pigments found in blueberries and onion skins to make natural dyes and to use these dyes on white cotton material and string.
3. To link the lesson to fine arts by creating friendship bracelets with the string, and quilt squares with the material.

Background Information

Plants contain different types of pigments that are important to plant metabolism. These pigments include chlorophyll, carotenoids, and flavonoids. Chlorophyll is a green pigment used by plants during photosynthesis to capture light energy and convert it to chemical energy. Photosynthesis also requires carbon dioxide (from the air) and water to produce chemical energy (food) and oxygen. Chlorophyll absorbs blue and red light and reflects green light, thereby allowing us to see the many shades of green in plant leaves. Carotenoids are yellow, orange, and red pigments that have a light-harvesting function during photosynthesis. Carotenoids also have antioxidant properties. Carotenoids are found in plant parts such as carrot roots, corn seeds, and tomato fruits. Flavonoids are yellow, red, blue and purple pigments. Their functions include attracting insects, resulting in pollination. Yellow flavonoids are found in potatoes and yellow onions, as well as many flowers. Anthocyanins are a type of flavonoid found in blueberries, grapes, and red cabbage with red colors visible at acidic pH and blue colors visible at basic pH.

Chlorophyll and carotenoids are fat soluble pigments found in leaves, fruits, and vegetables. These pigments are not water-soluble. Flavonoids are water soluble pigments found in many flowers, fruits and vegetables. It is important to know if pigments are fat soluble or water soluble when making natural dyes from plants.

Vocabulary

Pigment: Any coloring matter in the cells and tissues of plants or animals.

Chlorophyll: Green pigment in plants important to photosynthesis.

Carotenoids: Yellow, orange and red pigments.

Anthocyanins: Red, purple and blue pigments.



SCIENTIST IN RESIDENCE PROGRAM

Dyeing: The process of coloring something by saturating it in a solution containing a coloring agent.

Materials

- Strainer and large spoons
- Large glass jars
- Yellow onion skins
- Blueberries (Reasonably priced from Neptune Food Services Inc. in Delta, BC; phone #: (604) 540-5400; purchased 2 x 2.5 kg bags)
- 9 inch squares of washed, preshrunk cotton material, preferably white or natural beige.
- Saucepans
- Cotton string (Cabled cotton twine from Home Hardware works well)
- Hot plates
- Masking tape

In the Classroom

Introductory Discussion

1. Ask students to identify the colours of a variety of plants we eat for food. Referring to those we identified as being stems, fruits, roots, etc., in a previous lesson would be a way to draw on previous knowledge and to link the new concepts to familiar ideas and items. [See Scientist in Residence Program Science Unit and Lesson: Plants, Lesson 6, Plant Parts and Their Function]
 - What forms these colours? Explain that these colours are formed by plant pigments.
 - Discuss what a pigment is and introduce the names of the 3 types of pigments (chlorophyll, carotenoids, and flavonoids). Write the names of these pigments on a chart or on the blackboard together with the colours they produce.
 - Ask children to categorize orally several fruits and vegetables according to their pigmentation.
2. Discuss the changing pigmentation of leaves in autumn.
 - Why do leaves change colour? (The pigments that cause autumn colours are always present but the chlorophyll masks them. When the chlorophyll breaks down as winter approaches, we can see the colours of the other pigments.)
3. Discuss how, for centuries, people have used plant pigments to add colour to materials and clothing.
 - Point out that natural pigments produce gentle colours which are more subdued than many of the commercial dyes.
 - Suggest to the students that we can make two kinds of dyes in the classroom with blueberries and onion skins. See if the children can identify the names of the pigments contained in these plants.
 - Point out to students that if we dye some string and some cloth, we can use these materials in art projects later.
4. Discuss safety issues: Do not go near hot plates or hot pigment solutions, do not taste or drink plant pigment solutions, and rinse your hands after the lesson. Create a safety zone around the hot plate with a tape border on the floor. Instruct students that they need to be with an adult if they go inside the tape border.



Science Activity/Experiment

Note: The bulk of the dyes can be prepared ahead of time by adults, and students can contribute by preparing small batches. This way, students will gain experience with the process, while generating enough solution to dye string and material for future art projects by the entire class.

5. Strip the skins from onions (one per student) and put the skins in a saucepan. Add water to cover the skins and bring it to a boil, then reduce the heat and let it simmer for several hours. Add more water if necessary. (This can be done on a hotplate in the classroom with constant adult supervision for safety reasons). Cool the onion skin broth and strain. Pour broth into large glass jars.
6. Put a quart or so of blueberries in a saucepan, or watch an adult do it. Add water to cover berries, bring to a boil and simmer over reduced heat for several hours, adding water if necessary. Cool blueberry broth and strain. Pour blueberry broth into large glass jars.
7. While the new dye solutions are simmering, use the dye solutions that were prepared ahead of time to colour strips of string and squares of material.
 - Put the string and material into the dye solutions in non-reactive containers, such as large glass jars. Large jars sealed with lids work well since the material can soak for a long time (24 hours) without concern about spills.
8. Strain the material and string out of the dye solutions, and note the new colours. Wash and dry the material (an adult can do this at home if the classroom is not equipped with a sink and a convenient place for drying). Have the colours changed? (The blueberry stained cloth will now be a grey colour since soaps have a basic pH and will alter the purple colour. We did not wash the string and were able to compare the two. The string remained light purple.)
9. Use the materials in art projects such as weaving or braiding friendship bracelets (string), adding beads if desired, and quilt making (cloth).
 - This requires several lessons to complete depending on the skill level of the class and the available help.
 - For quilt making, students should create their own designs first on paper, then on the material. They can colour their designs with crayons, paints or pastels made especially for fabrics.
 - Be sure they leave an edge of about 2 centimeters so other material (flashing, etc.) can be added and/or squares can be sewn together.
 - A quilt can be pieced together in 3 layers—top, batting, and bottom. Stitch through all layers with the help of adult volunteers and the grade 6/7 buddies. Each piece may be edged independently of the others and linked with a system of buttons and loops. This way of joining the squares is advantageous because the squares can be displayed as one blanket, but students can take home their own piece of the quilt later.

Closure Discussion

Review plant pigments and why they are important to plants and to people. Discuss different uses of plants, including the uses of plant pigments.

References

10. Calder, Beth. University of Maine, Natural Dye Lesson Plan, www.umaine.edu/NSFGK-12/images/PDFs/natdye.pdf.
11. Kwon, Charlotte, Editor/Publisher, Maiwa Handprints, A Newsletter for the Fiber Artist, vol. 4, issue 9.
12. Natural Dyeing (leaflet #603216), Maiwa Handprints Ltd., #6 – 1666 Johnson St., Granville Island, Vancouver, B.C. V6H 3S2 Phone: 604-669-3939 Fax: 604-669-0609 (subscriptions to newsletter are available free of charge) www.maiwa.com.



Teacher Assessment of Learning

13. Were students able to classify common plants according to their pigmentation?
14. In their science journals, how detailed and complete were the students' descriptions and pictures of the processes involved in making and using dyes?
15. Through observation, determine how engaged students were in the discussions and activities. Were they able to understand what to do and to focus well while doing it?

Extension of Lesson Plan

16. Make onion soup with the peeled onions. Chop the onions, put them in a pot with water and add bouillon powder. Easy and delicious! Serve with crackers or bread. (Our grade 3 students did this with their grade 6/7 buddies.)
17. Have students explore the effects of acids and bases on plant pigments. The blueberry solution will turn light pink if vinegar is added, or dark purple if baking soda is added.