Target Grade: Science 7-8
Lesson: Natural Dye Investigation

By Katherine Jolda

Time required: 4 class periods, 50 minutes each, with HW, or 5 class periods with no HW

Summary: In this lesson, students will apply Science Fundamentals to a natural dye investigation. Students will investigate the color properties of several whole plants native to and landscaped in the Bay Area. Students will be grouped into teams of 3-5. Each team will use one plant and the recommended procedure, and follow the Scientific Method for their research. Team reports on each plant will be written and illustrated, resulting in a class set. This lesson has procedures for eight plants. This lesson may be conducted outside (propane or gas stoves) or inside (electric hot plates and good ventilation).

CA Science skills:

- Following the Scientific Method
- Metric Measurements for volume, mass, dimensions, and temperature
- Using the pH scale
- Calculating density
- Making tables and graphs for data
- Identifying and tracking manipulated and responding variables
- Recording observations with writing and sketching
- Writing an account of the investigation in paragraph form, following the Scientific Method

Materials needed:

- Triple Beam Balance – one for two teams
- Metric rulers – two per team
- Glass thermometers C/F – one per group
- Enamel or stainless steel stock pot – one per plant
- Stirring sticks - one per plant
- Scissors – two per group
- Calculator – one per group
- Hydrion pH paper
- Plastic quart containers – one per group
- Hot plate or propane/gas burner – ideally one per plant, though plants may be rotated for heat as needed
- Collection and compost or disposal system for the spent plants (e.g. 5 g buckets)
- Drying rack for the yarn
- For the final report: writing paper or access to typing, pencils for sketching

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|---|---|
| 1) Coyote brush | Mordant : alum<br>Manipulation: iron |
| 2) Eucalyptus | Mordant: alum<br>Manipulation: iron |
| 3) Fennel | Mordant: alum<br>Manipulation: iron |
| 4) Toyon | Mordant: fresh water<br>Manipulation: sea water |
| 5) Loquat | Mordant: none<br>Manipulation: iron |
| 6) Purple Corn | Mordant: alum<br>Manipulation: pH change |
| 7) Black walnut leaves | Mordant: alum<br>Manipulation: iron |
| 8) Oak Galls | Mordant: none<br>Manipulation: iron |

Background info:

According to the Oxford English Dictionary, the Scientific Method is "a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypothesis." The conventional sequence that students should follow for this lesson is 1) question, 2) hypothesize, 3) predict, 4) test (experiment), 5) observe and record data, 6), analyze, 7) conclude, and 8) communicate.

Calculating density: D=M/V. Density equals mass times volume. To calculate the density of 1000 mL liquid. Using the triple beam balance, find the mass of an empty 1000mL graduated cylinder. Fill the cylinder with 1000 mL of the liquid. Find the mass of the filled cylinder. Subtract the mass of the empty cylinder to isolate the mass of the liquid. Divide the mass of the liquid by the volume (here, 1000 mL). The unit for liquid density is g/mL.

Human societies around the world practiced dying fibers with whole plants and other wild substances. Some of the most famous dye plants may be indigo from Japan, woad from Scotland, madder red in Europe and Turkey, royal/Tyrian purple from the murex mollusk, and the mud cloths from many parts of Africa. Demonstrating a wealth of knowledge about the natural world, people pulled an incredible rainbow of deep and lasting colors into their clothing, home furnishings, and rugs. It wasn't until a lab accident by an English chemist, William Henry Perkin, in the mid 19$^{th}$ century gave a purple dye that the synthetic dye industry began.

Overview: print and distribute this to students so they have time to read before Day 1

Day 1

1. Your group will receive the full instructions for your plant, a paper bag, and a labeled plant sample.
2. We will go out to the Nature Area, get a pair of pruning shears, find your plant, and gather the required mass. Alternative: the teacher may gather and bring all plants to the classroom
3. After you have the required mass of plant, you will cut/tear it into small "bite-sized" pieces.
4. All "bite-sized" pieces will go into your paper bag.
5. Label your bag with class period and table number.

**HW: Pre-read the full instructions and write your hypothesis: What color do you think the plant will make, and why do you think this?**

Day 2

1. Using the required measurements for water, temperature, and plant mass, fill your cook pots and heat on the hot plates.
2. While the water is heating, cut and label your yarn lengths and put it to soak in the water tub. Wring it like a sponge so it absorbs water.
    - Label with your class period and table number. Make one set "A" (control) and "B" (manipulation).
3. When the water is heavily steaming, turn the heat down and put in the fiber.
4. While the yarn steeps, you should stir occasionally.
5. Record observations.
6. At the seven minute bell, turn heat off and begin clean up. Leave the plant mass, water, and yarn in the pot to steep overnight.

Day 3:

1. Go to your pot and fish out your labeled fiber samples.
2. Set "A" will be ready, so hang it to dry in the garden. You may temporarily remove set "B" while you modify the dye liquid.
3. For the manipulation, follow your procedure to modify the liquid.
4. When the liquid is prepared, place wet set "B" in the manipulation liquid.
5. Heat again, until steaming.
6. Write down all observations of change.
7. In the last 20 minutes of class, take "B" out of the liquid and hang to dry in the garden with set "A".
8. Dispose of the plant mass and liquid in the designated way. A compost pile is ideal, but trash and drains will also work.

DAY 4:

1. Sketch your plant sample. This may be color or BW. Computer time may be allowed for additional research.
2. Convert observation notes for the control and manipulation into paragraph form, focusing on sequence.
3. Begin drafting your report of the first five steps of the Scientific Method.

Day 5 or HW from Day 4:

1. Review your investigation and write your analysis and conclusion of the work. Convert all seven steps into a finished document, with illustration. This may be assigned as group work or individual reports.

Final step: Communication. This is flexible. Student groups can present to each other in class, for school Open House, to a younger science class, or even to school administrators, who will, invariably, be impressed!

# Coyote Brush

Scientific name: Baccharis pilularis

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Collect and weigh 200g of leaves and stems.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^0$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^o$C, add both wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry.
2) Add 500mL of iron water to the dye bath.
3) Turn on low heat and bring to 100 C. Record observations.
4) Test the pH again _____.
5) In the last 20 min of class, remove the yarn and hang to dry next to set A.
6) Dispose of the plant mass and liquid in the designated method.

# Red Ironbark Eucalyptus

Scientific name: Eucalyptus sideroxylon

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Weigh 200g of the bark chunks. Using stones, crush the bark into pieces about 2 cm2 and dust.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^{0}$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^{o}$C, add both wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry.
2) Add 500mL of iron water to the dye bath.
3) Turn on low heat and bring to 100 C. Record observations.
4) Test the pH again _____.
5) In the last 20 min of class, remove the yarn and hang to dry next to set A.
6) Dispose of the plant mass and liquid in the designated method.

# Wild Fennel

Scientific name: Foeniculum vulgare

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Collect and weigh 300g of green feathery leaves and stems. Don't collect yellow/brown parts.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^{0}$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^{o}$C, add both wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry.
2) Add 500mL of iron water to the dye bath.
3) Turn on low heat and bring to 100 C. Record observations.
4) Test the pH again _____.
5) In the last 20 min of class, remove the yarn and hang to dry next to set A.
6) Dispose of the plant mass and liquid in the designated method.

# Toyon

Scientific name: Heteromeles arbutifolia

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Collect and weigh 500g of leaves and stems, in two piles of 250 g each.
3) Count 40 pennies.
4) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

**Calculate the density of tap water and salty bay water.**
**D=M/V**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put 250g of small pieces of plant and 20 pennies in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^0$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put bundle A to soak in tap water.
8) When your water and plant mass are 100$^o$C, add the bundle.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Remove set A and hang to dry, and dispose of liquid.
2) Fill pot with 3L of Bay water, 250g plant, and 20 pennies.
3) Heat water and plant mass to 100 $^0$C.
4) Put bundle B into the new dye liquid and keep at 100C.
5) Stir occasionally while the yarn steeps.
6) Test the dye liquid pH with Hydrion paper. pH_____
7) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep. Remove B on day 4.

# Loquat leaves

Scientific name: Eriobotrya japonica

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Collect and weigh 200g of the leaves. Tear into pieces 3cm3.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^{0}$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^{o}$C, add both wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry.
2) Add 500mL of iron water to the dye bath.
3) Turn on low heat and bring to 100 C. Record observations.
4) Test the pH again _____.
5) In the last 20 min of class, remove the yarn and hang to dry next to set A.
6) Dispose of the plant mass and liquid in the designated method.

# Purple Corn

Scientific name: Zea Maize

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Twist the kernels off the cobs until you have 300g.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 96 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, and "B" and "C", the manipulated variables.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^0$C.
6) While water is heating, cut and label your yarn. You will need 96 lengths of 15cm. Tie three bundles of 32, like the teacher's example. Label each bundle with your table number and "A" , "B" or "C."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^o$C, add the wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry. Temporarily remove C.
2) Using plastic containers dip out half the liquid and save.
3) Add vinegar to the remaining liquid, until pH 4.
4) Turn on low heat and bring to 100 C. Record B observations.
5) Hang B set to dry and discard that liquid. Put C in the pot with the reserved liquid.
6) Add ashes to this liquid, until pH 11.
7) Record observations, and hang C to dry with A and B.
8) Dispose of the plant mass and liquid in the designated method.

# Black Walnut

Scientific name: Juglans nigra

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Weigh 500g of walnuts in husks, **or** 100g leaves. Using gloves, scrape and peel the hull from the nuts for more surface area. For leaves, tear them off the stems.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^{0}$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^{o}$C, add both wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry.
2) Add 500mL of iron water to the dye bath.
3) Turn on low heat and bring to 100 C. Record observations.
4) Test the pH again _____.
5) In the last 20 min of class, remove the yarn and hang to dry next to set A.
6) Dispose of the plant mass and liquid in the designated method.

# Oak Galls

These are the result of wasps living in oak trees, genus Quercus.

Day 1:

1) Label your paper bag with the common and Latin names of the plant, table number, and class period.
2) Weigh 50 g of oak galls. Use stones to crush them into chunks about 2cm2.
3) If you have time, begin cutting yarn samples.

**Yarn samples**

- 64 pieces of 15 cm each
- Made into two bundles of 32 each
- Label the bundles "A", the control, or "B" the manipulated variable.

**HW: Write your hypothesis here: What color do you think your plant will make and what is the possible explanation?**

Day 2

1) Find your table number stove, pot, and thermometer. Some will be outside and some inside.
2) Fill the pot with 3L of water from the sink.
3) Put your small pieces of plant in the pot.
4) Turn on or light your stove – set on "high."
5) Heat water and plant mass to 100 $^{0}$C.
6) While water is heating, cut and label your yarn. You will need 64 lengths of 15cm. Tie two bundles of 32, like the teacher's example. Label each bundle with your table number and "A" or "B."
7) Put these bundles to soak in tap water.
8) When your water and plant mass are 100$^{o}$C, add both wet yarn bundles.
9) Turn the water down to a simmer (hot, but not bubbling).
10) Stir occasionally while the yarn steeps.
11) Use the rest of the class time for sketching (B/W pencil or ink) a sample of your plant and writing your observations.
12) Test the dye liquid pH with Hydrion paper. pH_____
13) At the seven minute bell, turn heat off and clean up, but leave the dye mix in the pot to steep.

Day 3

1) Take set A out and hang to dry.
2) Add 500mL of iron water to the dye bath.
3) Turn on low heat and bring to 100 C. Record observations.
4) Test the pH again _____.
5) In the last 20 min of class, remove the yarn and hang to dry next to set A.
6) Dispose of the plant mass and liquid in the designated method