Science Unit: **Exploring Chemistry**

Lesson 4: ***Chemistry of Plant Colour and pH***

School Year:	2015/2016
Developed for:	Sir Wilfred Laurier Elementary School, Vancouver School District
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Grade level:	Presented to grades 3/4/5; appropriate for grades K – 7 with age appropriate modifications
Duration of lesson:	1 hour and 30 minutes, or more
Notes:	Activity 1 in this lesson was done in part in a Lesson on Flower colours and smells: http://www.scientistinresidence.ca/pdf/life-science/Plants-n-Bugs/SRP_Plants-n-Bugs_Lesson%205.pdf Activity 2 in this lesson was also conducted in the context of acids and bases: http://www.scientistinresidence.ca/pdf/earth-science/Water%20Quality/SRP_Water%20Quality_Lesson%201%20F.pdf

Objectives

1. Discover the variety of colours that arise from flower pigments by adding varying amounts of acid or base.
2. Understand how a flower pigment molecule changes chemically in acid or base.
3. Use a plant pigments as a pH indicator.

Background Information

Some plant pigment molecules (for example, *anthocyanins*) can change colour depending on whether they are in an acidic or basic environment. Many flowers (mostly dark red, purple and blue flowers) contain similar anthocyanin pigments but are different colours because of the varied pH in their petals. Anthocyanins are generally red or pink in acidic environments and blue in basic environments.

Red cabbage contains anthocyanins as well as other plant pigments that are yellow or colourless, so can make a great variety of colours when these pigments combine in various levels of acid or base. This makes red cabbage pigment an excellent indicator of pH.

Vocabulary

Pigment	A coloured material
Molecules and atoms:	Tiny particles that make up everything around us. Molecules and atoms are too small to see individually, but with enough of them together they make objects we can see. Two or more atoms are bonded together to make a molecule.

Hydrogen atom	A single atom of hydrogen, symbolized as "H" (actually existing as a charged ion H^+, but more simply called an H atom for Elementary level students). The concentration of free H atoms in biological and chemical systems profoundly affects the chemical reactions that can happen.
Acid	A substance that has many free H atoms. These H atoms can attach to other molecules and change their structure (and sometimes colour).
Base	A substance that has no free H atoms and might remove H atoms from other molecules.
pH	A measure of the concentration of free H atoms, usually on a scale from pH 1 to pH 14. A substance with a low pH is acidic, the lowest pH having the greatest concentration of free H atoms. Acids taste sour, with lower pH values tasting more sour (e.g. vinegar is pH 2, orange juice is pH 3 or 4.) A substance with pH of 7 is called "neutral" (e.g. pure water). A substance with a pH higher than 7 is basic, with pH 14 being the most basic, and so most able to remove H atoms. Many cleaners have basic pH values(e.g. ammonia, bleach).
pH indicator	A substance that changes colour depending on pH, and so can be used as a visual marker of pH.

Materials for Flower Colour activity

- dark red roses (one per table group)
- water in squeeze bottles (one per table group)
- baking soda (1 tspn) in water (1 cup) in fine-nozzled sqeeze bottle, labelled "base" (at least one per table group)
- optional: other dark red/pink/purple/blue flowers e.g. fallen rhododendron petals
- plastic dropper pipettes, or eye droppers (at least one per table group)
- waste tub (one per table group)
- mortar and pestle sets, (at least one per table group, more is better)
- small white paint trays (at least one per student pair)
- tissues e.g. toilet roll
- teaspoon measures (one per table group)
- vinegar in fine-nozzles squeeze bottle, labelled "acid" (at least one per table group)

Materials for Red Cabbage pH indicator activity

- red cabbage, one or two leaves sufficient
- sharp scissors
- heat proof pitcher or container, ideally transparent
- kettle for boiling water
- spoon
- small squeeze bottles (one per table group)
- white paint trays (at least one per student pair)
- straws, cut in half (at least 10 per table group, more on hand)
- liquid materials to test: e.g. baking soda in water (1 tspn in 1 cup), vinegar, tap water, lemon juice, apple juice, soap (squirt of dish soap in water), milk.
- small plastic cups, or doubled-up Dixie cups (enough to hold a set of test materials for each table group: 6 or more per table group)

In the Classroom

Introductory Discussion

Tell students that this lesson explores the chemistry of colours in plants.

Brief description of science activities in this lesson:

(1) Flower colour: change the colour of flower pigments by adding acid or base to crushed petals.

(2) Red cabbage pH indicator: use red cabbage dye (which changes colour with acid/base) as a pH indicator for testing household materials.

Processes of science that the students will focus on: exploration, curiosity, mechanical manipulation, close observation, recording results, inferring, concluding.

Science Activities

(1) Activity Title: Flower colour

Purpose of Activity: Show that flower colour variety is due to the chemistry of pigment molecules

Methods and Instructions:
Set-up prior to experiment: make up squeeze bottles of vinegar and baking soda solution.
Students will work at their table groups, sharing some equipment and working individually as well.

1. Tell students that some flowers can change colour depending on the chemical environment they are in, and that they will try adding acid (vinegar) or base (baking soda in water) to a crushed flower petal.

2. Demonstrate how to run the activity: pick one petal from a flower and put it in the mortar. Add one teaspoon of water, then use the pestle to crush the petal until the juice is as dark as the petal. The colour, or pigment, molecules of the petal are now in the water. Use the pipette to suck out the petal juice and distribute it between two or three wells of the tray. Then tell students that they will add acid or base to the tray and see what colours the petal juice turns. They should never add acid or base to the mortar, as it will affect the colour of the next petal added. When they want to start with another petal, they should thoroughly rinse out their paint tray in the waste tub, and wipe out the mortar with a tissue (or rinse it). If there is time students can try other flowers as well.
3. Distribute the worksheets and ask students to record what colours they make.
4. Discuss what colours the students made, and pull out a pattern: in acid the petal juice is usually pink or orange. In base the petal juice is usually purple or blue (or sometimes even green). The colour molecules, or pigments, can change colour.
5. Explain how this relates to flowers: different flowers can contain the same pigment molecules, but depending on the amount of acid/base in their petals, their petals can be different colours.
6. Plants have a wide variety of colours to attract animals that pollinate them. Some flowers even change colour before and after pollination to attract, then discourage, insects.
7. Show students the Rose colour molecule Challenge at the bottom of the worksheet. Work through it together. The molecule with an extra H forms in acid. Hence, by changing the concentration of H atoms, plants change the acid/base environment in their petals, and so their petal colour.

(2) Activity Title: Red cabbage pH indicator

Purpose of Activity: To introduce the concept of pH and to make a pH indicator

Methods and Instructions:
Set-up prior to experiment: prepare labelled cups of test materials (or work with students to prepare them)
Students will work at their table groups, sharing some equipment and working individually as well..

1. Tell students that chemists often use something that changes colour (like our flower petals) to indicate the H atom concentration in a substance. It is important to know the concentration of H atoms as it changes the chemistry of many systems: it is important in water and soil, changing how plants get nutrients and grow; it is important in our own bodies to make sure we digest food and make new cells.
2. A scale that measures the concentration of H atoms is called the pH scale, and a pH indicator changes colour with pH. Tell students that we will make a pH indicator from red cabbage, then test the pH of different chemicals and foods.
3. As a demonstration, cut up 4 cabbage leaves, add them to the pitcher, then add boiling water and stir with the spoon until the water is dark purple. Pour into squeeze bottles, one per table group.
4. Show students how to add some red cabbage indicator dye into a well of their tray, then use the straw as a pipette to add a small amount of test material (dip the straw in the test material, use a finger to block the end of the straw, lift the straw out of the test material, then release the end of the straw over a well of the paint tray). Show them how to read the pH using the scale on their worksheet and record what they find.
5. Share results.
6. Discuss what the results mean: If something is acidic it has a pH below 7. The more acidic it is, the lower its pH number is. Acidic foods often taste sour. The most acidic juices with the lowest pH should be the most sour tasting. Substances with a high pH number are basic. Cleaners are often basic. pH 7 means neutral - neither acidic or basic. Water is generally neutral.

References

1. Flower colour activity taken from <http://www.ingridscience.ca/node/145>. Accessed May. 18, 2016.

Extension of Lesson Plan

Students can make larger batches of red cabbage dye, in a variety of colours, for dyeing yarn or fabric. Use yarn or fabric made from natural fibres e.g. cotton and soak the fabric in the coloured red cabbage juice for a while. Note that without using a mordant, the dye will not permanently bind to the material, so avoid spilling water on the finished product.