Making Black Tea

Grade Level: 9 – 12

Introduction:

Malnutrition, a condition caused by chronic lack of necessary nutrients, afflicts thousands of children and adolescents every year. In particular, rural regions of developing countries are usually those that struggle with malnutrition the most. Lack of access to medical care and inadequate food supplies are key factors that contribute to issues of malnutrition.

Real World Connection:

Georgia Tech researchers have created a new way to test for zinc, an important mineral, using a small blood sample. The test is cheap and easily performed in outdoor settings - an important consideration for rural villages. Using the insides of bacteria, the test relies on the detection of a substance via a color change. When zinc is present in the sample, the color changes to purple. The more zinc present, the more intense the purple color is.

Color-changing chemistry isn't a new science, but scientists and engineers are continually creating new and ingenious ways to use it to solve the world's problems. In general, chemistry uses many techniques to identify the presence and amount of a substance in a sample. The formation of a precipitate, evolution of a gas, or a color change are not only indicators of a chemical reaction - they can signal the presence of a specific substance when planned and performed carefully.

In this activity, you'll use tea to confirm the presence of iron in an iron supplement tablet. Although malnutrition is relatively rare in the United States, anemia, a condition caused by iron deficiency is much more common. Iron supplements can help individuals increase the amount of iron in their bodies.

Vocabulary to Know:

- **Malnutrition** – a condition caused by chronic lack of nutrients in an individual's diet
- **Colorimetry** – a method of detecting the presence or amount of a chemical in a sample based upon color
- **Complex** – a unique arrangement of a metal ion surrounded by large molecules

Activity

Materials:

- 2 iron supplement tablets
- 2 black tea bags
- Water
- Heat-safe mugs or cups
- Kettle or microwave
- Small plastic bag (snack or sandwich sized Ziploc or similar)
- Spoon

Continued.

Instructions:

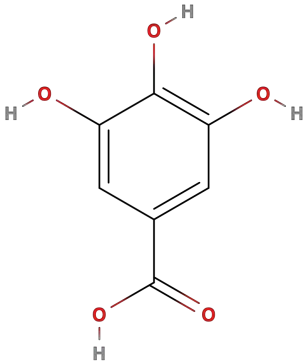
1. Begin by brewing the tea. Heat 100 mL of water (about 1/2 cup) using a kettle or microwave - do not bring the water to a boil. Once the water is hot, steep the tea bags for 3 minutes.
2. Remove the tea bags and let the tea cool so that it is safe to touch.
3. Place the iron supplement tablets in a plastic bag and crush using the back of a spoon.
4. Add the crushed supplement powder to the tea. Observe what happens.

Exploration Questions:

1. Try various kinds of tea. This procedure calls for black tea, but see if you can recreate the effects with green tea or herbal tea. Based on the explanation, why do you think that is?
2. Attempt to change the color of the tea + iron supplement system by adding other household liquids (vinegar, alka seltzer, etc.).

Explanation:

Tannins, a certain type of molecule, are present in relatively large quantities in tea. These molecules, such as gallic acid (shown to the right) are attracted to the iron that is present in the beverage and surround it. Which part of the Gallic Acid molecule do you think is attracted to the iron ion? Is Gallic Acid a relatively large or small molecule?



Gallic Acid
(image from molview.org)

Try to visualize what it would look like to have an iron ion surrounded by several gallic acid molecules. The combination of the iron ion, surrounded by attracted tannin molecules, is called a complex. Many complexes exist in chemistry and are used in myriad ways. Complex chemistry often involves color changes, much like the one witnessed in this demonstration.

Complexes can be used to detect the presence of a substance in a sample based upon the color change. For example, cobalt complexes are used to detect when water-absorbing powder, known as desiccant, have absorbed water and need to be recharged or replaced. Here, the cobalt complex changes color based upon the amount of water present.