Who says all the fun has to happen at The Tech Interactive? This DIY biotinkering activity can be done with inexpensive store-bought supplies and things you find around your home!

Introduction
For thousands of years, people have used colors from nature to create art. Many plants have natural pigments, and the one in red cabbage is very special—it can change color when it is mixed with ingredients from your kitchen. In this activity you will use acids (like lemon juice) and bases (like baking soda) to turn red cabbage into homemade paints in an array of colors. Then dry your custom watercolors and use them for months!

Design Challenge
Create your own colorful watercolor paints using pigments from red cabbage. Then paint a piece of art!

Subject:
Biodesign, Chemistry, Art

Age:
8+

Time:
Extract: 1½ hours
Mix & make colors: 30 min
Dry: 1-3 days
Create: 30 min

Key Concepts:
Biological pigments, pH, acids and bases, watercolors
This process uses a knife, a stove, and hot water, so ask an adult for help!

1. Cut ½ of the red cabbage into medium-sized chunks and place in a pot.
2. Add 3-5 cups of water.
   The water should be at least 1-2 inches deep, but doesn’t need to fully submerge your cabbage chunks. More water will take longer to evaporate!
3. Heat the pot on a stove until water is boiling.
   The water will start to turn bluish-purple - this is your pigment liquid!
4. Boil for 15-45 min to release the pigment and evaporate a lot of water.
   Evaporating water will concentrate your pigment liquid. The more water you evaporate, the more colorful your paints will be! Aim for a final volume of ½-1 cup of concentrated pigment liquid.
5. Turn off the stove and let everything cool.
6. Remove the cabbage chunks from the pot.
   **BONUS! Find a yummy recipe to use your cooked cabbage in!**
7. Purify your concentrated pigment liquid by pouring it through a strainer.
   This could be a coffee filter, mesh strainer, cloth, or anything that has holes smaller than your cabbage chunks.

**Biological pigment:**
A substance produced by a living thing that has a visible color.

**Materials**

You will need **½ a red cabbage** — your source of color-changing biological pigment!

In addition, you will need **equipment** to extract the pigment and **ingredients and supplies** to create your own watercolor paint mixtures. We have included a few suggestions, but there are a variety of ways you can experiment with these ingredients. Use what you have on hand — be creative!

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Ingredients and Supplies (choose at least 1 from each category or experiment with a few!)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction Tools</td>
<td>Acids and Bases (a pinch or drop)</td>
</tr>
<tr>
<td>Knife</td>
<td>Vinegar (any kind)</td>
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<tr>
<td>Cutting board</td>
<td>Lemon juice</td>
</tr>
<tr>
<td>Pot</td>
<td>Baking soda</td>
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<tr>
<td>Stove</td>
<td>Dish soap</td>
</tr>
<tr>
<td>Strainer</td>
<td></td>
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</tbody>
</table>

**Instructions**

**Step 1: Extract your pigment (1½ hours)**

First, we need to get the pigment out of the cabbage. You can do that by breaking open the cabbage cells with heat or crushing and soaking everything in water. The cabbage pigment will move into the water.

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**What is this pigment?**

Red cabbages contain a special pigment molecule called flavin, which is part of the anthocyanin family. You may not know their name, but you have seen anthocyanins before. They give many berries and flowers their vibrant colors and also help create the beautiful colors of fall leaves!
Step 2. Mix your own watercolor paint mixtures (15 min)

To turn your pigment liquid into watercolor paints, you’ll need a substrate (something that gives your paint substance, like flour or cornstarch) and a binder (something that will help the pigment stick to the paper, like honey or syrup). Experiment with different ratios and combinations of substrates and binders to explore how the texture, wetness, and color of your paint mixture changes.

Try our watercolor starter recipe:

<table>
<thead>
<tr>
<th>Paint Substrate(s)</th>
<th>examples on pg 2</th>
<th>2-4 tbsp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Binder(s)</td>
<td>examples on pg 2</td>
<td>1-2 tbsp</td>
</tr>
<tr>
<td>Concentrated Pigment Liquid</td>
<td>2-3 tbsp</td>
<td></td>
</tr>
</tbody>
</table>

1. Combine your substrate(s), binder(s), and concentrated pigment liquid in a bowl.
   You can choose to use one type of substrate and binder or mix several together! Be sure to write down your recipes so you’ll know what you did and what to change next time.

2. Mix well so there are no clumps.
   If the color of your paint mixture is too faint, add more concentrated pigment liquid, but remember - more liquidy paint mixtures will take longer to dry!

Step 3. Make new colors using chemistry (15 min)

Collect some safe acids and bases from around your house to explore the cool color-changing chemistry of this red cabbage pigment! Baking soda and vinegar are two great choices to begin your explorations with. We’ve listed some more suggestions in the materials chart (pg 2).

1. Spoon your goopy paint mixture into various small containers.
   A depth of no more than 2-4 mm in each container will help it dry faster later.

2. Add a different acid or base to each container.
   Start with just a few drops or a pinch and mix well before adding in more — too much might dilute your mixture.

3. Observe what happens to the color.
   Some colors are faster and easier to get than others. How many different colors can you make?

4. Explore more acids and bases to make many custom paint mixtures!
   You can paint with your mixtures right away, but they won’t be as flowing or vibrant as the final paints.

Chemistry Fun!

What is pH? Simply put, pH is a measure of how acidic or basic a solution is. Things with a pH below 7 are acids and things with a pH above 7 are bases. You can see where some common household acids and bases fall on the pH scale below:
Step 4. Dry out your paint mixtures (1-3 days)
• Set your paint mixtures somewhere to dry.
  This will take a day or more, depending on how much liquid you added.
• Place them in front of a fan or in the sun to speed up drying.

Step 5. Create some custom cabbage ink art!
(30 min)
• Once fully dry, use your paints like any other watercolors.
  Dip a paintbrush in water and swirl it on your dried paints until it picks up the color, and paint!
• Experiment with your art!
  Try different paper to get the effect you want. More absorbent paper (like watercolor paper) will work really well, but any type can be used.
• Magically change the color of your paint after it is on paper.
  Dip your paintbrush in any acid (such as vinegar) or base solution (try ½ tsp baking soda in 2 tbsp water) and use it on your artwork to alter the color of your dried paint!

Explore More
New paint recipes:
After trying your first set of paints, make another batch with different ingredients or ratios. Can you get paints with a different look and feel? You can also try for more colors with different acids and bases!

Fabric dye:
The cabbage pigment liquid can also be used as a fabric dye. What could you create? Remember that since this pigment dissolves in water, you won’t be able to wash these cloth items.

Other vegetables:
Try figuring out how to isolate biological pigments from other common fruits and vegetables such as beets, blueberries, or spinach - these might not all change color with pH, but they could add to your palette of colors!

Share Your Results! Keep us posted about your progress on social media with #TheTechatHome.