

Introduction

Biology can make all sorts of beautiful pigments and colors. For thousands of years, people have been interested in finding (or making!) good dyes. While lots of plants have pigments, red cabbage has a very special one that is pH-sensitive, meaning it can change color when it is mixed with either an acid or a base! In this activity, you will use ingredients from your kitchen to turn cabbage pigment into homemade paints that can change color. After being dried out, your custom watercolors can be used, and reused for a long time!

Design Challenge

Create your own colorful cabbage ink watercolors using pigment you extract from red cabbage and paint a piece of art!

Subject:

Biodesign, Chemistry, Art

Ages:

8+

Time:

Extract: 1 hour

Mix: 30 min

Dry: 1-3 days

Create: 30 min

Key concepts:

Natural Pigments, pH, Acids and Bases, Watercolors

Materials



You will need $\frac{1}{2}$ a **red cabbage** — this is your source of color-changing natural pigment!

In addition, you will need some **equipment** to extract the pigment and various **ingredients and supplies** to create your own watercolor paint mixtures. There are a variety of ways you can experiment with these ingredients to customize your paints. Here are a few suggestions. Use whatever you have on hand — be creative!

Equipment	Ingredients and Supplies (choose some)			
Extraction Tools	Household Acid and Bases	Paint Substrates	Paint Binders	Paint Containers
<ul style="list-style-type: none"> • Knife • Cutting board • Pot • Stove • Strainer 	<ul style="list-style-type: none"> • Vinegar (any kind) • Lemon juice • Baking soda • Laundry booster • Dish soap • Lime juice • Shampoo 	<ul style="list-style-type: none"> • Flour (any kind) • Corn starch • Diatomaceous earth 	<ul style="list-style-type: none"> • Honey • Corn syrup • Maple syrup • Glycerine 	<ul style="list-style-type: none"> • Small jars • Tupperware • Small bowls • Paper cups • Ice cube tray • Jar lids • Old takeout containers

Instructions

Step 1: Extract your pigment (1 hour)

 *This process uses a knife, a stove, and hot water, so ask an adult for help!*

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. This pigment dissolves in water, so by soaking it we can get the pigment to move into the water.

1. **Cut ½ of the red cabbage into chunks and place in a pot.**

2. **Add 3-5 cups of water.**

The water should be at least 1½-2 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 gently.**

The water will start to turn bluish-purple - *this is your pigment liquid!*

4. **Simmer for 15-30 min to fully release the pigment and evaporate a lot of water.**

Evaporating water will concentrate your pigment liquid. The more you evaporate, the more colorful your paints will be! Aim for a final volume of ½-1 cup of concentrated pigment liquid.

 *Pay attention so the liquid doesn't evaporate entirely and burn!*

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, pasta strainer, cloth, or any mesh you have.



What is the pigment?

Red cabbages contain a special pigment molecule called flavin, which is part of the anthocyanin family. You have seen anthocyanins before, whether or not you know it, because they are commonly found in nature - they are what give many berries and flowers their vibrant colors and play a role in the colors of fall leaves!

Step 2. Mix your own watercolor paint mixtures (15 min)

To turn your pigment liquid into long-lasting watercolor paints that you can use multiple times, you'll need a **substrate** (something that gives it substance, like flour or cornstarch) and a **binder** (something that will help the pigment attach to the paper, like honey or syrup). Experiment with different ratios and combinations of substrates and binders from the to explore how the texture, wetness, and color of your paint mixture changes.

Try our starter recipe below for your watercolor paint mixture:

Paint Substrate(s) - examples on pg 1	2-4 tbsp
Paint Binder(s) - examples on pg 1	1-2 tbsp
Concentrated Pigment Liquid	2-3 tbsp

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 to change next time.

2. Mix well so there are no clumps.

If the color of your paint mixture is too faint, you can always 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 above but what else can you think of to try?

1. Spoon your sloppy 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 a small amount and mix well before adding in more - too much will 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?

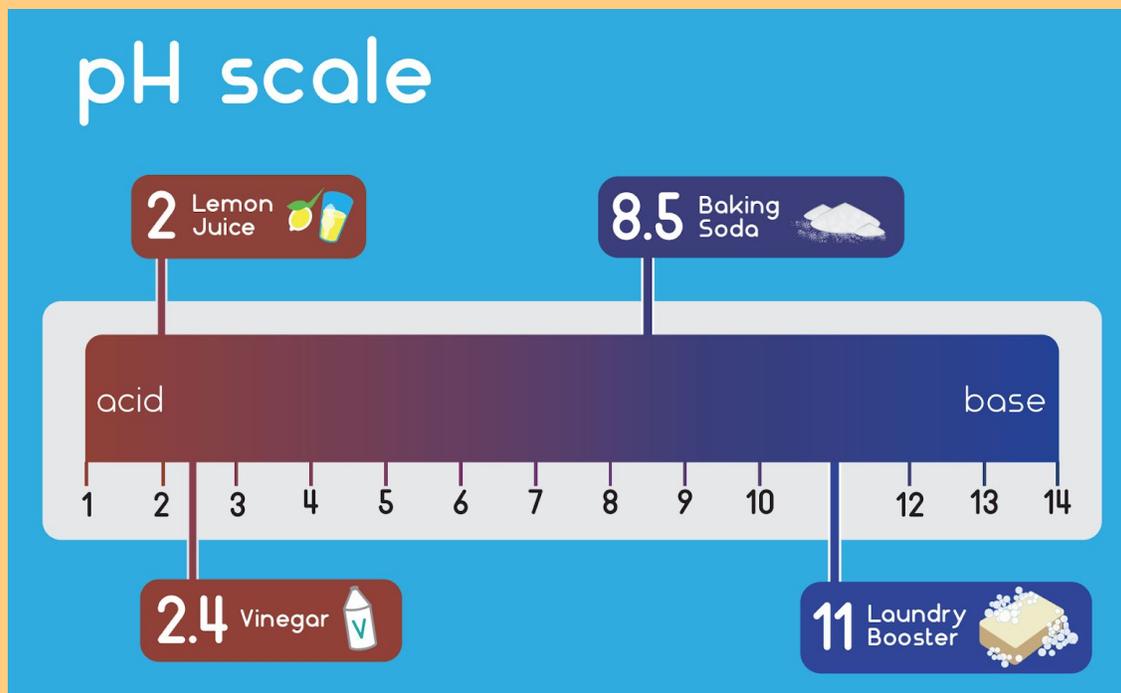
4. Explore more acids and bases to make many custom paint mixtures!

You can try painting with your mixtures right away, but they won't be as flowing or dark 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.**
You can even use a hairdryer for a bit if you want.

Step 5. Create some custom cabbage ink art! (30 min)

- **Once fully dry, you can use your paints like any other watercolors.**
Dip a paintbrush in water and rub it on your dried paints until it picks up enough color.
- **Now, get creative and paint something!**
More absorbent paper (like watercolor paper) will work really well, but any type can be used.
- **Try magically changing the color of your paint after it is on paper.**
Dip your paintbrush in an acid or base solution and use it on your artwork!



Explore More

Looking for more stuff to do? Here are a few ways to keep experimenting!

Try new paint mixture recipes

After your first batch of paints is dry and you have tried using them, make another batch with different ingredients or ratios to see if you can achieve paints with a different look and feel. You can also try for more colors with different acids and bases!

Use the red cabbage pigment as a dye

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

Explore other natural pigments sources

Try isolating pigments from other common vegetables - 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**.



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