Dear Parents and Caregivers,

This booklet contains four science activities your child can complete at home. These activities encourage your child to use experimentation in order to make scientific discoveries. By conducting experiments, your child will be able to explore the scientific method used in making a hypothesis, setting up a fair experiment, collecting data, and making conclusions about the observed results. Your child can complete these experiments independently, or you can work through these experiments together.

The goal of this booklet is to increase exposure of your child to STEM fields. Students learn better when engaged in hands-on problem-solving activities, like experimentation. By introducing kids to science earlier, they are better prepared to tackle science courses at the middle school, high school, or college level. Even in those who do not go on to a career in STEM, exposure at an early age can promote a life-long enthusiasm for the sciences. Additionally, this project increases exposure of students to science which supplements the time allotted for its instruction in schools.

These experiments align with the Next Generation Science Standards (NGSS). The NGSS are a set of academic standards developed by educators, policymakers, and content experts. The NGSS are widely used by teachers to identify age-appropriate concepts and practices that students should engage with at each grade level. Since the experiments within this booklet align with the NGSS, they reinforce crosscutting concepts and approaches that will likely be used in your child’s classroom. To know which standards apply to each experiment, reference the footer of any page. For more detailed descriptions of these standards, visit [https://www.nextgenscience.org/](https://www.nextgenscience.org/).

This booklet also contains a number of QR codes that refer you to related material to supplement each activity. To scan a QR Code, download a QR code reader app, or utilize the QR reader ability that is integrated into the camera software of some cell phones.

This booklet was produced as part of a year-long project through the Latham Science Engagement Initiative (LSEI) at the University of Iowa. Each year, Latham Fellows create, plan, and implement self-directed STEM outreach projects. These projects seek to engage the Iowa City community in thinking about science by making science more accessible to the general public. For more information about LSEI, or to access additional activities, please visit [www.stem-o-sphere.org](http://www.stem-o-sphere.org).

Sincerely,

Emily Ruba
Latham Fellow, 2017-2018
LEMONADE STAND

Biology | Chemistry

**Learning Goals:**

#1 Make weaker solutions from stronger ones.

#2 Practice data collection to compare samples.

#3 Identify differences in taste buds between adults and kids.

**Related Careers:**

Food Scientist
Food Manufacturer
Chemical Engineer
Food Marketing Specialist

**Supplemental Videos:**

“Your Tongue: The Taste-Maker!”

“Controlled Experiments”

**Background:**

Your taste buds can detect 5 tastes: **sweet, sour, salty, bitter, and savory.** These different flavors are detected by your taste buds, which send information to your brain about what kind of food you are eating. We like sweet foods because they provide the body with sugar, an important energy source. Bitter foods taste unpleasant, which can be the body’s way of warning us we are eating something dangerous, like sour milk! Your taste buds can even change as you get older, causing adults to often like different flavors than kids do.

**Materials Needed:**

- Water
- 2 cups of sugar
- 32 oz. 100% lemon juice
- Measuring cup
- Four containers
- Small cups for tasting
- Stovetop
- Saucepan

**Set Up**

A **stock solution** is a liquid that you will use to set up your samples of lemonade. Your stock solution will be a **concentrated** solution of sugar and water. There will be a lot more sugar dissolved in the stock solution than your lemonade samples will have. What this means is that the stock solution will taste more sugary that the lemonade will.
Set Up, Continued.

You will combine different amounts of the sugar stock solution with the lemon juice and water. The sugar in your samples will be diluted when you add it to water, giving the correct amount of sugar. You will need to boil water to dissolve the sugar. By making concentrated sugar water first, you will save time by only needing to boil water once.

With an adult's help, prepare the sugar stock solution:

1. Boil water in a saucepan.
2. In another container, carefully combine 3 cups of hot water with 1 cup + 5 tablespoons of sugar.
3. Mix it to dissolve the sugar.
4. Put a few drops of lemon juice in it. This will help it stay fresh!
5. Let it cool before making your lemonade!

Directions:

1. Make the lemonade

Using the recipe list below, create 6 lemonade mixtures. Make sure to label your mixtures #1 through #6 so you don’t mix them up. Trials 1 through 3 will be used to compare sourness of lemonade, so the amount of sugar in each will remain the same while the lemon juice varies. Trials 4 through 6 will be used to compare sweetness of lemonade, so the amount of lemon juice in each will remain the same while the sugar varies.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Batch</th>
<th>Water</th>
<th>Sugar (from stock)</th>
<th>Lemon juice</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Low sourness</td>
<td>3 cups</td>
<td>1/3 cup</td>
<td>1/8 cup</td>
</tr>
<tr>
<td>2</td>
<td>Medium sourness</td>
<td>3 cups + 2 Tbsp</td>
<td>1/3 cup</td>
<td>1/2 cup</td>
</tr>
<tr>
<td>3</td>
<td>High sourness</td>
<td>2 2/3 cups</td>
<td>1/3 cup</td>
<td>1 cup</td>
</tr>
<tr>
<td>4</td>
<td>Low sweetness</td>
<td>3 1/3 cups</td>
<td>2 Tbsp</td>
<td>1/2 cup</td>
</tr>
<tr>
<td>5</td>
<td>Medium sweetness</td>
<td>3 cups + 2 Tbsp</td>
<td>1/3 cup</td>
<td>1/2 cup</td>
</tr>
<tr>
<td>6</td>
<td>High sweetness</td>
<td>3 cups</td>
<td>1/2 cup</td>
<td>1/2 cup</td>
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</tbody>
</table>

STOP! Make a prediction.
Do you think the high sweetness, low sweetness, high sourness, or low sourness lemonade will be the most popular? Why?

This activity is adapted from “Do You Have the Willpower to Taste Something Sour?” by Science Buddies

4-LS1-2, 3-5-ETS1-3, 5-PS1-1
2. Test the lemonade
You will need help from your family and friends in order to test the lemonade samples you have made. It is your goal to determine which sourness and sweetness are preferred by your test subjects. Find 15 people who are willing to be subjects and sample your lemonades. Determine the order people will sample the lemonade samples and use the same order for each person. Try to collect information from a mix of kids and adults. Fill out the chart below to record your data.

<table>
<thead>
<tr>
<th>Test Subject</th>
<th>Name</th>
<th>Kid or Adult?</th>
<th>Favorite Sour Drink (Drinks #1-3)</th>
<th>Favorite Sweet Drink (Drinks #4-6)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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</table>

Discussion Questions
1. Can you see any trends in the types of lemonade your subjects liked?
2. Can you make any conclusions about which drink is preferred by kids and by adults? Why?
3. When you were making your lemonade samples, did you notice that the same recipe was used to make the medium sourness (Trial #2) and medium sweetness (Trial #5)? Why were these two lemonade samples the same? Did any of your test subjects notice that they were the same?
INK PEN CHROMATOGRAPHY

Forensic Science | Chemistry

**Learning Goals:**

#1 Use fair methods to test and compare samples.

#2 Demonstrate that different types of ink can be separated in characteristic ways.

#3 Understand that ink consists of molecules which can be pulled along as water moves through the paper.

**Related Careers:**

Forensic Scientist
Biochemist
Chemist
Materials Scientist

**Follow Up Activities**

Replicate this experiment using four different colors of the same pen to see how different colored inks behave.

**Background:**

A robbery has taken place at a nearby store. The suspect left a note at the scene, written in black pen. Only two words were on the note: “I’m sorry”. The police have found four suspects who were near the scene and were carrying black pens with them at the time the crime was committed.

To determine which suspect’s pen was used to write the note, you will carry out an ink pen chromatography experiment. This is a forensic science technique used to separate the components of a liquid. By comparing the way each type of ink separates, we can match the pen to the note.

Before starting, create a mystery sample to test. Ask someone to secretly select one of the pens and write “I’m sorry” in the middle of a coffee filter. Make sure they do not show you which pen they used! This will be the “suspect’s” pen, and it your job to determine which pen was used to write the note.

**Materials Needed:**

- Coffee filters
- Four identical glasses
- Four pencils
- Four binder clips
- Three black pens. These should be a mix of different types and brands of pens.
- Scissors
- Water
- Ruler
- Masking tape

**Set Up**

1. Cut a thin rectangle out of the sample coffee filter. Your rectangle should include only the letter “o” of the word “sorry”. The “o” should be two inches from the bottom of the paper, with three inches of space above the “o”.

“Traveling Waters Experiment”
2. Cut out three more rectangles that have the same dimensions as the rectangle you made in Step #1. Using the ruler and a pencil, draw a line $\frac{1}{2}$ inch from the bottom on the paper. Draw another line 2 inches from the bottom of the paper. These are shown in red on the picture to the right.

3. Using these three strips of paper, create a sample of each of the three black ink pens. These will be used to compare the pens, and each sample should resemble the mystery sample. Draw pencil lines on the strips of paper, just like you did in Step #2. Label each paper strip at the top with a pencil so you know which pen was used for each strip.

3. Clip one binder clip to the end of each sample paper you labeled. The prongs of the clip should point upwards rather than resting on the paper. See the diagram to the left to see how to set this up.

4. Put a pencil through the middle of the binder clip, and rest the pencil on a glass so that the paper hangs down into the glass. Standing at eye level with the glass, place a piece of masking tape on the glass. Use your pencil to mark the location of the bottom line on the tape. This is the fill line for how far you will fill the glass with water. Do this for all four samples.

**Experiment**

1. Remove the samples from the glasses before filling them with water. Carefully add water to the fill line that you marked on the tape.

2. Return the samples to the glass, with the pencil resting on the glass and the paper hanging into the water. The ink on the paper should be above the water line, not underwater. Allow the paper to hang into the water until the water line rises up the paper two-thirds of the way to the top.

3. Write down your observations on the data chart below as the water migrates up the paper.

4. Remove the samples from the glass. In the data chart below, color in the rectangles to record what the paper strips look like. Compare the separation patterns of the samples with the separation pattern of the suspect’s note. See if you can identify which pen belongs to the suspect!

STOP! Make a prediction. What will happen to the ink when you place the bottom of the paper in the water?
Data Collection

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mystery Sample</th>
<th>Pen #1</th>
<th>Pen #2</th>
<th>Pen #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
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<tr>
<td>Appearance</td>
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</tbody>
</table>

Capillary Action and Ink Pens

Capillary action is the process in which liquids move through a solid, like water trickling through a rocky stream. In your chromatography experiment, the liquid water moved upward through the solid paper, despite gravity pulling it downward. This occurs because the paper has small pores in it, giving the water many channels to move through as it spreads upward.

The water is propelled upward by cohesion, adhesion, and surface tension. Cohesion is what causes the water molecules to stick to each other like droplets. Adhesion occurs when these water droplets stick to the paper. Surface tension is important for the water molecules closest to the top of the paper, causing this top layer of water to behave like a sheet. This holds the water together as it moves upward.

The ink in the pens you used is made up of materials that may not all interact with the water in the same way. Some inks, like those made with water-based materials, will dissolve better in the water, so it will be easier for the water to carry these inks with it as it moves through the paper. Other inks may not dissolve in the water, like those made with oil-based materials, and will be left behind as the water moves upward. Inks will often vary in how long they take to dry, how much they form clumps, and how thick they are. Many inks are made up of a combination of these different materials. This will have an impact on the process of capillary action by affecting the cohesion, adhesion, and surface tension of the water and ink.

Discussion Questions

1. Is black ink really black? Explain.

2. Ink is often made of a mixture different pigments, liquids, waxes, and drying agents. What characteristics of the ink causes it to separate? What makes some components of the ink travel farther than others?
BALLOON LUNG CAPACITY

Exercise Science | Anatomy

Learning Goals:

#1 Demonstrate that activities like walking, running, and talking affect your lung capacity.
#2 Measure lung capacity using balloons.
#3 Identify general trends in balloon sizes.

Related Careers:

Exercise Scientist
Cardiologist
Respiratory Therapist
Biomedical Engineer

Supplemental Videos:

“How to Measure Your Lung Capacity”
“How to Feel Your Heart Beat”

Background:

Why does your heart beat faster when you are exercising? The answer lies in the fact that exercise uses more energy than normal activity does. Your blood carries the oxygen that you breathe to your muscles. Your muscles use more energy and more oxygen when they are working hard. Since your muscles demand extra oxygen, your body reacts to this by increasing your breathing and your heart rate. When you breathe harder, your lungs inhale more oxygen, and when your heart beats faster, your blood moves more quickly to carry oxygen to your muscles.

Materials Needed:

- A pack of balloons
- Running shoes
- Measuring tape
- Permanent marker
- An empty park or playground
- String
- A friend. One person should be the runner, and the other person should be in charge of the balloons.

Collect Data:

1. Find a straight stretch of grass. Measure out 50 feet with the measuring tape. Mark the starting line and finishing line so that you know where to start and stop each time.

STOP! Make a prediction. Which balloon will be bigger: a balloon you blow up after running, or a balloon you blow up after resting?
2. The runner should stand at the starting line. Have a balloon in your hand, ready to blow up. Stretch the neck of the balloon three times to get the balloon ready.

3. **Walk** from the starting line to the finishing line.

4. As soon as you get to the finish line, take a large breath of air and blow into the balloon. Blow into the balloon four more times, for a total of five times. Tie a knot in the neck of the balloon. With a permanent marker, write “Trial 1” on the balloon. Tie a string to the balloon so that the balloon holder can hold onto it without it blowing away.

5. Make sure to rest for 1 minute in between each trial.

6. Repeat steps 2-5 with a second balloon. Instead of walking regularly, **speed walk** from the starting line to finish line, like shown in the chart above. Write “Trial 2” on the balloon after you have tied it off.

7. Repeat steps 2-5 five more times, following the directions in the chart for each balloon.

8. Compare the sizes of your balloons from Trials 1 through 7.

**Anatomy of the Lungs**

Your lungs are often described as balloons, responsible for exchanging air with the environment. **Oxygen**, which makes up 20% of the air in the atmosphere, is important for breathing. Oxygen enters the lungs through the **trachea**, or windpipe, and then splits off into the left lung and right lung at the **bronchus**. The bronchus branches off into smaller **bronchioles**, carrying air deeper into the lungs. At the deepest point, small air sacs called **alveoli** allow oxygen to move into your blood so that it can travel around the body.
The **diaphragm** is a muscle located under the lungs that helps the lungs inflate and deflate. When the lungs inflate, air moves into the lungs through the trachea, bronchus, bronchioles, and alveoli. When the lungs deflate, air moves back out the same way it came in. When your lungs inflate, you are inhaling. When your lungs deflate, you are exhaling.

Your blood contains **red blood cells**, which carry oxygen from the alveoli to other places in your body where it is needed. Oxygen is especially important for your muscles, brain, and liver. The red blood cells also carry **carbon dioxide** back to the alveoli so that it can be exhaled back out. Carbon dioxide is made by your body as it uses up oxygen. When exercising, your muscles use up oxygen more quickly as well as produce carbon dioxide more quickly than normal. This is why you breathe harder when exercising.

**Discussion Questions:**

1. For each trial, you had to start and stop at the same spot and stretch the balloon the same number of times in order to get the balloon ready. Why is it important to make sure each trial is conducted in the exact same way?

2. Your **lung capacity** is the amount of air your lungs are able to hold, which we can measure by seeing how much air you can blow into the balloon. How did exercise affect your lung capacity? How did talking or screaming impact your lung capacity? Which affected your lung capacity more? Why?

3. The balloon from Trial 7 is your **control** trial. The control shows you what a normal amount of air is when you haven’t been running or talking. You can compare Trials 1 through 6 to Trial 7 to decide much of an effect the running and shouting had on your ability to blow up the balloon. Why is it important to have a control trial to compare all your experiments to?
# Learning Goals:

1. Define acids and bases.
2. Classify liquids according to observations of their physical traits.
3. Collect quantitative data on pH and identify trends seen in the results.

# Related Careers:

- Food Science Technician
- Nutritionist
- Chemical Engineer
- Biochemist

# Supplemental Videos:

- “What is the pH scale”
- “Acids and Bases”

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## Directions:

You can test how acidic or basic a material is using the **pH scale**. Most common have a pH between 0 and 14. Find 10 readily available liquids to test their acidity.

In order to test the acidity, use a toothpick to put one drop of the liquid on a fresh pH strip. Watch for the pH strip to change color, and compare the color to the color code on the container the pH strips came in. Record the value in the chart at the top of the next page.

**Materials Needed:**

- pH strips. These can be found from Amazon, Walmart
- 10 various liquids. See materials chart for suggestions, but feel free to come up with your own as well!
- 10 toothpicks

**Some possible materials to test are:**

- Water
- Lemon juice
- Carbonated water
- Vinegar
- Toothpaste
- Milk
- Orange juice
- Soapy water
- Coffee
- Tea
- Apple Juice
- Soda
- Window cleaner
- Mouthwash
- Maple syrup

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STOP! Make a prediction. Is the pH of orange juice more similar to soap or to water?
**Collect Data**

Record the name of the item you tested, then record the pH you found with the pH strips.

<table>
<thead>
<tr>
<th>#</th>
<th>Item Tested</th>
<th>pH</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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</tbody>
</table>

**Observations**

Select which words from the list below best describe each liquid, and write these words in the Observations box on your data chart above.

<table>
<thead>
<tr>
<th>Sweet smelling</th>
<th>Bitter smelling</th>
<th>Doesn’t have a smell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>Light colored</td>
<td>Darkly colored</td>
</tr>
<tr>
<td>Does not have bubbles</td>
<td>Has bubbles</td>
<td>Thick</td>
</tr>
<tr>
<td>Transparent</td>
<td>Opaque</td>
<td>Runny</td>
</tr>
<tr>
<td>Safe for eating or drinking</td>
<td>Used for cleaning</td>
<td>Colorless</td>
</tr>
</tbody>
</table>

**About Acids and Bases**

**Water**, also called H₂O, is one of the most common materials on the planet. Water is also called H₂O because it is made up of hydrogen (H) and oxygen (O). The “2” of “H₂O” means that there are two atoms of hydrogen. There is only one atom of oxygen in water. The parts of the water molecule can be broken apart into hydrogen (H⁺) and hydroxide (–OH).
The **pH scale** can be used to determine the amount of hydrogen atoms are present in a liquid. Most common items have a pH between 0 and 14. Regular water has a pH of 7, which is the middle of the pH scale, or neutral. Tap water may have a higher or lower pH depending on the chemicals added to purify it.

In water, the number of hydrogen atoms and hydroxide particles are equally balanced. However, some liquids have unequal amounts of hydrogen or hydroxide atoms, which gives those liquids special characteristics. Liquids with extra hydrogen atoms are called **acids**. Acids have much fewer hydroxide particles than hydrogen particles. Acids have a pH that is between 0 and 7. The acid in your stomach is a very strong acid, meaning that it is a very high number of hydrogen particles in it. Stomach acid, called **hydrochloric acid**, breaks down food as a part of digestion. It was a very low pH of around 1. **Citric acid**, which is found in citrus fruit, is a mild acid. Mild acids like citric acid often taste tart or sour. It has a pH of between 2 and 3.

**Bases** are essentially the opposite of acids. Bases have more hydroxide particles than hydrogen particles. Bases have a pH that is between 7 and 14. Bases are often slippery or slimy, and if you taste them they often have a bitter, unpleasant taste. You have probably experienced this if you have ever gotten soap in your mouth accidentally. Many bases are used in cleaning products. While mild bases (between 7 and 10) can usually be eaten, strong bases (between 11 and 14) can be dangerous to consume because bases can react with the acid in your stomach. In a lab, reactions between acids and bases can be very powerful because they release a lot of heat, even exploding in some cases.

**Discussion Questions**

1. What trends did you see in the types of liquids that had a pH of less than 7 and the types of liquids that had a pH of more than 7? What does it mean to have a pH less than 7? More than 7?

2. Based on your observations, what characteristics do acids have in common? What characteristics do bases have in common?