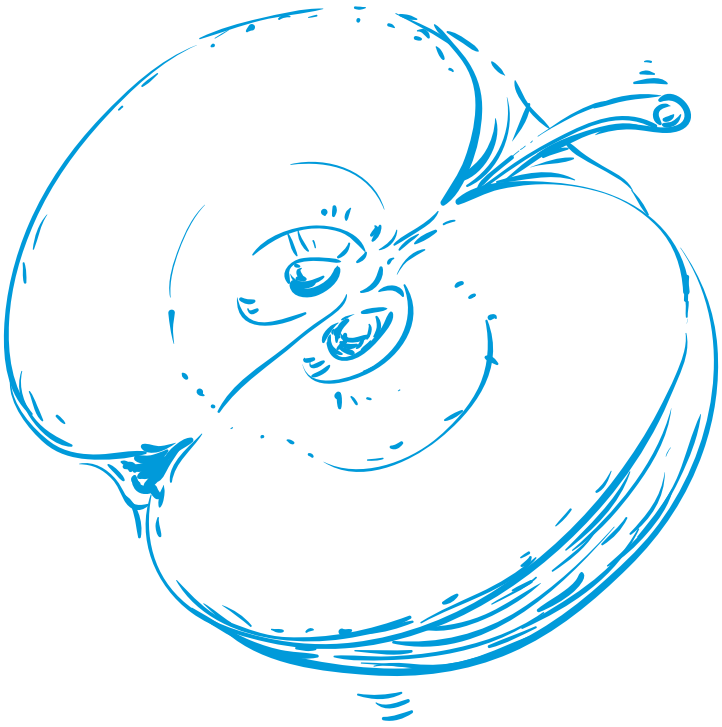

UNIT 3
FOOD CHEMISTRY

BOYS & GIRLS CLUBS OF AMERICA

Time Warner Cable®

The Food Chemistry DIY Unit provides members with hands-on experiences to teach them how chemical reactions from combinations of different ingredients can be used to create products they can eat. This unit also teaches them how to develop experiments that can be explosive. From creating rock candy to building explosive rockets from Mentos and soda, participants will be able to formulate hypotheses about food chemistry, collect data about their experiments, and verify and interpret their results. Additionally, members will be encouraged to record their data and observations in their scientific notebooks and observe safety practices in their laboratory experiments. Each activity and module is aligned with the NGSS to help members and Club facilitators determine how the activities will prepare them to be successful. Moreover, the practical nature of the experiments will engage and connect them with their understanding of how science plays a major role in the reactions of the foods they eat daily. The approximate cost range for the materials can be found in the Appendix B: Materials List with Estimated Costs.

UNIT 3 - FOOD CHEMISTRY		
Activity	**Goals**	**Recommended Time Allotment**
Grow Your Own Rock Candy	Study physical and chemical changes by creating rock candy	90-120 min. (5-7 days)
Breaking the Tension	Observe the chemical reactions when Mentos in different states are placed in a bottle of Coke	80 min.
Make Your Soda..POP!	Study the properties of acids and bases while members create their own soda	120 min.

GROW YOUR OWN ROCK CANDY
(90-120 MINUTES)

Introduction: This activity will introduce participants to a concept known as a physical change. A substance may sometimes change color, shape or appearance, but otherwise remain the same. This is known as a physical change. Sometimes an object loses energy or changes its state of matter, (e.g. liquid to a gas). This is known as a chemical change.

Objective: To introduce participants to the concepts of physical and chemical changes.

NGSS Alignment: **5-PS1-1:** Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-2: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling or mixing substances, the total weight of the matter is conserved.

KEY VOCABULARY

Solution – A blended mixture of liquids

Substance – What an object is made of

Particle – A tiny or very small amount of something

MATERIALS

- ☐ Mason jars – pint or quart size
- ☐ Yarn or cotton string
- ☐ Water
- ☐ Measuring cup
- ☐ Measuring spoon
- ☐ Small plate
- ☐ Granulated sugar
- ☐ Wax paper
- ☐ Screws for weights
- ☐ Wooden beads
- ☐ Popsicle sticks
- ☐ Metric ruler (with centimeter markings)
- ☐ Scotch tape
- ☐ Pot
- ☐ Stove
- ☐ Wooden mixing spoon
- ☐ Potholders
- ☐ Paper towels
- ☐ Markers

Facilitator: Participants will use a hot, boiling solution for part of this activity! Make sure participants are safe while handling hot containers and transferring the boiling solution, which can cause a bad burn if spilled.

GROW YOUR OWN ROCK CANDY A: SET-UP (20 MINUTES)

Facilitators:

1. Remind participants to use precaution when handling the sugar-water solution.
2. Divide participants into groups of three or four.
3. Have materials organized on a table or project the materials for the group to see.
4. Ask one member of the group to gather all project materials.
5. Review steps for each section before beginning.

FACILITATOR'S TIP BLOCK

Allow members 15-25 minutes during each session to write their answers to the discussion questions in their scientific notebooks. Members can also document the work they completed for the day and record the growth of their rock candy over time.

Instruct Members To:

1. Take two minutes to pick one person to gather all the materials for this project.
2. Cut two pieces of yarn 1-2 inches longer than the height of the Mason jar.
3. Set one string to the side until later in the activity - this is your control string.
4. Seeding the rock candy:
    a. Soak the second string of yarn in water for 7-10 minutes. This is the yarn that will seed your rock candy.
    b. Squeeze the water from the string so that it still remains moist, but it not dripping wet.
    c. Roll the moistened string of yarn in 1 tablespoon of sugar on a plate.
    d. Play with varying quantities of sugar and use this later as a class comparison.
5. Place your seeded (sugar-coated) string and your non-seeded string on a piece of wax paper, make sure they are not touching. We will continue with part two of this activity tomorrow.

Discussion Question:

1. Will the amount of sugar on a plate affect how much rock candy will grow?

GROW YOUR OWN ROCK CANDY B: PREPARING THE STRINGS (45 MINUTES)

Facilitators:

1. Review materials to be used as weights and find substitutes when needed.
2. Divide members into their teams and ask them to retrieve the strings that were prepared in the previous session.

Instruct Members To:

1. Take each of your strings and tie one end to a small object that serves as a weight. Some sugar may fall off of the string during this step (this is okay!).

2. Tie the other end of each piece of string to a pencil or other object that serves as an anchor.
3. Use a marker, colored tape or another method to mark the pencil that holds the seeded string.
4. Write down what you marked on your seeded string in your lab notebook in case you forget later.
5. Lower the weighted end of the string into each of the jars, rest the pencil across the top (mouth) of the jar.
6. Each string should be about 1 centimeter from the bottom the jar. You may have to roll your string around the pencil to adjust the height.

These next steps are very important. Please take your time and be careful as you'll be working with hot water!

FACILITATOR'S TIP BLOCK

Give members 15-25 minutes during each session to write the answers to their discussion questions in their scientific notebooks. Members can also document the work they completed for the day and record the growth of their rock candy over time.

Instruct Members To:

1. Fill each jar with boiling water using a funnel or other device to reduce the risk of splashing water and spills.
2. Keep the boiled water in each Mason jar until you are ready to replace this water with your sugar-water solution.

FACILITATOR'S TIP BLOCK

Continue to emphasize the scientific method with an emphasis on the experiment and analysis steps used to test their experiments and hypothesis. Require members to use their scientific notebook to record their information.

GROW YOUR OWN ROCK CANDY C: MAKING THE SUGAR-WATER SOLUTION (30 MINUTES)

Facilitators: Complete the following steps for the group and give out appropriate amounts of the solution for each group to complete the activity.

1. Use a measuring cup to add 1 cup of water to a pot; bring the water to a rolling boil on the stove.
2. Reduce heat to low.
3. Use a measuring cup to add 2 cups of sugar to the hot water, then mix with a wooden mixing spoon until all the sugar has dissolved.

4. Turn the heat back up and wait until the sugar-water solution returns to a rolling boil, keep stirring to keep the solution consistent.
5. Remove the boiling sugar-water solution from the stove.
6. Continue to add 1 tablespoon of sugar at a time to the solution. Stir thoroughly after each spoonful, making sure the sugar is completely dissolved before adding more.
7. Continue adding sugar until no more dissolves in the solution. After all the sugar has dissolved, let the solution cool for five minutes.

Making the Candy:

8. Pour the hot water out of the preheated glass jars.
9. After the sugar-water solution has cooled for five minutes, pour the solution into the two preheated glass jars, dividing the liquid equally between the two containers.

Flavoring the Candy:

10. Flavor the sugar-water solution with individual packets of flavored candy or squeeze bottles used to flavor water.
11. Sample different flavors of rock candy at the end of the activity!

Safety: Be extremely careful when handling the jars of sugar-water solution. It is hot and will burn if spilled on your skin. This step may be completed for participants by the facilitator.

12. Using potholders, move the jars of sugar-water solution to a place where they can be left undisturbed for one week. Place both jars in the same location.
13. Temperature may disrupt the crystallization process. Avoid putting the jars in direct sunlight, or where they may be exposed to extreme hot or cold temperatures.
14. Lower the weighted strings into the jars of sugar-water solution, one string per jar.
15. Tape the pencils to the edges of the jars to prevent them from falling/rolling off.
16. Cover the jars with a paper towel to prevent dust and debris from flying in.

GROW YOUR OWN ROCK CANDY D: OBSERVING AND MEASURING

(30-45 MINUTES, ONCE A DAY FOR 3-5 DAYS)

FACILITATOR'S TIP BLOCK

Give members 15-25 minutes during each session to write the answers to their discussion questions in their scientific notebooks. Members can also document the work they completed for the day and record the growth of their rock candy over time. They should be focused on the results section of the scientific method in their notebooks to record the results of their food experiments.

Facilitators: Let participants look at their jars once a day. Encourage participants to record their observations in their science notebook. On the seventh day, have participants remove the strings from the jars and take measurements of their rock candy crystals.

Observation Questions:

1. What do you see?
2. Are any crystals growing?
3. Where are the crystals?
4. Which string has more crystals - the one that was or wasn't seeded?

Troubleshooting:

1. If there is a hardened layer of sugar-water solution at the top of your jar, use a spoon to break that layer before pulling out your sugar crystals.
2. Rinse the rock candy crystals in cold water and allow them to dry on a paper towel for one hour.

Instruct Members To:

1. Using a ruler, measure the length of the rock candy, and the width at its widest point.
2. Record your measurements in a data table in your lab notebook.
3. Once you've recorded all your measurements and observations, you can enjoy your hard work by eating the rock candy you grew and sample the different flavors made by others in the class!

Extension Activity Questions:

1. Did the amount of sugar on your seeded string make a difference in the size of your rock candy?
2. What other steps could you have included to increase the growth of your rock candy?

BREAKING THE TENSION
(80 MINUTES)

Safety: Make sure all participants wear safety goggles when testing the explosions so no one gets sprayed in the eyes!

Introduction: Participants will test crushed Mentos in three separate trials to test how chemicals react when they are combined, then measure the reactions. In the first trial, participants will use crushed Mentos and Coke. In the second trial, participants will use whole Mentos and Coke. For the third trial, participants will use either whole or crushed Mentos with a new variable soda.

Objective: To develop and test their hypothesis about what will happen when various states of Mentos and Coke combine.

NGSS Alignment: **MS-PS1-2:** Structure and Properties of Matter. Each pure substance has characteristic physical and chemical properties that can be used to identify it.

MS-PS1-5: Substances react chemically in characteristic ways.

MS-PS1-5: The total number of each type of atom is conserved, and thus the matter does not change.

MS-PS1-6: Some chemical reactions release energy, others store energy.

MS-PS1-6: A solution needs to be tested, and then modified on the basis of the test results in order to improve it.

MS-PS1-6: Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.

MS-PS1-2: Analyze and interpret data to determine similarities and differences in findings.

MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MATERIALS

- ☐ Eye protection, such as goggles or glasses
- ☐ Mentos® mint flavored candies (24 candies)
- ☐ Wax paper
- ☐ Cutting board*
- ☐ Knife
- ☐ Funnel
- ☐ Measuring cup
- ☐ Index cards (at least 2)
- ☐ 2-liter bottle of Diet Coke®
- ☐ Blue painter's tape
- ☐ Metric tape measure or meter stick
- ☐ Ladder*
- ☐ Outdoor space next to an exterior wall where tape can be applied with permission
- ☐ Video camera*
- ☐ Tripod*

*Optional

KEY VOCABULARY

Variable – Something that changes or that can be changed

Diameter – The distance through the center of something from one side to the other

RST.6-8.3: Follow a multi-step procedure precisely when carrying out experiments, taking measurements, or performing technical tasks.

RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually, (e.g. in a flowchart, diagram, model, graph, table, etc.). This is met through the creation and analysis of multiple graphs at the end of this activity.

FACILITATOR'S TIP BLOCK

Continue to emphasize the scientific method with an emphasis on the experiment and analysis steps used to test their experiments and hypothesis. Require members to use their scientific notebook to record their information.

BREAKING THE TENSION A: PREPARING THE CANDY (10 MINUTES)

Facilitators: Have participants form groups of three or four, and distribute all project materials. Be sure to have different flavors of soda available for the third trial, (e.g., root-beer, sprite, orange, etc.).

Instruct Members To:

1. Place a piece of wax paper on their desk.
2. Divide the Mentos into three equal groups on the wax paper (8 pieces).
3. Carefully use their chosen tool (hammer, book) to crush the Mentos candies into many small pieces.

BREAKING THE TENSION B: MAKING THE CANDY TUBE (10 MINUTES)

Instruct Members To:

1. Take one of the index cards and roll it into a tube that is slightly larger than the diameter of a Mentos candy. The easiest way to do this is to wrap it around an unopened tube of Mentos.
2. Tape the tube together on the side.
3. Place the other index card beneath the tube of Mentos to keep the Mentos from dropping into the soda bottle until they are ready.

BREAKING THE TENSION C: LAUNCHING PREPARATION AND GEYSER TRIALS

(30 MINUTES)

Facilitators:

1. Prepare your test site to measure the height of the geysers.
2. Use a ladder if needed to mark off the taller measurements.
3. Members may add 4-8 whole Mentos (or the crushed equivalent) to their tube for each trial. Use funnels to help load the crushed Mentos candy pieces into the candy tube.
4. Go outside the Club and set one bottle of Coke (or other soda) against an exterior wall.
5. Mark the top of the soda bottle with blue painter's tape. This will be your baseline measurement.
6. Mark the rest of the wall in 18-inch increments to measure your geysers as you conduct individual trials.
7. If available, a member of the group could use a video camera on a cell phone or a tablet to capture each trial and verify the height of each geyser.
8. Place an unopened soda bottle outside of the area you have marked off, at least 6 feet away from the building. It's important to make sure that the bottle is also placed in a safe area where it is away from buildings or a covered area that could be damaged after the bottle top launches. A clear open field with no coverings or roof would be ideal.
9. Remove the cap from the soda bottle and place the flat index card on top, covering up the mouth of the bottle.
10. Put on safety goggles.
11. For each trial, measure the following:
    a. The reaction time (from the last candy dropped in, to the time a geyser erupted).
    b. The height of each geyser.
    c. The volume remaining in the bottle after the geyser erupted.
12. Place your full candy tube on top of the flat index card by lining the mouth of the bottle with the opening of your tube.
13. Remove the flat index card by pulling it to release the Mentos into the bottle.

Safety: The geyser will erupt quickly, so remove the empty candy tube and step away from the bottle as soon as the last candy has dropped into the bottle.

14. When the bottle stops spouting, stop recording.
15. Remove the used soda bottle and set it aside. Do not pour out the remaining soda yet! You will measure the remaining volume of each soda bottle at the end of the activity.
16. Label the bottle with the trial number, and record whether it was used with whole or crushed Mentos.
17. Repeat the steps two more times, for a total of three trials using 4-8 whole or crushed Mentos each time.

Soda and Mentos Surface Tension Data

Instruct Members To:

1. Make the following four bar graphs of whole Mentos versus crushed Mentos:
   a. One of the average reaction time.
   b. One of the average geyser height.
   c. One of the remaining soda volume.
   d. One of the soda geyser height and "other" soda geyser height. Make sure the type of Mentos used for this comparison is the same (crushed or whole for both trials).
2. For each graph, put whole Mentos and crushed Mentos on the x-axis (the horizontal axis). Record average reaction time, average geyser height and remaining soda volume on the y-axis (the vertical axis).
3. Calculate the average reaction time, geyser height and remaining soda volume for the trials using whole Mentos and the trials using crushed Mentos.

FACILITATOR'S TIP BLOCK

Give members 15-25 minutes during each session to write their answers to the discussion questions in their scientific notebooks. Members can also document the work they completed for the day and record the different reactions of the liquid when it interacts with Mentos in different physical states.

Extension Activity Questions:

1. What makes the Coke/soda suddenly form a geyser?
2. Does the speed of the candy entering the bottle affect how large the geyser is?
3. Do you think that using crushed Mentos makes a difference in the reaction?
4. Were the results what you expected or were they different? Why or why not?
5. How do you think the reaction time, geyser height and remaining soda volume might correlate with each other?
6. Was there a significant difference in geyser height, reaction time or remaining soda volume in your trial with the "other" soda?

MAKE YOUR SODA...POP!

(120 MINUTES)

Introduction: Members will be creating their own soda using the scientific property of chemical reactions among acids and bases.

Objective: To give members opportunities to explore mixtures and solutions as well as practice recording data in their science notebooks.

NGSS Alignment: **MS-PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures.

MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

MATERIALS

- ☐ **Baking soda** (8 oz. box)
- ☐ **Citric acid** (50 g) - **you can find food-grade citric acid at your local health foods store or online**
- ☐ **Measuring teaspoons** (1/4 tsp and 1/8 tsp)
- ☐ **Plastic cups, clear**
- ☐ **Liquid measuring cup, 1 cup**
- ☐ **Wooden coffee stirrers**
- ☐ **Paper towels** (1 roll)
- ☐ **Sugar** (50g)

KEY VOCABULARY

Grittiness - Containing very small pieces of sand or stone

MAKE YOUR SODA...POP! A: SIMPLE REACTIONS: ACIDS AND BASES (20 MINUTES)

Facilitators:

1. Show or print an example of the data table for participants as a guide for them to make their own data table to record their soda experiments.
2. Let participants know they are free to spit out the liquid after they have tasted it. It won't harm them to swallow it, but it might not taste very much like soda yet. Swallowing will over-acidify their stomach (which could give them a slight stomach ache).
3. Reintroduce the scientific method before beginning the experiment. After answering the engagement questions, members should develop their own hypothesis about what they think will happen in the experiment.
4. At the end of the experiment, members will evaluate their hypothesis to determine if their analysis was correct.

Instruct Members To:

1. Add 1/16 teaspoon of baking soda to the plastic cup.
2. Add 1/4 teaspoon of citric acid to the same plastic cup.
3. Gently swirl the cup to mix the baking soda and citric acid together.
4. Using the measuring cup, add 1/4 cup of cool, clear water to the plastic cup.
5. Use the wooden stirrer to quickly mix the solution together and then taste the beverage.
6. Rate how much it bubbles on a scale of 1 to 5 - where 1 is very bubbly and 5 is not bubbly at all in the Initial Bubbliness column (first column) of the data table.

Questions:

1. Are there a lot of bubbles?
2. Is the liquid mildly bubbly or is it bubbling a lot?
3. How does the liquid feel on your tongue?
4. Is the liquid too gritty?

Instruct Members To:

1. Rate the grittiness of the beverage on a scale of 1 to 5 - where 1 is very gritty and 5 is not gritty at all - in the Initial Grittiness column of the data table.
2. Set the timer for one minute and leave the beverage alone. After one minute has gone by, take a sip of the beverage again.
3. Rate the bubbliness and grittiness using the same scale you used before in the Bubbliness After One Minute and Grittiness After One Minute columns in your data table.

Questions:

1. How are the bubbliness and grittiness after sitting undisturbed for one minute?

Tip: Set the timer right after you mix the solution for each experiment. This ensures you are consistent about how long the mixture sits before you taste it.

FACILITATOR'S TIP BLOCK

Continue to emphasize the scientific method with an emphasis on the experiment and analysis steps used to test their experiments and hypothesis. Require members to use their scientific notebook to record their information.

AMOUNT OF BAKING SODA	AMOUNT OF CITRIC ACID	TRIAL	INITIAL BUBBLINESS	INITIAL GRITTINESS	BUBBLINESS AFTER ONE MINUTE	GRITTINESS AFTER ONE MINUTE
1/16 TSP.	1/4 TSP.	1				
		2				
		3				
1/8 TSP.	1/4 TSP.	1				
		2				
		3				
1/4 TSP.	1/4 TSP.	1				
		2				
		3				
1/2 TSP.	1/4 TSP.	1				
		2				
		3				
1 TSP.	1/4 TSP.	1				
		2				
		3				

Instruct Members To:

1. Repeat the procedure four more times using the following mixtures of baking soda and citric acid:

BAKING SODA	CITRIC ACID
1/8 TSP.	1/4 TSP.
1/4 TSP.	1/4 TSP.
1/2 TSP.	1/4 TSP.
1 TSP.	1/4 TSP.

Instruct members to do the following each time they make a mixture or solution:

1. Pour any remaining liquid down the drain.
2. Rinse out all plastic cups and wipe them with a paper towel. Make sure there isn't any extra baking soda or citric acid in the bottom of the cup you use to mix the ingredients.
3. Repeat the procedure two more times, for a total of three trials for each measurement

Note: It is always necessary to repeat your experiment to ensure the data you have collected is reliable and reproducible. Record all data in your data table.

MAKE YOUR SODA...POP! B: ADDING THE SUGAR (10 MINUTES)

Instruct Members To:

1. Once you've decided on your favorite recipe, add sugar to sweeten the drink.
2. Make a table like the one shown below in your science notebook.

Base recipes with sugar

AMOUNT OF SUGAR	TRIAL	SWEETNESS OBSERVATIONS
1/4 TSP.	1	
	2	
	3	
1/2 TSP.	1	
	2	
	3	
1 TSP.	1	
	2	
	3	

Instruct Members To:

1. Take a new, clean plastic cup and duplicate your favorite recipe from the first section.
2. Add 1/4 tsp. of sugar to the beverage and quickly stir in the sugar with a clean, wooden stirrer.
3. Taste the beverage and record your observations in the data table in your lab notebook.
4. Rate the sweetness of the beverage on a scale of 1 to 3, where 1 is not sweet at all and 3 is too sweet.
5. Record your data in your lab notebook.
6. Repeat these steps, adding 1/2 tsp. of sugar each time.
7. Repeat these steps again, but add 1 tsp. of sugar each time.
8. Discard all extra liquid and rinse out the plastic cups.
9. Repeat these steps two more times, for a total of three trials for each sugar amount.

MAKE YOUR SODA...POP! C: ANALYZING YOUR DATA (30 MINUTES)

Facilitator: Encourage participants to work together to calculate the average. Encourage younger members to ask for help with the math if they need it. Have participants calculate the average sweetness for the data collected in the second table.

Instruct Members To:

1. Go back to your first data table from Activity 3a where you rated the bubbliness and grittiness of your different mixtures/solutions on a scale of 1 to 5.
2. Use the equation below to calculate the average bubbliness and grittiness data that you collected in the first data table across all three trials for each solution.
3. Do the same for the sweetness to find the average sweetness for each amount of sugar.

$$\text{Average} = \frac{\text{Trial 1} + \text{Trial 2} + \text{Trial 3}}{3}$$

Use tables like the ones shown below to collect your average data.

AMOUNT OF BAKING SODA	AMOUNT OF CITRIC ACID	AVERAGE BUBBLINESS	AVERAGE GRITTINESS
1/16 TSP.	1/4 TSP.		
1/8 TSP.	1/4 TSP.		
1/4 TSP.	1/4 TSP.		
1/2 TSP.	1/4 TSP.		
1 TSP.	1/4 TSP.		

AMOUNT OF SUGAR	AVERAGE SWEETNESS
1/4 TSP.	
1/2 TSP.	
1 TSP.	

Instruct Members To:

1. Plot your data on a graph – you can plot the data by hand using graph paper, or you can plot the data online at a website such as Create a Graph.
2. Label the x-axis "Recipe" and label the y-axis "Average Bubbliness." Make an identical plot for the average grittiness.
3. Finally, make another plot for the average sweetness.

Extension Activity Questions:

1. According to your data, which combination of baking soda, citric acid and sugar yields the most enjoyable soda?
2. Was your hypothesis about the experiment verified? If not, what was incorrect about your hypothesis?