Cooking Chemistry
Activity 6—Make Your Own Marshmallows

Materials Needed:

Ingredients for your marshmallows:

- Water (½ cup + amount needed for gelatin according to package)
- *2 packets unflavored gelatin (0.25oz each—please note gelatin is not vegetarian and may not be Kosher—you may substitute agar or vegan jel, but the volume needed may be different)*
- cornstarch (2 tablespoons—optional, can use all powdered sugar)
- powdered sugar (½ cup)
- granulated sugar (2 cups)
- vanilla extract (2 teaspoons—can substitute another flavor but may need to adjust amount)
- vegetable oil (needed to work with the marshmallows/grease the pan)

Kitchen supplies:

- electric mixer or stand mixer with mixing bowl and whisk attachments, or a whisk
- kitchen timer
- measuring cups and spoons
- saucepan
- spatula
- pizza cutter or knife (to cut marshmallows)
- storage container or plastic storage bag
- square baking pan or library-provided foil pie pan
- plastic wrap
- candy thermometer (included in kit from library)

What to Do:

1. **Prepare your ingredients and supplies:** Sift or mix together 2 tablespoons cornstarch with ½ cup of powdered sugar. You can use all powdered sugar if you don't have cornstarch, but the marshmallows will taste sweeter.

2. **Prepare your gelatin.** Mix the gelatin with ½ cup of cold water in a bowl and set it aside so it has time to "set." What's happening to the gelatin? Is it changing *state*?

3. **Make rich syrup (grown-up needed).** In a large saucepan, add ½ cup of water and 2 cups of granulated sugar over medium heat. Stir until the sugar dissolves, then turn the heat up. Use your candy thermometer to measure the temperature of the sugar solution. You want to reach 240° Fahrenheit.

Although you added ½ cup of water and 2 cups of sugar (totaling 2½ cups when you started cooking your simple syrup), do you end up with that much? Why?

4. **Whip the prepared gelatin and the simple syrup together and add vanilla.** Pour the gelatin into your mixing bowl (you may need a spatula). Use the included candy thermometer to monitor the syrup's temperature. As soon as your simple syrup reaches 240° Fahrenheit, remove the pan from the heat and slowly pour the syrup into the mixing bowl, over the gelatin, while mixing on a low setting using the whisk attachment. Add 2 teaspoons of vanilla (or your desired flavor, and food coloring if you wish).

5. **Whip the mixture, gradually increasing the speed to its maximum (so you don't splatter the hot mixture), until the mix has nearly doubled in size.** This will take up to 15 minutes, and you will see the texture of the mixture change and become a more opaque white (like marshmallow fluff). What happens to the volume of the mixture? You are looking for it to approximately double in size.

6. **Prepare your pan for the marshmallows.** Prepare either a square baking pan or one of the foil pie pans you received from the library. To prevent the marshmallows from sticking, spray or rub vegetable oil on your pan and sprinkle it with the cornstarch/powdered sugar mixture. You can also line the pan with plastic wrap before spraying and dusting for even easier cleanup.

7. **Before pouring the marshmallows into your pan, let them sit in the mixing bowl for 10-15 minutes.** You will see the mixture start to form harder edges, like it's pulling away from the bowl into a ball.

8. **Pour them into the prepared pan and let them sit at room temperature to firm up.** You may need to use your spatula, lightly greased with vegetable oil, to get everything out of the mixing bowl. The marshmallows need time to "set." As they return to room temperature, the protein bonds in the gelatin start to reconnect, making the marshmallows change from liquid to a soft solid. They will need to sit for at least a few hours, but it's even better if you let them sit overnight.

9. **Cut them up (adult help needed) in to marshmallow-sized squares and cover your marshmallows in the mixture of cornstarch and powdered sugar.** You can use a pizza cutter or a knife, but you may want to use some vegetable oil on the knife and your fingers for easier handling. If you want to get creative, you can also use cookie cutters in different shapes. After cutting your marshmallows, roll them in your cornstarch/powdered sugar mixture.

STEAM Connections

Making food usually involves plenty of *chemical reactions, chemical changes,* and *physical changes*. Foods are also all made up of chemicals! Did you know the *chemical name* for sugar is *sucrose?*

What is gelatin? Gelatin comes from *collagen*, a type of *protein* found in animals' skin and bones. Proteins are one of the *nutrients* you need in your diet that provides *energy.*

Adding water changes the physical structure of gelatin, turning it from powder to gel. If it gets hot enough, gelatin becomes a runny liquid, like water. This is a *physical change.* The heat from the water weakens the bonds in the protein. Another example of a physical change is boiling water. Boiling doesn't change the *chemical structure or properties* of the water, so it is a *physical change, even though you see bubbles. These aren't bubbles that result from a chemical reaction, like when you add vinegar to baking soda.*

When you made simple syrup, it seemed like you got less out than you put in because dissolved sugar has less *volume* than dry sugar granules—this is a physical change. If you cook *sucrose* long enough, it turns brown like caramel—this color change means a *chemical change* is occurring. More on this below!

Why do marshmallows turn brown when heated? Marshmallows (if you don't let them catch on fire!) turn that golden-brown color over a campfire thanks to the *Maillard reaction*, a *chemical reaction* that occurs between sugars and proteins when they're heated up. The Maillard reaction changes the taste and smell of the food, bringing out different flavors. If you cook meat, it's the same reaction that you look for when "searing" steaks or browning chicken; when you bake bread, the Maillard reaction is what makes the crusts a golden brown. When you burn your marshmallow and it turns black, that is actually a different set of chemical reactions. Some common signs a chemical reaction is occurring are new smells or sounds, or changes in color or temperature (without adding heat/cooling it down on purpose).

Take it Further: Add some flair to your marshmallows by adding different types of flavor extracts if you have any on hand (coconut, almond, or fruit), or change their color by adding a

Commented [MM1]: ^The other two sources of energy are fats (like vegetable oil) and carbohydrates (like sugar).^ and are also called macronutrients. The two other macronutrients that provide energy are fats (like vegetable oil) and carbohydrates (like sugar). You also need vitamins and minerals (micronutrients), but these aren't a source of energy, they support your metabolism.

few drops of food coloring! You can also paint the marshmallows with food coloring: just mix the color with water until you get the shade you want, then paint with a small craft paintbrush (just make sure the paintbrush is clean and previously unused).

- Most of the time we roast marshmallows over a fire, but you can also microwave them. Watch as the marshmallows cook in the microwave: they expand with heat, and contract as they cool.
- What happens when you use too much simple syrup or too much gelatin? What if you use corn syrup in your sugar syrup? Does this change the texture or volume of the marshmallows? If you have time, experiment with different ratios of ingredients as you make your marshmallows.

Vocabulary used in this activity:

- **Boiling**
- **collagen**
- **chemical reaction**
- **chemical change**
- **Maillard reaction**
- **physical change**
- **protein**
- **states of matter (solid, liquid, gas)**

Other Cooking Science Resources:

- https://foodcrumbles.com/gelatin-gelatin-science-basics/
- https://www.sciencefriday.com/educational-resources/secret-marshmallow-message/
- https://www.nutrition.gov/topics/nutrition-age/children/kids-corner
- https://www.thoughtco.com/physical-and-chemical-changes-examples-608338