Berkeley Engineers and Mentors

A Scientific Feast

Target Grade: Elementary/Middle School
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Brief Overview

In this lesson, we will take a sneak peak into the world of molecular gastronomy. The mentees will have the opportunity to learn the science behind how some of their favorite foods are made. In the first module will demonstrate where the rising properties of bread come from through a visual demonstration of yeast fermenting. In the second module, the mentees will learn why Pop Rock candies fizzle when they place them on their tongues. The final module will focus on spherification and how polymer cross-linking allows the mentees to make their very own fruit boba!

Teaching Goals

- **Molecular Gastronomy:** is a subdiscipline of food science that seeks to investigate the physical and chemical transformations of ingredients that occur in cooking
- **Fermentation:** the chemical breakdown of substances by microorganisms such as yeast and bacteria
- **Dissolution:** where a solid substance gets broken down to its small molecules, typical by water
- **Polymer:** a large molecule that looks like a chain of small repeating parts called monomers
- **Cross linking:** where different polymer chains are chemically linked together, resulting in a stronger structure which can change the properties of a substance

Careers and Applications

Molecular gastronomy is a relatively new subdiscipline of food science, coined in 1988 by late Oxford physicist Nicholas Kurti and the French INRA chemist Hervé This. Most food science studies focused on industrial food and production, and so the creation of molecular gastronomy allowed scientists and chefs to come together to discuss the science behind traditional cooking methods used in the home. Molecular cuisine is integrated into a modern style of cooking, and a firm grasp and solid practice with molecular gastronomy techniques may lead to a culinary career focused on food ranging from homestyle to gourmet. There’s even a highly reviewed modern French restaurant in San Francisco called Atelier Crenn that serves many dishes concocted with the use of similar techniques.

Agenda

- Introduction- What is molecular gastronomy?
- Module 1: Rise Bread, Rise (10-15 min)
- Module 2: Pop Rocks Rock(10-15 min)
- Module 3: (15-20 min)
- Conclusion

Introduction

We recommend you start by asking your students questions about food. Have they ever considered why some types of bread (like buttermilk) are very puffy, while others (like multigrain) are more dense? Have they ever wondered how milk is turned into butter? It turns out that the process of creating food is a lot more scientific than most people think! In this lesson, students will explore the science behind food through the world of molecular gastronomy and answer these questions, among many more. Encourage students to pay attention to the scientific concepts introduced in each module; their understanding will affect the taste of their creations.

Module 1: Rise Bread, Rise!

Introduction

In this module, students will learn about the chemical process known as fermentation through a hands-on experiment. Students will learn how the fermentation process is instrumental for food we consume on a daily basis, such as bread, which uses fermentation to rise.

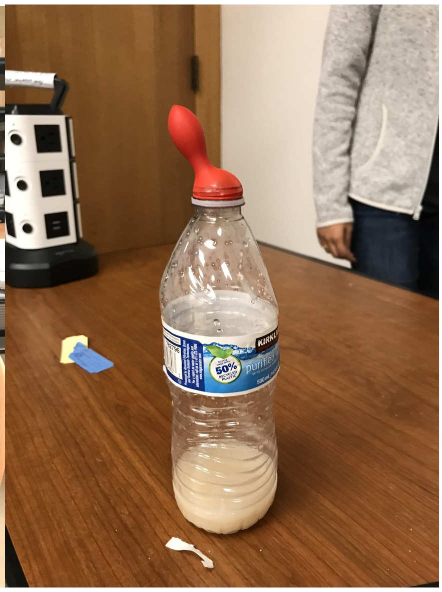
Teaching Goals

1. **Dissolution** is the breakdown of a solid object, typically into a liquid phase.
2. **Fermentation** is the process through which yeast consumes sucrose and releases ethanol and carbon dioxide.
3. The production of CO2 gas during the fermentation process allows bread to rise.

Background for Mentors

Dissolution is the breakdown of a solid object, typically into a liquid phase. It's another word for the process of dissolving. In the context of this activity, sugar is going to be dissolved into water. When a substance (known as the solute) is dissolved into a liquid (known as the solvent), the bonds between the solute and the solvent molecules are broken so the solute can insert itself between the solvent's molecules. Further, unless the dissolution process is favored (which it typically isn't), the dissolution process requires external energy, such as heat or stirring. Consider the example of dissolving sugar into water. If you pour sugar into cold water, it typically doesn't dissolve by itself, since it lacks external energy in the form of heat or agitation. In order to make the sugar dissolve, we typically agitate it (the solute) and the water (the solvent) by stirring. This provides enough external energy to break the bonds between individual sugar and water molecules, allowing them to mix together. Since the sugar molecules get spread out (and since there are a lot more water molecules than sugar), we typically can not see the sugar in the solution with our naked eye.

Broadly speaking, fermentation usually refers to the anaerobic breakdown of energy-holding molecules (like glucose). This process generates energy, but also yields waste in the form of gases, the most common of which are ethanol and carbon dioxide. The phrase anaerobic refers to the fact that oxygen is not required for this reaction. For example, yeast, a type of single-celled fungi that is used in the baking of bread and brewing of beer, does not require oxygen to undergo fermentation. This means that yeast does not require oxygen to generate energy and survive; coincidentally, yeast will be used to demonstrate fermentation in this module. When yeast undergoes fermentation, it consumes glucose (sugars) in order to generate energy and releases ethanol and carbon dioxide as waste products of the reaction. For example, When used in the baking of bread, the ethanol and carbon dioxide molecules released by the yeast get trapped by the strands of gluten in the bread. This creates an amalgamation of small air pockets within the dough, causing the dough to rise. When the bread is baked, the ethanol is burned off and the carbon dioxide is released, leaving a risen bread loaf with many small air holes inside.



Materials

- 3 empty, clear plastic water bottles
- 4.5 teaspoons of yeast
- 3 teaspoons of sugar
- 3 balloons

Procedure

1. Add 2.5 teaspoons of yeast into each of the three bottles
2. Add 0 teaspoons of sugar into the 1st bottle, 1tsp into the 2nd, and 2tsp into the 3rd.
3. Add 1 cup of warm water into the first bottle. Have the students observe the consistency of the substances in the bottle; students should notice that the sugar, yeast, and water are all separately visible.
4. Gently mix the contents of the bottle by spinning the bottle until the yeast and sugars have dissolved, and cover the bottle mouth with a balloon. Repeat this process for the remaining two bottles.
5. Ask the students to describe the consistency and color of the water in each of the bottles. Students should notice that the agitation has caused the yeast and sugar to completely dissolve into the water. Explain how the addition of energy (via the

process of agitation) helped break the bonds between the water, yeast, and sugar molecules, allowing them to dissolve.

6. **Place the bottles aside; return to this module with ~10 minutes left in the lesson.**
7. Bring the 3 bottles back and ask the students to comment on the size of each balloon. Students should notice the first bottle's balloon is the smallest (and probably did not inflate at all), while the third bottle's balloon is the largest. Ask students why they think this is occuring.
    a. Since the third bottle has the highest sugar concentration out of all the three bottles, it is easiest for the yeast to "find" and "eat" the sugar, allowing for the production and release of more CO2. On the other hand, since there was no sugar in the first bottle, the yeast could not undergo the process of fermentation, meaning no CO2 was released.

Additional Notes for Mentors

This could get messy if you're not careful (yeast and sugar are hard to clean up), so try to be careful and conduct this as a demonstration that is observed (not participated in) by students.

Module 2: Pop Rocks

Introduction

Pop rocks are a candy many of us have grown up loving, not just for their taste but their unique ability to create a sensation of fireworks in our mouths. In this module, the kids will learn why pop rocks are able to pop.

Teaching Goals

1. **Pressure**: substances move from areas of high pressure to areas of low pressure. This principle is what causes air trapped in the pop rocks to quickly escape once they melt in your mouth, causing a popping sensation.
2. **Solubility**: a chemical property referring to the ability for a given substance, the solute, to dissolve in a solvent. Sugar is soluble in water, but not in oil giving rise to the differences observed when pop rocks are placed in water vs oil.

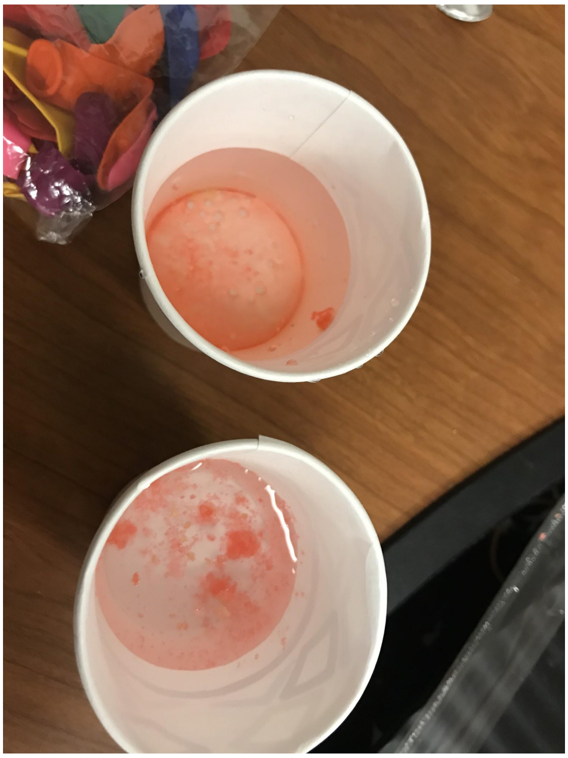
Background for Mentors

Pop rocks are made with sugar, water, corn syrup and artificial flavoring. None of the ingredients by themselves provide it with its popping ability. Rather, this quality comes from the production process of the pop rocks. First, all the ingredients are heated until they form a syrup. Conventionally, this syrup would be poured into molds and allowed to harden. This would result in the formation of regular hard candies. However, in the case of pop rocks, the syrup is exposed to CO_2 gas at very high temperatures, which causes the gas to form bubbles within the liquid. As the syrup containing bubbles is allowed to cool, the candy shatters to release the pressure, causing the formation of the tiny “rocks.” However, the small bubbles trapped inside the little pieces are still in a high pressure situation.

When you eat pop rocks, your saliva quickly dissolves the thin sugar layer surrounding the pressurized bubbles. The pressure in your mouth is much lower than that inside the pop rock, and as soon as the CO_2 trapped inside is allowed to escape, it does. This is what causes the forceful feeling of air or popping on your tongue as you eat pop rocks.

The key idea to emphasize is that substances prefer areas of low pressure. Whenever given the chance to move, they will migrate to the area with lower pressure. To make this easier to explain to the kids, you could use the analogy of a really crowded classroom. Imagine it’s a rainy day and all the kids from 3 different classes are forced to crowd into one classroom. It would obviously be very uncomfortable and hard to move around in. Now suppose the weather suddenly turns pleasant and the teacher opens the classroom door, allowing the kids to go into the large playground outside. Where would the kids prefer to be: in the crowded classroom or the free, open playground? Most of them would say playground and mentors can explain that just how all the kids would run out as soon as the door is open, so too the CO_2 rushes out the moment the shell surrounding it is dissolved.

In this module, the students will be able to place pop rocks in oil and water and observe whether they pop. They’ll soon see that the candy pops when in water but not in oil. This is because sugar has different solubility based on what solvent it is put in. The solubility of substances in different solvents is determined by their physical properties. This principle is best described as “like dissolves like.” Substances that are similar in composition (ie. both polar or both non-polar) will dissolve. Sugar is a relatively polar molecule, indicated by the numerous -OH groups in its structure. Water is also polar, thus is able to dissolve sugar. Oil, on the other hand is non-polar and thus when mixed with sugar does not cause it to dissolve. Thus, when the candy is placed in oil, the CO_2 trapped inside can’t be liberated and the pop rocks don’t pop.



Top: Pop Rocks popped in water
Bottom: Pop rocks didn't pop in oil

Materials

- Pop Rocks (2 packets per group)
- Water
- Oil
- Clear cups (2 per group)

Procedure

1. Fill one cup with water and the other with oil.
2. Place the pop rocks in the oil and note that nothing happens
3. Place the pop rocks in the water and note the popping
4. Allow the kids to try it out for themselves! Give them a small spoonful and tell them to place it on their tongues to feel the popping.
5. Add pictures and describe what is going on in your pictures using captions!

Additional Notes for Mentors

Your mentees might ask if the popping is similar to what happens when you mix mentos with soda and it causes bubbling. However, they are NOT the same process. In the mentos and soda case, a chemical reaction has to occur which produces carbon dioxide. In the case of pop rocks, no reaction occurs, but rather carbon dioxide that is already present within the candy is simply liberated when the coating around it is dissolved by your saliva. The rapid change from a high pressure condition within the candy to the low pressure environment of your mouth is what causes the bubbling.

Also, ensure that students are not lactose or soy intolerant before letting them taste the pop rocks.

Module 3: Nutella Powder

Introduction

This module will focus on the chemistry behind maltodextrin, a polysaccharide that is often used as a food additive. It is derived from starch through partial hydrolysis and appears as a white, spray-dried powder. For cooking purposes, it can serve to thicken different kinds of food. This concept will be displayed through the use of Nutella.

Teaching Goals

1. **Polysaccharide:** a carbohydrate whose molecules consist of many sugar molecules bonded together
2. Maltodextrin, a type of polysaccharide, has the ability to easily absorb oils and fats

Background for Mentors

In this module, we are looking at a reaction between maltodextrin, a polysaccharide, and Nutella. The maltodextrin is derived from tapioca. This kind is usually non-GMO, organic and gluten-free. In general, maltodextrin is used to create bulk in foods that have a liquid or gelatin-like texture. The addition of this compound reduces viscosity, making it ideal for use when thickening food. Furthermore, it is also can have a drying effect, which is displayed in this particular module when combining it with Nutella.

Materials

- 1 small steam table pan
- Blender (handheld or tabletop)
- ⅔ cup Tapioca Maltodextrin
- ⅓ cup Nutella
- Spoon

Procedure

6. Pour the maltodextrin and Nutella in the blender. If a blender is unavailable, pour the ingredients in a pan and mash them together.

7. Blend to mix the maltodextrin powder into the Nutella. Continue this for 2-5 minutes until the mixture appears to be homogeneous
8. Add more maltodextrin or nutella to increase/decrease the fineness of the powder as desires (you could potentially use this as an interactive activity with students, if time permits).

Additional Notes for Mentors
This particular experiment can create a mess very easily, so make sure to be careful when combining ingredients. Maltodextrin is a very fine and light powder that can spread throughout the air if not used with care. It is also important to stick to the assigned ratio, as too much of either ingredient could lead to undesirable results.

Module 4: Cr[EAM]

Introduction

In this module the mentees will get to make their own whipped cream and butter! In the process, the kids will be learning about the components of heavy cream and how they contribute to the formation of whipped cream and butter.

Teaching Goals

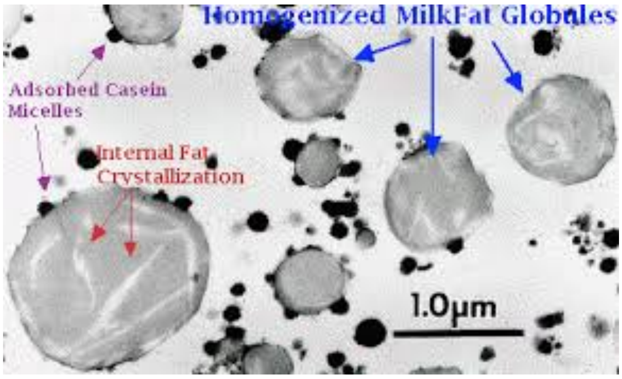
1. **Emulsion**- An emulsion is a mixture of two or more liquids that do not form a homogeneous mixture when combined together
2. Whipped cream is formed when the fat molecules coalesce in chains and clusters and surround the bubbles of air that are incorporated from the whipping
3. Shaking the jar filled with cream breaks the cream's fat globules (tiny balloons filled with fat molecules) and the fat molecules join together creating one large mass of fat which we recognize as butter.

Background for Mentors

Milk and cream are examples of emulsions in which the components include water, fat, proteins, lactose, and minerals. Our main focus today is that of the component of fat. Milk and cream consist of fat globules. Fat globules are a concentration of fat molecules surrounded by a thin membrane layer. Cream has a fat content of about 35%-40%, greater than that of milk which explains its thicker structure.

Whipped cream is formed by whipping the cream. The whipping motion not only adds air into the mixture but agitates the mixture, forcing the fat globules to partially coalesce into chains and clusters and form a protective shell around the air bubbles. Thus the liquid cream turns into a light and fluffy foam.

Butter is the result of the rupture of the fat globules. By shaking the jar the globules bump into each other many times, until their membranes finally rip. The continuous shaking allows the molecules to come in contact with one another and grow until they form one large lump of fat which separates from the rest of the mixture. This fat is our butter.



Materials
- Bowl
- Whisk
- Jars (2 per site)
- Heavy Cream (1 Quart)
- Sugar

Procedure
1. Add half a quart of heavy cream and three teaspoons of sugar into the bowl. Let the kids take turns whisking until the liquid reaches a fluffy texture, indicating whipped cream has been formed. This might take a while, so keep rotating the bowl among students and ensure that everyone gets time to try.
2. Pour the remaining half quart of cream equally into each jar. Let the kids shake the jars vigorously until mixture begins to solidify. This process will result in butter.
3. Ask the students why whisking the heavy cream created whipped cream, while shaking the heavy cream created butter. Shouldn't they both have created the same thing since they're formed from the same liquid?
4. Let the kids have a taste!

Additional Notes for Mentors
This module can get very messy if not careful. Make sure the kids keep the bowl away from the edge of the table at all times and that the jars are sealed tight. The cream must be whipped and/or shook very vigorously in order for the cream to change textures. There after all the kids have made an effort to whisk/shake, the mentors should continue doing so until the desired texture is achieved.

Conclusion
Like many things, the creation of food is a far more scientific process than many people

think. You can conclude by asking students the same questions we posed in the intro, giving them an opportunity to demonstrate their newfound knowledge. If students want to eat any of the leftover whipped cream, butter, or powdered nutella, they can do so as well (double check that they're not allergic first).

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Summary Materials Table

Material	Amount per group	Expected $$	Vendor
Clear, plastic, empty water bottles	3	0.56 for 3 Packs of 12 (2.23)	Amazon
Yeast	4.5 teaspoons	1.89	Target
Sugar	6 teaspoons	0.04 for 3tsp Packs of 4lb (2.5)	Target
Balloons	3	0.21 for 3 Packs of 72 (5)	Target

Pop rocks	2 packets		
Water	Enough to fill half a plastic cup	0	At Site
Oil (any kind)	Enough to fill half a plastic cup	2.69 for 24oz	Target
Plastic cup (preferably clear)	2		Inventory
Calcium Chloride	3 grams	$5.99 for 50 g	Modernist Pantry
Hawaiian Punch	250 mL	$1.99 for 1 gallon	Target
Proctor-Silex 59738A Hand Blender or standard blender	1 for the class	$12.74	Amazon
Syringes	1	$10.99 for pack of 20	Amazon
Sodium Alginate	5 grams	$7.49 for 50 g	Modernist Pantry
15.5oz 6pk Plastic Kids Bowls - Pillowfort™	3	$2.99 for 6 bowls	Target
Heavy Cream	1 quart	$5.58	Walmart
Bowl	1	0	Inventory
Whisk	1	$4	Target
Jar	2	0	Inventory