Kitchen Chemistry

Learning About Food Through Chemistry

Summer Camp Framework

Description: Visitors learn chemistry through hands-on activities using everyday materials found around the kitchen.

Audience: Summer campers and other groups of children ages 8 and up

Learning Objectives

1. **Matter and atoms**
    - Everything is made of tiny particles called atoms. Atoms group together into particles called molecules.
    - There are three states of matter: solid, liquid, and gas.

2. **Chemicals**
    - Chemists sort substances into groups. One way to classify chemicals is according to their pH in water, identifying them as acidic, basic (alkaline), or neutral.

3. **Chemical reactions**
    - A chemical change is different from a physical change, because it results in an entirely new substance.
    - Chemical changes (or reactions) occur when the bonds between atoms or groups of atoms are broken and rearranged to form new compounds.

4. **Properties**
    - Different foods have different properties, because of their chemistry.

5. **Testing foods**
    - Chemistry can help us analyze the foods we eat and make healthy choices.

Matter and Atoms

Everything around us is made of tiny particles called atoms. Atoms group together into particles called molecules. Atoms and molecules are very, very small: too small to see even with a super powerful microscope. We can observe these particles using our sense of smell. Let's try this out by investigating these balloons.

Explore matter and atoms (20 min)

Smelly Balloons – Sniff out the scents hidden inside balloons

- Each colored balloon has a different extract inside it (vanilla, strawberry, lemon, pine, garlic, smoke). We can use our sense of smell to identify the extracts placed in each balloon.
- Matter is made of atoms that bond together to form molecules. These particles are too small to see, but we can smell some of them! Scent molecules are so small, they can travel through the balloon membrane.

In our everyday lives, we experience three states of matter. These are solids, liquids, and gases. The difference between these states depends on the tiny particles that make them up—how tightly they're packed and how fast they're moving. Any substance can change from one state to the other. Let's explore the three states of matter by making root beer floats!

Explore the states of matter (90 minutes)
Root Beer – Make your own soda pop!
Ice Cream – It's easy to make ice cream in a bag!

- Add a solid (dry ice) to a liquid (flavored water), and what do you get? A fizzy drink! When the dry ice sublimates, it changes directly from solid to gas forming the bubbles in the drink.
- Use salt to lower the freezing temperature of water, cooling a cream and sugar mixture enough to allow tiny crystals of ice to grow. With a little shaking, the result is an emulsion of liquid cream, tiny crystals of ice, and air bubbles…also known as ice cream.

Why does the root beer foam up so much when we add ice cream? Let's look at this phenomenon with another activity, the Mentos and Diet Coke fountain.

Explore physical changes (10 min)
Soda Fountain – Make a jet of soda pop that shoots into the air!

- A fountain of soda erupts when several mint-flavored Mento candies are dropped in a 2-liter bottle of Diet Coke.
- The pitted surface of the Mento encourages the rapid growth of CO_2 bubbles in the Diet Coke. The physical surface of the candy interferes with the polar attraction of water molecules, creating nucleation sites for bubbles to grow.

Now we have a pretty good handle on the three states of matter, solid, liquid, and gas. Or do we? Let's investigate "Ooze." What, exactly, is Ooze—solid, liquid, gas?

Explore the states of matter (continued) (15-30 minutes)
Ooze – What is this stuff – solid or liquid?

- The cornstarch and water suspension has some pretty surprising properties. Sometimes it feels hard and nearly solid, and other times it feels runny and liquid.
- Ooze is a Non-Newtonian fluid, meaning that it doesn't act like a typical liquid. Its viscosity changes with the speed and strength of the force applied to it.

Extension
Popping Candy – Will your stomach explode if you drink soda while eating Pop Rocks®?

- Can you figure out what makes Pop Rocks candy pop? Will your stomach really explode if you wash down Pop Rocks with soda pop?

Chemicals

There are around 100 basic chemicals, called elements. Elements are the building blocks of chemistry. Examples of elements are gold, iron, oxygen, and carbon. Elements are made of only one kind of atom.

Chemists sort substances into groups. There are lots of different ways to sort, or classify, chemicals. We've already sorted some substances according to their state of matter: solid, liquid, or gas. Now we're going to sort substances according to their pH, figuring out if they're acids, bases, or neutral.

Explore a pH indicator (10 min)
Red Cabbage Paper – Use a vegetable indicator to test acids and bases!

- Paper that's been painted with red cabbage juice is a light blue color. It turns different colors when it comes into contact with different substances.
- Red cabbage is a natural *indicator.* It turns different colors in the presence of acids and bases. It turns red, pink, or purple in the presence of an acid. It is blue in the presence of a neutral substance. It turns green or yellow in the presence of a base.

Chemicals can be acids, bases, or neutral. Acids and bases have characteristic properties, so if we know something about a substance, we might be able to predict if it's an acid or a base. Let's try this out in our next activity, where we'll investigate common household products.

Explore acids and bases (30 min)
Acids and Bases Around the House – Use a pH indicator to find acids and bases

- Different chemicals turn the universal indicator different colors. Scientists measure the relative strength of acids and bases using the *pH scale.* Using a *pH indicator* allows us to identify chemicals as acidic, basic, or neutral.
- Chemicals (including common household products) can be acids, bases, or neutral. Acids and bases have characteristic properties.

Extension
Black Bean Indicator – Using a natural indicator to test acids and bases

- Soak black beans in water, and use the juice as another natural pH indicator.

Chemical Reactions

Chemists study what things are made of and how they react with other things. A lot of chemistry focuses on chemical reactions, or changes. One important thing to understand is the difference between a physical and a chemical change.

Remember when we made root beer floats? When we introduced dry ice into our flavored water, we created a mixture of carbon dioxide and flavored water. The ice cream helped to unmix the gas and liquid making the root beer foam up. This activity is an example of a physical change, where different substances were mixed up together, but remained the same thing (carbon dioxide and flavored water). They didn't create something entirely new, and we could unmix them later.

A chemical change is different from a physical change, because it results in an entirely new substance. Chemical changes (or reactions) occur when the bonds between atoms or groups of atoms are broken and rearranged to form new compounds. Today, we're going to do some kitchen activities that result in chemical changes!

Explore chemical reactions (20 min)
Baggie Reactions – Puff up sandwich baggies using simple chemical reactions

- Yeast and hydrogen peroxide create oxygen. Baking soda and vinegar create carbon dioxide.
- In both of these cases, a chemical reaction between a solid and liquid creates a new substance, a gas.

Both yeast and baking soda can be used to create a gas. We observed the reaction, seeing and hearing the bubbles, feeling the temperature change, and seeing and feeling the baggies puff up. Chemical reactions that create gases are important in cooking. Bread, cakes, and many other baked goods are fluffy and soft because chemical reactions create gas bubbles as they bake. We're going to bake a yeast bread.

Explore yeast (60 minutes plus baking time)
Baking Bread – Make fresh bread and explore the chemical action of yeast!

- If you look at the structure of bread closely, you'll see tiny holes where gas bubbles formed inside the dough.
- Yeast is an example of a leavening agent. Leavening agents create a gas that separates and pushes apart proteins in bread dough to make it rise.
- Yeast is a microbe that uses simple carbohydrates to produce carbon dioxide in a chemical reaction.

Extension

- Chew on Wint-O-Green mints in the dark with a friend, and watch for sparks!

Properties

Chemical reactions that create gases are important to other foods, too. Swiss cheese gets its holes from carbon dioxide produced by bacteria. Our next activity is a fun example of how a chemical reaction can change the structure of food. We're going to make "volcano" candy!

Explore chemical reactions (20 min)
Volcano Candy – Use a chemical reaction to make a foamy candy!

- The thick, bubbles we see erupting in this sugar syrup are carbon dioxide, created when the baking soda and vinegar reaction.
- This candy is an example of a *polymer,* which is a large molecule made of repeating structural units.

Polymers have lots of interesting properties. This one is lightweight, hard, and brittle. Let's use chemistry to make another edible polymer candy, and compare its properties to our foam candy.

Explore properties of polymers (20 min)
Gummy Worms – Make gooey, slimy worms!

- When you squirt a stream of sodium alginate into the calcium chloride, it solidifies into a jelly-like, slippery "worm."
- The sodium alginate solution is made of short polymer molecules that can slip past each other. The calcium in the calcium chloride solution can grab onto the short polymer strands, cross-linking them and creating a flexible gel.

Testing Foods

All foods, like everything else, are made of chemicals. Chemists can test for different substances in food, helpful or harmful. Food scientists and nutritionists use chemistry to create and improve foods, and to help us make healthy choices.

Explore enzymes (20 min)
Plant Power – How do plants control chemical reactions?

- Hydrogen peroxide will bubble when it comes into contact with some fruits and vegetables.
- Some plants have an enzyme called *catalase* that breaks hydrogen peroxide into water and oxygen. Enzymes are complex proteins that act as catalysts to speed up reactions.

We add sugar, salt, herbs, and spices to make our foods taste good. These flavorings are okay in small amounts, but too much sugar and salt aren't good for our bodies. Many of the processed and prepared foods we buy have a lot more salt and sugar than we realize!

Investigate salt content (30 minutes)
A Grain of Salt – Figure out just how much salt is in your food

- We can figure out how much salt is in some foods by using a titration procedure with a sodium chromate indicator.
- Processed and prepared foods are often very high in salt. Our bodies need salt in small amounts, but too much salt is not a healthy choice because it can cause high blood pressure.

Investigate sugar content (30 min)
How Sweet It Is – Wow-there's a lot of sugar in drinks

- Drinks with more sugar weigh more, so we can compare the amount of sugar in different drinks by weighing them.
- Sugar is naturally present in fruit juices, and added to soda pop, flavored waters, and other drinks. The relative amount of sugar in different drinks can be surprising! Sugar provides our bodies with energy but no nutrients, so consuming too much sugar is not a healthy choice.

Sugar provides calories, or energy for our bodies. It's an example of a carbohydrate. Another kind of carbohydrate is starch.

Test for starch (20 min)
Starch Test – Use Iodine to test for starch

- Foods with starch in them will turn blue when they come into contact with iodine. The deeper the blue, the more starch a food contains.
- Cooked food reacts strongly to iodine because cooking breaks down the cell walls and releases the starch.
- Bread reacts to iodine, but chewed bread does not. That's because the enzyme *amylase* in saliva breaks down starch into sugar.

We can also test foods for vitamins and minerals that help keep our bodies healthy. Vitamins and minerals are present in many foods naturally. Processed foods and ingredients are often fortified with vitamins and minerals to make them more nutritious.

Test for Vitamin C (20 min)
See Vitamin C – Which foods have Vitamin C?

- Using a titration procedure and an indicator made from cornstarch and iodine, we can identify the presence of vitamin C in foods.
- Vitamin C is present in orange juice, potatoes, and other foods. Heat breaks down vitamin C, so cooked foods contain less vitamin C than raw foods.
- Vitamin C is an antioxidant, and helps our bodies to create the collagen in our cell walls, and prevents scurvy.

Test for iron (20 min)
Magnetic Cereal – Attract iron-fortified cereal with a magnet!

- Many breakfast cereals are fortified with iron, and the tiny iron particles in the cereal are attracted to magnets.
- Iron is an important part of many proteins and enzymes that our bodies need to be healthy. The proteins that carry oxygen through our body are made of iron and other elements. Lack of iron can cause anemia.

Extension
Bounce an Egg – Can you drop an egg without breaking it?

- Find out why your bones need calcium to be strong. Soak raw eggs and clean chicken bones in vinegar overnight. The acid of the vinegar will break down the calcium in the eggshell and chicken bone, making them soft and rubbery.

Smelly Balloons

Sniff out the scents hidden inside balloons

Activity Guide

Try This!

SAFETY: If your balloons are latex, warn visitors of possible allergic reactions.

1. Each balloon has a different scent inside it. Your challenge is to figure out which scent is in which balloon.
2. Smell the balloons. Can you identify all the extracts?

What's Going On?

Matter is made of atoms that bond together to form molecules. These particles are too small to see, but we can smell some of them! Scent molecules are so small they can travel through the balloon membrane.

Scent molecules are very volatile, which means that they easily vaporize from liquid extract into a gas. We added a liquid extract to the balloon, but it soon vaporized, filling the balloon with scented air.

Air gradually leaks out of the tied balloon. This is because the tiny air molecules inside the balloon move through the pores of the balloon's skin, in a process known as diffusion. Air always diffuses from areas of higher pressure to areas of lower pressure. An inflated balloon has greater air pressure inside it, so the air gradually diffuses into the lower air pressure surrounding the balloon.

Learning Objectives

- Molecules are too small to see, but we can smell some of them.
- Scent molecules are so small they can travel through the balloon membrane by diffusion.

Materials

- Selection of scented balloons *(Requires advance preparation; see below.)*

Advance Preparation

- Round balloons in different colors
- Variety of extracts (e.g. vanilla, strawberry, garlic, smoke)
- Pipettes or eye droppers
- Balloon pump

1. Use a pipette or eyedropper to put about ½ teaspoon extract in a balloon. Insert the dropper as far as possible into the balloon before you squeeze it, so the extract doesn't get onto the neck of the balloon.
2. Holding the balloon carefully so you don't get extract in your mouth (or balloon pump), blow up the balloon and tie it.
3. Shake the balloon a few times to encourage the extract to vaporize.
4. Repeat steps 1-2 for all your extracts. Choose a different color balloon for each extract.
5. Make a key identifying the scent in each balloon. Optional: Make a list of the scents—without keying them to the balloon colors—for visitors to see.

Root Beer

Make your own soda pop!

Activity Guide

Try This!

1. In a large cooler, mix together the sugar, cold water, and root beer extract, stirring to dissolve sugar completely.
2. Break up the dry ice into small pieces and place into the cooler with tongs.
3. Loosely cover the cooler with the lid. Do not completely secure the lid, as pressure may build up.
4. Let the mixture brew for about an hour before serving.

What's Going On?

Dry ice is another name for frozen carbon dioxide (CO_2). When the dry ice sublimates, it changes directly from solid to gas and carbonates the flavored water, turning it into root beer.

Learning Objectives

- Dry ice is frozen carbon dioxide.
- Dry ice sublimates, changing from solid to gas.

Materials

- 6 cups white sugar
- 3 gallons cold water
- 1 two-ounce bottle root beer extract
- 4 pounds food grade dry ice
- Large cooler (not a styrofoam cooler—styrofoam particles break off and get into the drink)
- Measuring cups

Ice Cream

It's easy to make ice cream in a bag!

Activity Guide

Try This!

1. For each portion, put 1-2 cups of ice in a gallon bag with ¼ cup of salt.
2. Pour sugar, milk and vanilla into the small bag and seal.
3. Place the small bag inside the large bag and seal.
4. Shake for 10-15 minutes.
5. Remove the small bag and rinse the salt water off, or wipe it with a paper towel.
6. Open and enjoy! Add chocolate syrup if you wish.

What's Going On?

Salt lowers the freezing temperature of water, which cools the cream and sugar mixture enough to allow tiny crystals of ice to grow. With a little shaking, the result is an emulsion of liquid cream, tiny crystals of ice, and air bubbles…also known as ice cream.

Heat always flows from an area of higher temperature to an area of lower temperature. So, heat is transferred from the milk mixture to the ice and salt mixture in the outer bag. If only ice is used in the outer bag, the milk mixture would become cold as the ice melted, but would not actually freeze. Adding salt to the ice lowers the freezing point and allows the milk mixture to freeze.

Learning Objective

- Salt lowers the freezing point of water, allowing us to make ice cream out of cream and sugar.

Materials

For each portion:

- 1-2 cups ice
- 2-3 teaspoons sugar, or 2 sugar packets
- ½ cup half and half
- ¼ teaspoon vanilla extract
- ¼ cup rock salt
- 1 pint or quart size zip or slider freezer weight bag
- 1 gallon size zip or slider freezer weight bag (slider is best)

For the group:

- Small cups and plastic spoons for serving ice cream
- Measuring cups and spoons
- Paper towels
- Sheet plastic or newspaper to protect working surface
- Chocolate syrup (optional)
- Large container to hold discarded ice and salt

Soda Fountain

Make a jet of soda pop that shoots into the air!

Activity Guide

Try This!

1. Stand the bottle of soda straight up, or hold it at an angle away from visitors.
2. Drop 4 or more Mentos® into the bottle.

What's Going On?

The Mentos candies cause the carbon dioxide gas in the soda to rapidly form large bubbles, creating a fountain of foamy soda that can rise many feet in the air.

The most important factors in this reaction are:

- The bumpy surface of the candies encourages bubble growth because it disrupts the polar attraction between water molecules, creating nucleation sites for the carbon dioxide gas to form bubbles.
- Diet Coke® works better than regular Coke because the artificial sweetener aspartame lowers the surface tension of the water, which allows large bubbles to form more easily and quickly.
- The coating on Mentos candy contains gum arabic, a surfactant that also reduces surface tension in water. (Mint Mentos have a rougher surface than fruit-flavored Mentos, so they work better.)
- Mentos are dense, so they sink rapidly. Bubbles forming at the bottom of the bottle rise quickly, encouraging further bubble growth as they rise.

Learning Objectives

- A bumpy surface on candy can disrupt the polar attraction between water molecules in soda pop.
- Carbon dioxide comes out of solution at nucleation sites on the bumpy surface of candy.

Materials

- 2 liter bottle of Diet Coke® (other diet colas will work)
- Roll of peppermint Mentos® candy
- 1 large plastic tarp or ground cover to protect your demo area

Background Information

Check out http://www.youtube.com/watch?v=aLo8FExLouA

Ooze

What is this stuff-solid or liquid?

Try This!

1. Add two measures of cornstarch to the small bowl.
2. Add one measure of water to the bowl. (Optional: Add food coloring to the water before you put it in the bowl.)
3. Use your hands to combine the cornstarch and water.
4. Poke the ooze gently, then stir it slowly with your finger. How does it behave?
5. Now poke the ooze sharply, and drag your finger through the bowl quickly. Does it react differently when you apply more force?
6. Pick up some ooze, and let it run through your fingers. Now squeeze some in your hand. How does it behave?

Note: You can make as much or as little "ooze" as you like, using a ratio of 2 parts cornstarch to 1 part water.

What's Going On?

The cornstarch and water mixture has some pretty surprising properties. The "ooze" looks and feels like a thick liquid when you touch it gently, or let it run through your fingers. But it seems to get hard like a solid when you apply more force, and can even appear dry and powdery.

Ooze is a *non-Newtonian fluid,* meaning that it acts like a liquid when being poured, but like a solid when a force is acting on it. Its viscosity increases with the speed and strength of the force applied to it, so sometimes it feels hard and nearly solid, and other times it feels runny and liquid.

*A **Newtonian fluid** has a constant rate of flow regardless of the forces acting on it.*

*A **non-Newtonian fluid** is any fluid that behaves differently depending on the amount of force acting on it.*

Learning Objective

- A non-Newtonian fluid acts like a liquid when being poured, but like a solid when acted on by a force.

Materials

- Cornstarch
- Water
- Food coloring (optional)
- Bowls
- Measuring cup

Popping Candy

Will your stomach explode if you drink soda while eating Pop Rocks®? **Activity Guide**

Try This!

Put a couple of pieces of candy in your mouth. What happens?

What's Going On?

When you eat the candy, you hear and feel it fizzing. The candy pops and fizzes because it contains bubbles of carbon dioxide under high pressure. When you melt the candy shell, the carbon dioxide escapes with a pop.

When Pop Rocks® are made, the hot candy syrup is mixed with carbon dioxide gas under high pressure (600 pounds per square inch). This forms tiny, high-pressure bubbles of carbon dioxide gas in the candy. When the candy mixture cools and the pressure of the gas is released, the hard candy breaks into small pieces of carbonated candy.

Now Try This!

1. Pour the contents of one packet of Pop Rocks candy into a balloon.
2. Attach the opening of the balloon to the opening of the soda pop bottle, being careful not to spill the candy into the bottle until you're ready.
3. All at once, dump the contents of the balloon into the soda. What happens?

What's Going On?

You might have expected the balloon to fill up with the carbon dioxide from the candy and the soda pop. But actually, the balloon barely inflates.

When you combine the Pop Rocks and soda pop, no new gas is created—you're just releasing the gas that's in the candies and the soda pop. In other words, this is a physical reaction, not a chemical reaction.

And there isn't really much gas in the candy and soda pop combined—only enough to inflate the balloon a little bit. So it's pretty unlikely that your stomach would explode if you had a snack of Pop Rocks and soda pop.

Learning Objectives

- Pop Rocks candy mixed with soda pop release gas in a physical reaction.
- There is not enough gas trapped in the candy to cause your stomach to explode.

Materials

- Pop Rocks® candy
- 12- or 16-ounce bottle of soda pop
- Balloon

Red Cabbage Paper

Use a vegetable indicator to test acids and bases!

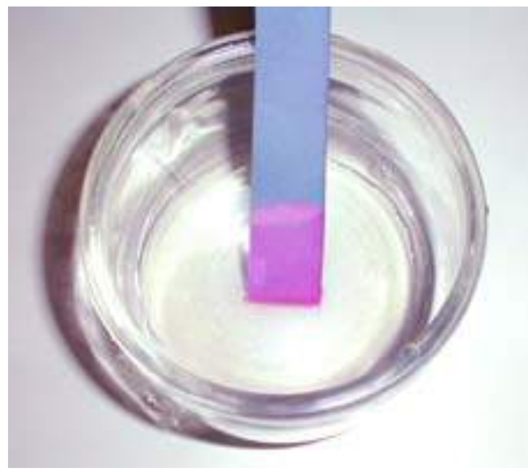
Activity Guide

Try This!

1. Take a strip of red cabbage paper.
2. Use a cotton swab to paint some of the dilute acid on the paper or dip a strip into a small container containing the dilute acid. What color does the paper turn?
3. Now try the base and the water. Does the paper turn the same color?

What's Going On?

The paper was painted with the juice from cooked red cabbage. Red cabbage is a natural pH indicator. An *indicator* is a chemical that turns different colors when it comes into contact with an acid or a base.



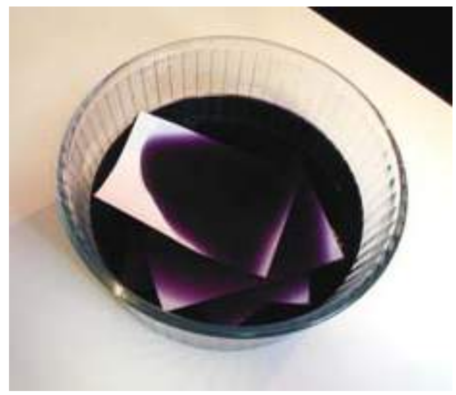
Red cabbage paper starts out pale blue. It turns red or pink when it comes into contact with an acid, and green or yellow when it comes into contact with a base. It stays blue when it comes into contact with water, because water is neutral.

Learning Objectives

- An indicator is a chemical that turns different colors when it comes into contact with an acid or a base.
- Red cabbage is a natural pH indicator.

Materials

- Red cabbage paper *(Requires advance preparation; see below)*
- Cotton swabs
- Container for used cotton swabs
- Labeled cups of known chemicals:
  - Acid: white vinegar
  - Base: saturated solution of washing soda in water
  - Water



Advance Preparation:

- Head of red cabbage
- Knife or cabbage shredder
- Water
- Large pot to boil water
- Large bowl
- Strainer
- Cardstock
- Foam paintbrush

To make the red cabbage paper:

1. Add two quarts of water in the large pot, and put it on to boil.
2. In the meanwhile, shred or chop the cabbage and put it in the large bowl.
3. Pour the boiling water over the cabbage, and leave it to soak for 15 minutes.
4. Strain the cabbage, saving the liquid and discarding the solids.
5. Soak each sheet of cardstock in the red cabbage juice. Coat each sheet twice, allowing the paper to dry between coats.
6. Let the paper dry and then cut into strips.

Acids & Bases Around the House

Use a pH indicator to find acids and bases

Lesson Plan

Description: Visitors predict whether various household solutions are acids or bases, and test their hypotheses using a universal pH indicator. Then, visitors are challenged to line up household chemicals in "rainbow" (pH) order.

Audience: Hands-on activity for families and children ages 8 and up

Length: 20 minutes

Learning Objectives

Visitors learn:

- Chemicals (including common household products) can be acids, bases, or neutral.
- Acids and bases have characteristic properties.
- When acids and bases combine they neutralize each other, which cancels out their acid and base properties.
- Scientists can use *pH indicators* to identify chemicals as acidic, basic, or neutral.
- Scientists measure the relative strength of acids and bases using the *pH scale*.

Visitors develop skills related to chemistry and science, including:

- Developing and testing predictions
- Observing, communicating, and discussing experimental results

Learning Standards

National Science Education Standards

1. Science as Inquiry
   - K-4: Abilities necessary to do scientific inquiry
   - K-4: Understanding about scientific inquiry
   - 5-8: Abilities necessary to do scientific inquiry
   - 5-8: Understanding about scientific inquiry
   - 9-12: Abilities necessary to do scientific inquiry
   - 9-12: Understanding about scientific inquiry

2. Physical Science
   - K-4: Properties of objects and materials
   - 5-8: Properties and changes of properties in matter
   - 9-12: Chemical reactions

Background Information

When most people hear the word "**acid**," they think of something very dangerous that can dissolve metal and burn skin. In fact, many acids are not dangerous at all. Some are even found in the foods we eat! Any food that tastes sour is acidic. For example, vinegar in salad dressing is acetic acid, oranges and lemons contain citric acid, and apples contain malic acid. Vitamin C is an acid, ascorbic acid.

Bases are also found in common household products. Bases can be very strong and dangerous, or weak and safer for use around the house. Lye or washing soda are very strong bases. Weaker bases are often used as cleaning products, like household ammonia used to clean windows. We don't find many bases in our foods because they taste bitter—think about the taste of soap!

Chemists use a scale known as the **pH scale** to indicate the amount of acid or base present in a solution. The pH scale goes from 1-14. Neutral substances have a pH of 7. A pH less than 7 is an acid, with lower numbers indicating stronger acids. A pH greater than 7 is a base, with higher numbers indicating stronger bases.

1 2 3 4 5 6 7 8 9 10 11 12 13 14

acid neutral base

A universal indicator (such as Bogen's universal indicator) identifies pH by turning a rainbow of colors:

- **Red** (acids of pH ~2-4)
- **Orange** (acids of pH ~5)
- **Green** (pH ~6-7)
- **Blue** (pH ~9)
- **Purple** (pH ~10 and up)

If an acid and base are mixed in equal amounts they react together to make a salt and water.

ACID + BASE → SALT + WATER

In the first part of this activity, visitors use the universal indicator to test what color it turns in acid and what color it turns in base. Then, visitors try to predict whether common household chemicals are acidic, basic, or neutral. They test their predictions using the indicator. Finally, visitors can mix acids and bases to try and get each pH level (indicated by a different color).

EXPECTED RESULTS

	Vinegar	Lemon juice	Seltzer	Baking soda	Detergent	Ammonia cleaner	Washing soda
Universal indicator	hot pink	pink	orange	green	purple	purple	purple

Materials

For each pair of visitors

- Well plate
- Transfer pipettes (around a dozen)
- Labeled dropping bottle of known chemicals:
    - o Acid: vinegar (5% acetic acid, by weight)
    - o Base: washing soda in water (1% by weight, in water)
    - o Water
- Labeled dropping bottle of universal indicator
- Labeled dropping bottles of acids found around the house
    - o Seltzer water
    - o Lemon juice
    - o Vinegar
    - o Light-colored sports drink (like Gatorade)
- Labeled dropping bottles of bases found around the house
    - o Baking soda (1% solution by weight, in water
    - o Dishwashing detergent (1% solution by weight, in water)
    - o Ammonia based cleaner
- Safety glasses and gloves (for each visitor)

For the presenter

- One set of visitors' supplies
- Trash can
- Paper towels (to clean up spills)

Sources

- Bogen's universal indicator, well plates, and pipettes are available from scientific suppliers, including Carolina (http://www.carolina.com).
- Safety supplies (glasses and gloves) are available from Flinn Scientific or other scientific suppliers.
- Household chemicals can be found at grocery stores and pharmacies.

Notes to the Presenter

You can let visitors investigate the pH of almost any clear, light-colored liquid that it's safe for them to handle. Visitors like to see the original containers, but it's not convenient for them to work from them. Labeled dropping bottles are easy for visitors to use and minimize spills.

CAUTION: Always supervise visitors during this activity. Be sure visitors wear safety glasses and gloves, and don't let them taste any chemicals (even food or drinks).

Set Up

Set up takes approximately 30 minutes.
(Set up will take longer the very first time you do the activity.)

1. Prepare the known base solution by dissolving 1 gram of washing soda in 100 ml water.
2. Pour the vinegar and water into labeled dropper bottles.
3. Pour the household items into dropper bottles.

Program Delivery

In today's program, we're going to learn about one way that chemists classify foods and other products we can find around the house: as acids or bases.

Do you know what acids and bases are? Can you name any examples? *Range of responses.*

Lots of people think of acids as being super strong chemicals that can burn through your skin. But there are lots of weak acids, too. You even eat some acids! Acids taste sour. *Name or reiterate acids in foods: citric acid in lemons, acetic acid in vinegar, malic acid in apples.*

What about bases? Bases are the opposite of acids. We don't eat bases, because they taste soapy or bitter. Bases can be strong or weak, too—they come in a range of pHs.

Can anyone name any common bases? *Name or reiterate bases found around the house: baking soda, washing soda, ammonia, lye soap.*

Acids and bases can be strong, or weak, or somewhere in between. Chemists measure the strength of acids and bases using a scale called the pH scale.

The pH scale goes from a strong acid at one end (1) to a strong base at the other end (14). In the middle are weaker acids, things that are neutral (meaning they're not acids or bases), and weaker bases. On a pH scale, acids range from 1 to 6, 7 is neutral, and bases range from 8-14. Pure water is neutral and has a pH of 7.

Let's say we had a chemical, like the stuff in this bottle. *Hold up bottle of water.*

How would you figure out what pH this is? Would you want to taste it to see if it's bitter or sour? No! It might be poison.

Here's what you could do: You could use something called an *indicator*. An indicator is a chemical that turns different colors if it's in an acid or a base. Today, we're going to use a *universal indicator,* which indicates the whole range of pH from acid to neutral to base.

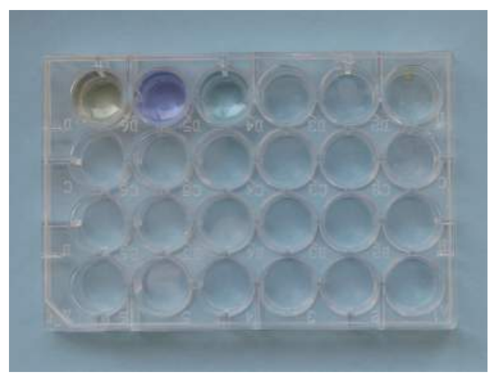
Let's find out how the indicator can help us identify chemicals as acids or bases. We'll test it using a known acid and a known base. Then, we'll try to figure out whether some other chemicals are acids or bases.

Is everyone wearing safety glasses and gloves? *Make sure everyone is wearing safety glasses and gloves.*

Let's get started! *Demonstrate the following procedure.*

<u>Identifying acids and bases with universal indicator</u>

1. Put a few drops of the solution in the "acid" bottle in the first well of the first row. This will be your Acid row.
2. Add a few drops of indicator.
3. Note the color change.
4. Put a few drops of the solution in the "base" bottle in the first well of the second row. That will be your Base row.
5. Add a few drops of indicator.
6. Note the color change.
7. Put a few drops of water in the first well of the third row. This will be your Neutral row.



What color did then indicator turns in acid? M*agenta*

What color did it turn in the base? P*urple*

What about in water, which is pretty close to neutral? *No change/minimal change*

Here's something neat: our indicator doesn't just tell us whether we have an acid or a base—it can tell us how strong it is, too.

I mentioned that we're using a *universal indicator*, which turns different colors depending on the pH. The most acidic is red, then orange, then yellow then green at neutral; then blue and purple.

Now that we know that we know how to use the indicator, we can test some common household products to see if they're acidic, neutral, or basic. *Indicate chemical containers.*

You can predict whether these chemicals are acids, bases, or neutral. You can also predict which ones are stronger. *Demonstrate the following procedure.*

Further exploration

1. Put a few drops of a solution you think is acidic in the Acid row.
2. Add a few drops universal indicator.
3. Note the color change. Was your prediction correct?
4. Now, do the same for products you think are basic and neutral, using the Base and Neutral rows of your well plate. Did you predict correctly?
5. When you're done with that, you can predict which products you think are *more* acidic or basic than others.

And after you get the hang of it, you can experiment by mixing the acids and bases. See if you can get a solution of each color of the rainbow, and try to line them up in rainbow order!

If visitors use up all their wells and want to keep working, they can get a fresh plate or rinse off their plate in the sink.

Clean Up

- The unused universal indicator can be poured into a storage bottle and saved to use again.
- The dropper bottles of acids and bases can be stored to use again.
- Consult the labels of the household chemicals for storage and disposal information.
- Rinse the well plates and leave them out to dry before storing them.
- Paper towels that have been used to clean up spills can be disposed of in the trash.

Black Bean Indicator

Use a natural indicator to test acids and bases

Activity Guide

Try This!

1. Using a pipette, put a few drops of the acid in a well of your well plate.
2. Add a few drops of black bean indicator. What color does the indicator turn?
3. Now try the base and the water. Does the indicator change color?

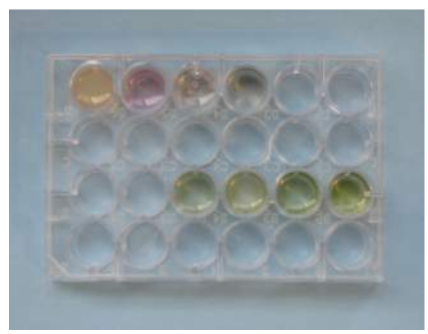
What's Going On?

Black beans are a natural pH indicator. An *indicator* is a chemical that turns different colors when it comes into contact with an acid or a base.

Black bean indicator starts out a grayish-purple color. It turns pink when it comes into contact with an acid, and green when it comes into contact with a base. It stays purple when it comes into contact with water, because water is neutral.

Now Try This!

1. Now you can try other household chemicals, and find out whether they're acids or bases. Choose a test product and predict (guess) if it's an acid or base.
2. Use a pipette to put a few drops of the solution in a well.
3. Add a few drops of black bean indicator. What color did it turn? Did you guess correctly?
4. Keep trying different chemicals. Does the indicator always turn the same color pink or green?



What's Going On?

The black bean indicator lets you compare how strong or weak different acids and bases are. It turns a deeper color for stronger chemicals, and a paler color for weaker chemicals.

	Lemon juice	**Vinegar**	**Seltzer**	**Water**	**Baking soda**	**Detergent**	**Washing soda**	**Ammonia cleaner**
Black bean indicator	pink	pink	pale pink	purple	pale green	pale green	green	green
pH	2	3	5	7	8	10	12	13

Learning Objectives

- An indicator is a chemical that turns different colors when it comes into contact with an acid or a base.
- The deeper the color of the black bean indicator, the stronger the household chemical.

Materials

- Black bean indicator *(Requires advance preparation; see below)*
- 24-well plates
- Transfer pipettes or eyedroppers
- Labeled cups of known chemicals:
    - Acid: white vinegar
    - Base: saturated solution of washing soda in water
    - Water
- Labeled cups of test solutions:
    - Seltzer
    - Lemon juice
    - Saturated solution of baking soda
    - Saturated solution of dishwashing detergent
    - Ammonia-based cleaner
    - Light-colored sports drink, like Gatorade
    - Other clear, light-colored liquids
- Safety glasses

Advance preparation:

- Dry black beans
- Bowl
- Isopropyl alcohol
- Hot water

1. Soak black beans in a 50-50 mixture of hot water and isopropyl alcohol for 30-60 minutes. (The alcohol prevents the bean mixture from spoiling. If you don't plan to keep it, you can soak the beans in plain hot water.)
2. Drain into a container, saving the liquid and discarding the beans. The liquid is your indicator.

Baggie Reactions

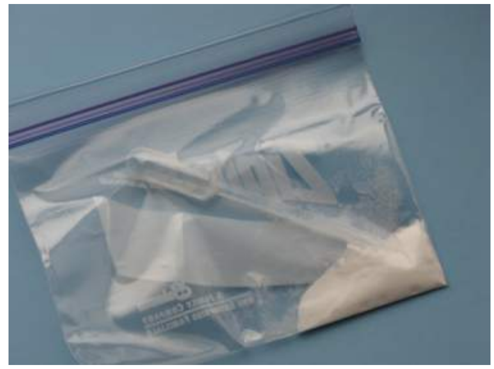
Puff up sandwich baggies using simple chemical reactions!

Activity Guide

Try This!

Carbon dioxide

1. Put 1 teaspoon of baking soda into a baggie.
2. Shake the baggie so the baking soda settles into one corner.
3. Fill a pipette with vinegar. Don't squeeze it out!
4. Place the full pipette inside the baggie, with the stem facing the baking soda.
5. Gently pat the baggie to get out as much air as possible.
6. Seal the baggie.
7. Wait until everyone is ready.
8. Squeeze the bulb of the pipette to start the reaction!



Kids should see bubbles and hear a fizzing sound right away. After awhile, they should notice that the bag has inflated and that the contents feel cold.

Oxygen

1. Put ¼ teaspoon yeast into a baggie.
2. Shake the baggie so the yeast all settles into one corner.
3. Fill a pipette with hydrogen peroxide. Don't squeeze it out!
4. Place the full pipette inside the baggie, with the stem facing the yeast.
5. Gently pat the baggie to get out as much air as possible.
6. Seal the baggie.
7. Wait until everyone is ready.
8. Squeeze the bulb of the pipette to start the reaction!

Kids should see bubbles and hear a fizzing sound right away. After awhile, they should notice that the bag has inflated and that the contents feel hot.

What's Going On?

Carbon dioxide can be generated from baking soda and vinegar. This kind of reaction is called an *endothermic* reaction. It takes in heat, so the baggie feels cold. *Endo* means "in."

Oxygen can be made from hydrogen peroxide and living cells (in this case, yeast). This kind of chemical reaction is called an *exothermic* reaction. It gives off heat, so it feels hot. *Exo* means "out."

> ***Endo*** means "in," as in endothermic.
>
> ***Exo*** means "out," as in ***exothermic***.

Learning Objectives

- Gases can be a product of a chemical reaction.
- Some chemical reactions are exothermic (give off heat) and some are endothermic (take in heat).

Materials

- Measuring teaspoon
- Zipper sandwich baggies
- Jumbo (15 ml) transfer pipettes
- Yeast
- Baking soda
- Vinegar
- 6% hydrogen peroxide (sold as “20 volume developer” at beauty supply stores)

Baking Bread

Make fresh bread and explore the chemical action of yeast!

Activity Guide

Try This!

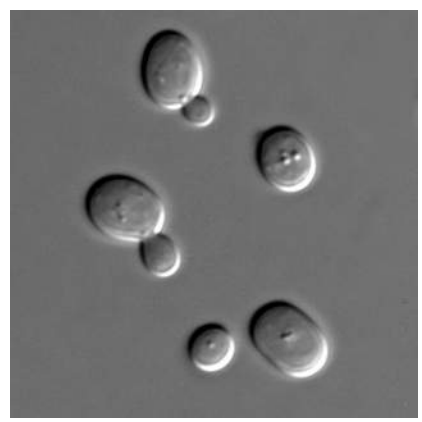
1. Dissolve yeast in warm water and set aside to proof.
2. Combine sugar, salt, shortening and egg in a large bowl. Mix with an electric mixer on low.
3. Add yeast mixture and stir in about 4 cups of flour. Mix on low.
4. Stir in remaining flour by hand, adding flour if needed to make a soft dough.
5. Cover dough with plastic wrap or a moist cloth and refrigerate. Punch down occasionally.
6. Preheat oven to 400 degrees, and shape dough into small loaves. Let rise until almost doubled in size.
7. Place loaves into mini-loaf pans or onto baking sheets.
8. Bake for 8-10 minutes.

Recipe makes about two dozen mini-loaves.

What's Going On?

Yeast is a microbe (a single-celled fungi) that feeds on simple carbohydrates, such as sugar. As it feeds, yeast produces carbon dioxide (CO_2).

Yeast is an example of a *leavening agent.* When the bread rises and bakes, the carbon dioxide creates thousands of bubbles in the dough. This is what gives bread its airy texture and makes it rise.



Yeast is a living organism!

Learning Objectives

- Yeast is an example of a leavening agent. Leavening agents create a gas that separates and pushes apart proteins in the dough to make it rise.
- Yeast is a microbe that uses simple carbohydrates to produce carbon dioxide in a chemical reaction.

Materials

- Measuring teaspoon
- 4½ - 5 teaspoons active dry yeast
- 2 cups warm water
- ½ cup sugar
- 2 teaspoons salt
- ½ cup soft shortening (butter or margarine)
- 1 egg
- 6 ½ cups all purpose flour, plus extra as needed
- Small bowl
- Large bowl
- Electric mixer
- Plastic wrap or cloth dish towel
- Mini-loaf pans or baking sheets
- Oven

Volcano Candy

Use a chemical reaction to make a foamy candy!

Activity Guide

Try This!

SAFETY: Extreme caution is necessary when heating and handling the candy. It is recommended that you do this activity as a demonstration and do not allow visitor participation.

SAFETY: The candy is safe to eat only if you use food-grade ingredients and clean kitchen equipment to prepare it.

1. Prepare the pan by lining with aluminum foil.
2. Coat the foil with the cooking spray.
3. Combine ¼ cup sugar and ½ cup corn syrup in the pot.
4. Add 1-teaspoon vinegar to the pot and stir.
5. Heat to boiling until all the sugar dissolves.
6. While you wait for the candy to heat up, measure out 1 scant teaspoon baking soda, crushing any lumps so you have a uniform powder. Set the baking soda aside.
7. Continue heating and stirring the sugar syrup until the temperature reaches 290° F.
8. Remove the pot from the heat and place it on a trivet.
9. Quickly stir in the baking soda. Observe the reaction.
10. Pour the mixture into the prepared pan. Don't spread out the mixture (or you'll pop the bubbles).
11. Let the candy cool, then break it into pieces and eat it.

What's Going On?

The bubbles that erupt in the sugar syrup are carbon dioxide that was created when the baking soda and vinegar reacted. This chemical reaction is used to leaven many baked goods. (It's also familiar to many kids from making model volcanoes in school.)

The resulting holes in the candy crystal make the candy lightweight, and give it a foamy structure. This candy is an example of a polymer, which is a large molecule made of repeating structural units.

Learning Objectives

- Carbon dioxide is created when baking soda and vinegar react.
- A polymer is a large molecule made of repeating structural units.

Materials

- Granulated sugar
- Light corn syrup
- Cooking spray (butter or oil)
- Vinegar
- Baking soda
- Aluminum foil
- Small pan (about 6 inches square)
- Transparent glass pot, pan, or casserole that is safe for stovetop use
- Rubber spatula
- Candy thermometer
- Hot plate or stovetop
- Glove or hot pad
- Trivets or heatproof surface.

Gummy Worms

Make gooey, slimy worms!

Activity Guide

Try This!

SAFETY: The gummy worms are safe to eat only if you use food-grade chemicals and clean kitchen equipment to prepare them.

4. Put the sieve into the bowl of calcium chloride solution.
5. Squirt a stream of sodium alginate mixture into the bowl, making long, wormy strands.
    - Make sure you squirt inside the sieve so you can remove your worms easily.
    - Let the worms rest in the sieve for a minute.
6. Remove the sieve, and rinse the worms in fresh water. (Otherwise, they'll taste salty.)
7. Touch and taste the worms—if you dare!

What's Going On?

Your gummy worms are an example of a *polymer,* a large molecule made of repeating units.

The sodium alginate in the squirt bottle is made of short polymer molecules that can easily slide around each other inside the water. The calcium ions in the bowl cross-link these short polymers together into longer strands turning the stream of liquid from the squirt bottle into a thick gel.

A polymer is large molecule made up of repeating units

Learning Objectives

- Polymers are large molecules made of repeating units.
- Short polymer molecules, like sodium alginate, can be joined into longer polymers.

Materials

- Sodium alginate mixture *(Requires advance preparation; see below)*
- Calcium chloride solution *(Requires advance preparation; see below)*
- Blender
- Squirt bottle
- Large mixing bowl
- Measuring cup
- Measuring spoons
- Sieve (mesh strainer) that nests inside the bowl

Food grade chemicals are available at www.willpowder.com.

Advance Preparation

Sodium alginate mixture

- Sodium alginate (food grade)
- Flavored extracts (food flavorings)
- Packet artificial sweetener
- Food coloring (optional)

6. Put ¼ teaspoon sodium alginate in the blender.
7. Add ½ cup water.
8. Blend.
9. Add 1 tablespoon extract and packet of artificial sweetener.
10. Blend.
11. Optional: Add a few drops food coloring to make the color more intense.
12. Pour into the squirt bottle. Label the bottle "sodium alginate."

Calcium chloride solution

- Calcium chloride
- Mixing bowl

1. Put ¾ teaspoon calcium chloride in the mixing bowl.
2. Add 2 ¼ cups water.
3. Stir until dissolved.

Clean Up

Left over liquids can be flushed, **one at a time,** down the drain.

Plant Power

How do plants control chemical reactions?

Activity Guide

Try This!

1. Put 10-20 drops of hydrogen peroxide into a well.
2. Drop in a piece of fresh fruit or vegetable. What happens?
3. Now try a cooked piece of the same fruit or vegetable. Does the hydrogen peroxide react the same way?
4. Try more kinds of fruits and vegetables. Do you notice any differences between the different kinds?

What's Going On?

The raw fruits and vegetables contain an enzyme called *catalase* that breaks up hydrogen peroxide into water and oxygen. This causes the bubbling you see when you put the piece of produce into the hydrogen peroxide. Some kinds of fruits and vegetables have more catalase than others:

- *High in catalase:* sweet potato, kiwi fruit, carrot, red pepper, mushroom, watermelon, pineapple, turnip
- *Low in catalase:* apples, grapes, zucchini

Cooking inactivates enzymes, so the cooked fruits and vegetables don't have active catalase. The chemical reaction that creates bubbles in the hydrogen peroxide doesn't happen.

Enzymes are complex proteins that act as catalysts to speed up reactions. Almost all living things contain catalase to break apart peroxides. Living systems can be damaged by unwanted reactions caused by peroxides, but catalase quickly turns peroxides into harmless water and oxygen.

Catalase *is a complex protein, called an* ***enzyme****, that acts as a catalyst.*

A ***catalyst*** *causes or speeds up a reaction without being affected.*

Learning Objectives

- The enzyme catalase speeds the breakdown of hydrogen peroxide into water and oxygen.
- Cooking inactivates enzymes.
- Catalysts speed up reactions without being affected.

Materials

- 24-well plate
- Labeled dropping bottle with 3% hydrogen peroxide
- A variety of raw and cooked cut up fruits and vegetables *(Requires advance preparation; see below.)*
- Small cups to hold fruits and vegetables
- Knife and cutting board
- Microwave-safe containers and microwave OR pot, hotplate, and mesh strainer

Advance Preparation:
- 4 kinds of produce high in catalase: sweet potato, kiwi fruit, carrot, red pepper, mushroom, watermelon, pineapple, turnip
- Produce low in catalase: apples, grapes, zucchini

SAFETY: Be careful when boiling the water.

NOTE: All fruit and vegetables should be cut *just* before using.

1. Cut your fruits and vegetables into very small pieces. Make separate piles for each kind.
2. Divide each pile in two and cook half of the cut pieces of each kind separately.
    - Stovetop: Place in a strainer, and cook for a few seconds in boiling water (holding the strainer in the water).
    - Microwave: Place in a microwave-safe dish and cook for 30 seconds.
3. Put the pieces of cooked fruits and vegetables into cups (keeping each kind separate, and keeping the cooked and uncooked pieces separate).

A Grain of Salt

Figure out just how much salt is in your food

Lesson Plan

Description: Visitors test liquids for salt content using a titration technique. They then test food samples to see how much salt they contain.

Audience: Hands-on activity for families and children ages 8 and up

Length: 30 minutes

Learning Objectives

Visitors learn:

- Many processed foods contain a lot of salt.
- The maximum salt recommended for daily consumption is no more than 2400 mg/day.

Visitors develop skills related to chemistry and science, including:

- Using titration
- Analyzing data
- Communicating and discussing experiment results

Learning Standards

National Science Education Standards

1. Science as Inquiry
   - K-4: Abilities necessary to do scientific inquiry
   - K-4: Understanding about scientific inquiry
   - 5-8: Abilities necessary to do scientific inquiry
   - 5-8: Understanding about scientific inquiry
   - 9-12: Abilities necessary to do scientific inquiry
   - 9-12: Understanding about scientific inquiry

2. Physical Science
   - K-4: Properties of objects and materials
   - 5-8: Properties and changes of properties in matter
   - 9-12: Structure and properties of matter
   - 9-12: Chemical reactions

6. Personal and Social Perspectives
   - K-4: Personal health
   - 5-8: Personal health
   - 9-12: Personal and community health

Background Information

Salt is essential for good health, but too much salt can be harmful. Studies show that people who eat too much salt in their diet have higher chances of developing heart disease. The Food and Drug Administration recommends consuming no more than **2400 mg** of salt per day.

Processed and prepared foods are often very high in salt. People who eat a lot of these foods may be eating much more salt than they realize. This activity helps make visitors aware of how much salt is in common foods, including many family favorites such as canned soup. (Although the amount of salt in processed foods appears on the nutrition label, determining it themselves often makes people aware of salt content and reinforces its importance.)

The salt we eat is a compound made up of one atom of the element sodium (Na) and one atom of the element chlorine (Cl). Its chemical name is *sodium chloride.*

To determine the exact amount of salt in a mixture, chemists find that it is easier to measure the amount of chlorine in the mixture. Because there is one chlorine atom for every salt molecule, if you determine the amount of chlorine, you know the amount salt present. The amount of salt in food is usually measured as milligrams (10^{-3} grams) per serving.

One way to determine the amount of chlorine in a solution takes advantage of the fact that silver nitrate reacts on a one-to-one basis with chlorine ions to form a white solid called a *precipitate*.

Silver nitrate + Sodium chloride → Silver chloride + Sodium nitrate
in solution *in solution* *a white solid* *in solution*

If you add silver nitrate to a solution one drop at a time, the silver will react with the chloride until the chloride is used up. After this point, adding more silver nitrate just adds silver to the solution. To tell when this happens, we add an *indicator* that detects excess silver in solution and changes color to indicate the presence of the silver.

Silver nitrate + Potassium chromate → Silver chromate + Potassium nitrate
in solution *in solution* *a red solid* *in solution*

In this activity, visitors follow a procedure called *titration*. They use a sodium chromate indicator, which turns red in the presence of excess silver. The appearance of the red color signals that all the chlorine has been used up (because it has reacted with the silver). This is called the *endpoint* of the titration.

Analytical chemists almost always do titrations several times (called *replications*), to be sure that they were done correctly. If the results do not agree, it suggests that there may have been a mistake in one of the titrations or that the method may not be reliable. By comparing results with the group we will achieve replication.

EXPECTED RESULTS

Each drop of silver nitrate used in the titration represents approximately 110 mg of sodium per cup. For example, if we use 5 drops of silver nitrate when titrating a soup, this means that there are about 550 mg of sodium per cup of that soup. See the last page for the graphical representation that museum visitors will use when doing the activity.

Materials

For each pair of visitors

- 24-well well plate
- Set of chemicals in labeled dropping bottles:
    - 0.2 M (moles/Liter) silver nitrate solution (filled halfway and taped shut)
    - 0.2 M (moles/Liter) potassium chromate indicator solution (filled halfway and taped shut)
    - Distilled water (0 mg salt solution)
    - 2 g of salt dissolved in 225 ml of water
    - Miso soup mix dissolved in directed amount of hot water; be sure to strain before placing in bottle.
    - Chicken noodle soup mix dissolved in directed amount of hot water; be sure to strain before placing in bottle.
    - Light-colored sports drink
    - Pickle juice
    - Chicken-flavored bouillon cube dissolved in water (follow preparation instructions)
    - Macaroni & cheese powder dissolved in water (for a standard box, substitute 1/4 cup of water for the milk)
    - Optional: other food samples to test
- Sheet of white paper
- Toothpicks (to use as stirrers)
- Results sheet
- Pen or pencil
- Laminated graph (found on last page)
- Safety glasses
- Gloves

For the presenter

- 6 g table salt placed in a baggie (representing RDA of 2400 mg of sodium)
- One set of visitors' supplies
- Paper towels
- Tray (to use when disposing of chemicals)

Notes to the Presenter

All solutions should be in labeled dropping bottles. Dropping bottles eliminate cross contamination, spills, and excessive use of reagents.

Silver nitrate will turn black or brown when exposed to air. It will stain skin and clothing. Stains on skin are harmless and will eventually wear off. Stains on clothing are permanent. Visitors should wear gloves to avoid getting silver nitrate on their skin.

Miso soup has about 800 mg of sodium per serving, whereas chicken noodle soup only has about 500 mg of sodium per serving. Even with a very rough titration, it should be clear to visitors which one has more salt.

CAUTION: The experiment uses small quantities of silver nitrate and potassium chromate solutions. Both of these chemicals are poisonous if they are ingested or if they get in eyes. Visitors must wear safety goggles. To limit risk, only provide these chemicals in small dropper bottles, fill the bottles halfway only, and tape the bottles shut.

CAUTION: Always supervise visitors during this activity. Be sure visitors wear safety glasses and don't let them taste any chemicals (even food or drinks).

Set Up

Set up takes approximately 20 minutes. (Set up will take longer the very first time you do the activity.)

1. Set up enough workstations so that visitors can work individually or in pairs. At an eight-foot table, you can comfortably fit 4 pairs of visitors.
2. Decide where you (the presenter) will demonstrate procedures. You may want to set up a demonstration station for yourself at the front of the room, or you may demonstrate the activity's procedures at the head of one of the visitors' tables, using the equipment from one of their workstations.

Program Delivery

Welcome visitors. Explain that they will be working individually or in pairs, and divide them among the workstations.

What do you know about salt? What is it? What is it used for? *Visitor response.*

What is your favorite salty food? Do you think it's good for you? *Visitor response.*

People need to have a little salt in their diets, but most of us get way too much. Studies have shown that too much salt can raise your risk of heart disease, including high blood pressure. So it's important to know how much salt you are eating.

Show the salt in the baggie and state that it is the recommended amount of daily salt intake per day.

Does that seem like very much salt? *Most visitors will say that it doesn't seem like very much at all.*

Do you know how to figure out how much salt is in your food? *Visitor response.*

If you buy it at the grocery store, you can check the label*. Show where sodium content appears on label.*

So, food labels are one way to find out how much salt is in food.

Today we're going to learn another way to measure salt in food. It's a chemistry procedure called *titration*. You might not decide to do this at a restaurant, but it is an interesting way to find out how much salt is in your food!

Before we start, everyone should put one their safety glasses and gloves.

The chemicals we're using today are safe, but you should take special care when you use the silver nitrate. This one turns black when it's exposed to light. If you get it on your clothing or skin, it will stain. The stain will eventually come off your skin, but not out of your clothing.

Safety: Make sure everyone is wearing safety glasses and gloves.

In the first part of this program, we're going to learn how to do a titration, using distilled water (which has no salt in it), and water that has a known amount of salt added to it. *Hold up water and broth.*

Then, once we know how to do the titration, we're going to test whether miso soup or chicken noodle soup has more salt in it.

Which one do you think is healthier or has less salt in it? *Show visitors the packages without showing them the nutrition information.*

Let's find out!

Everyone has one of these, which is called a "well plate". It's sitting on a white piece of paper. That's so you can see the color of the different liquids we're going to put in it.

You also have a sheet of paper and a pen/pencil for recording your results, and a graph to use to find out what your results mean. *Hold up each object.*

I'm going to go through the steps of doing the titration with distilled water. Then, you can try the distilled water and the salt water. When everyone's done, we'll compare results. *Demonstrate the following procedure.*

<u>Titration procedure</u>

1. Place a 24-well plate on a piece of white paper.
2. In the first well, carefully add 10 drops of water.
3. Add one drop of potassium chromate indicator.
4. Stir with a toothpick.
5. Add one-drop silver nitrate solution.
6. Stir with a toothpick.

7. Add silver nitrate solution one drop at a time until the mixture turns reddish-orange, counting each drop as you add it.
8. As you add the silver nitrate, an orange or red color may appear that will disappear as you stir the mixture. Be sure to stir after each drop is added.
9. Add silver nitrate until the red color does <u>not</u> disappear when the mixture is stirred.
10. When that happens, record the number of drops you added to well. That's known as the *endpoint.*

Repeat procedure using salt water.

How many drops did it take to get to the endpoint with the water? *Responses may vary.*

Most of you found that it took one drop.

How about the salty water? *Responses may vary.*

It sounds like for most of you, it took around 7 or 8 drops.

There are lots of us doing this activity so we each only needed to do it once, because we can compare results. But if we were chemists doing it alone, we'd do each one (the plain water and the salt water) three times, to be sure we got the same answer each time.

Now let's look up our results on the graph, and see what they mean. *Show how to use the graph.*

<u>Looking up results on the graph</u>

Take the average of all the endpoints (number of drops needed to get to red) in the group.

Look at the graph (drops vs. amount salt) to see how much salt is in a cup of liquid. *For every drop of silver nitrate needed to get to red there are 110 mg of sodium in a cup of the liquid.*

How much salt is in one cup of the plain tap water? *None, or a negligible amount.*

How much salt is in one cup of the salt water? *800 mg*

The recommended daily amount of salt per day is 2400 mg.

So we could drink three cups of salt water in a day, if we didn't eat anything else with salt. Does anyone here drink salt water? No? So, let's test some foods that you might eat!

Testing foods

You can use the same procedures to test these real foods. *Indicate foods.*

First, you'll do the titration, to see how many drops it takes before the indicator turns permanently red.

Have visitors compare the two soups first. Then, if they wish, they can test and compare other foods.

Then, you'll look up your results on the graph, to see how much salt is in one cup of the food.

If you like, you can do the titration more than once, to be sure your results are accurate. You can also compare your results to the nutritional information on the package! (Remember that if you do that, you'll have to take the serving size into account.)

Visitors experiment. When a majority has finished the miso soup and chicken soup, compare results.

Before we go, let's compare results. Which food had the most salt? The least? *Miso soup had the most.*

Does this make you think differently about some of your food choices? *Responses will vary.*

If you'd like you can stick around and keep experimenting!

Clean Up

CAUTION: DO NOT DUMP THE LIQUIDS FROM THE WELL PLATES DOWN THE SINK!
The precipitates should not enter the water supply.

To dispose of the contents of the well plates:

1. Layer a pile of paper towels onto the tray.
2. Dump over the well plate, and knock it onto the pile of paper towels on the tray. You need to get the precipitates out of the well plate and onto the paper towels.
3. Dispose of the paper towels in the trash.
4. After dumping the contents out, the well plates can be rinsed in the sink with water and wiped out with a paper towel.

Tips and Troubleshooting

With younger visitors, it’s easier to have them compare the number of drops, rather than use the graph.

For each drop of silver nitrate used there are 110 mg of sodium in a cup of the test solution.

Calculations used to determine graph

Salt = NaCl = sodium chloride 58.43 g/mol
Na = sodium 22.98 g/mol
Cl = chlorine 35.45 g/mol

Recommended daily allowance: 2400 mg sodium = 2.4 g sodium

Our silver solution has 0.2 Moles of silver nitrate in 1 L of water.

There is 0.05 mL (.00005 L) in 1 drop of solution (20 drops = 1 mL). So there are 0.00001 moles of silver nitrate in 1 drop of the solution.

Each atom of silver nitrate reacts with one atom of chlorine. So 1 drop of silver nitrate solution reacts with 0.00001 moles of chlorine. When the chlorine is used up, the color will change.

Sodium chloride has one atom of sodium for every atom of chlorine, so if 1 drop of silver nitrate is used it means there are 0.00001 Moles of sodium.

The molecular weight of sodium is 22.98 g/mole. So 0.00001 moles of sodium has a weight of 0.0002298 g. or 0.2298 mg.

In the well there are 10 drops of salt solution. So, in the well there is 0.0005 Liters of solution. So if there are 0.2298 mg of sodium in 10 drops of salt solution there are
(0.2298mg/10drop)(1drop/0. 00005Liters)(0.24L/1cup) = 110mg of sodium in one cup of salt solution

If 1 drop of silver nitrate (0.0005 L) reacts with all the chlorine in the 10 drops in the well, there are 110 mg of sodium in a 1 cup serving of the solution.

How Sweet It Is

Wow-there's a lot of sugar in drinks

Lesson Plan

Description: Visitors predict and determine the sugar content of a variety of commercial drinks, by comparing the weight of a given volume to that of standard sugar solutions.

Audience: Hands-on activity for families and children ages 8 and up

Length: 30 minutes

Learning Objectives

Visitors learn:

- Many drinks, including natural fruit juice, soda pop, and sports drinks, contain a surprising amount of sugar.
- Sugar content can be found in the nutritional label of a commercial product.
- The sugar content of some drinks can be checked by comparing their weight to that of a known standard.

Visitors develop skills related to chemistry and science, including:

- Measuring volumes of solids
- Pipetting liquids
- Weighing using a digital scale
- Recording and analyzing data
- Communicating and discussing experiment results

Learning Standards

National Science Education Standards

1. Science as Inquiry
   K-4: Abilities necessary to do scientific inquiry
   K-4: Understanding about scientific inquiry
   5-8: Abilities necessary to do scientific inquiry
   5-8: Understanding about scientific inquiry
   9-12: Abilities necessary to do scientific inquiry
   9-12: Understanding about scientific inquiry

2. Physical Science
   K-4: Properties of objects and materials
   5-8: Properties and changes of properties in matter
   9-12: Structure and properties of matter

6. Personal and Social Perspectives
   K-4: Personal health

Background Information

Sugar has no nutritional value, other than calories for energy, which is why it is often referred to as "empty calories."

Most of us are aware that soft drinks have lots of added sugar. But fewer people are aware that even 100% juice has lots of sugar!

When something such as sugar dissolves in water to make a sugar solution, the volume doesn't change very much but the weight of the solution increases. The more sugar that is dissolved, the more the solution weighs (compared to an equal amount of pure water).

You can determine how much sugar is in a drink by weighing a volume of water with a known amount of sugar dissolved in it, and then the same volume of another drink and compare their weights. (The bubbles must be removed from carbonated drinks.)

Materials

For each pair of visitors

- Digital scale
- Labeled 100-mL bottles of sugar standards:
    - Water (colorless)
    - 3 tsp sugar (colored **red** with food color)
    - 6 tsp sugar (colored **orange** with food color)
    - 9 tsp sugar (colored **blue** with food color)
    - 12 tsp sugar (colored **green** with food color)
- Test solutions (variety of drinks in small bottles)
    - Soda pop, diet and regular
    - Sweetened tea
    - 100% juices
    - Juice drinks
    - Sports drinks
- Small cups to pour test solutions in
- Marker to label cups
- Several jumbo, 15 ml thin-stem plastic transfer pipettes
- Data sheet
- Pencil
- Safety glasses (for each visitor)

For the presenter

- One set of the materials at the visitors' workstations
- Transparent container of water (large enough to float cans of soda pop)
- Can of diet soda pop and regular soda (same brand)
- Paper towels (to clean up spills)

Notes to the Presenter

- Inexpensive postal scales will work for this activity, so long as they measure in grams and are accurate to 0.1 g.
- If they're not refrigerated, the sugar standards and commercial drinks will keep for a week or so before they start to get slimy. They'll last some weeks if refrigerated.
- Before you do the density demonstration with visitors, try floating both of your soda pop cans in water. The diet soda should float and the regular soda should sink. Occasionally, however, there will be a big enough difference in the amount of air inside the cans that they will behave differently. If you don't get the correct results, try different cans.

CAUTION: Always supervise visitors during this activity.
Be sure visitors wear safety glasses and don't let them taste any chemicals (even drinks).

Set Up

Set up takes approximately 30 minutes. (Set up will take longer the very first time you do the activity.)

4. To measure the sugar in commercial carbonated beverages, you will need to remove the carbonation from the drink before the activity. You can do this by whirling it in a blender, a small amount at a time. Another method is to heat the drink to boiling and let it cool. Either way, return the drink to its bottle for the activity.
5. If your test drinks come in small bottles (16 ounces or smaller), you can have visitors work directly out of the product packaging. If your drinks come in containers that will be too large for visitors to use, you can decant them into smaller, labeled bottles or cups. In this case, you should find a place to display the original containers during the program.

Program Delivery

Welcome visitors. Explain that they will be working in pairs or groups of three, and divide them among the workstations. Explain to parents that this is a family activity, and they should work with their children.

DENSITY DEMONSTRATION
Here I have two cans of soda. They're both *[brand name].* **Who can tell me one important difference between them?** *Response*

Right! One is diet and one is regular. And that means one has sugar and one has artificial sweetener.

Now we're going to find out another difference between them. I'm going to drop them both into this bin of water. What do you think will happen? Any ideas? *Responses*

All good suggestions! Let's find out.

Place both cans in the container of water.

That's interesting! One floats and one sinks.

Which one floats? *Diet*

Which one sinks? *Regular*

Why do you think the regular soda sinks and the diet soda floats? *Response*

Right! The regular soda is heavier because it has lots of sugar in it. The diet soda floats because there's only a tiny amount of artificial sweetener and it doesn't weigh much. So, there's the same amount of liquid in the two cans, but the one with a lot of sugar is heavier.

We can use this information to figure out how much sugar is in other things we like to drink!

Who can tell me what their favorite thing to drink is? *Various responses.*

Have you ever had someone tell you your favorite drink isn't good for you? What did they say wasn't good for you? *Listen to responses until someone says, "sugar".*

Today, we're going to find out how much sugar really is in a variety of drinks. *Show some of the drinks.*

Based on what we just learned, which do you think weighs more—plain water *[hold up bottle]* **or the same amount of water with 12 teaspoons of sugar in it** *[hold up bottle]*? *Response: The water with sugar will weigh more.*

In order to find out how much sugar is in these drinks, we're going to weigh them. But first, we need something to compare them to. These five bottles contain what we're going to call our "sugar standards"—water with a known amount of sugar. *Explain how much water and sugar each contains.*

We're going to weigh each of these, so that we can find out how much each one weighs.

We need to weigh the same amount of each liquid. To do that, we're going to fill the bulb (the fat part) of one these pipettes with liquid, and weigh it. *Show pipette.*

I'm going to show you how to fill the pipettes, weigh them, and record your answers on the data sheet. Then you can get started on the experiment.

First, does everyone have on safety glasses? *Make sure everyone is wearing safety glasses.*

<u>Filling pipettes for weighing</u>

You will need to carefully fill a plastic pipette with liquid until the bulb is <u>completely filled</u> and contains no air bubbles, and there is no extra liquid in the stem. This can be a bit tricky and may take a few tries.

Demonstrate procedure, following the instructions below.

1. Insert the stem of the pipette into the bottle, then bend the stem so the bulb is pointing up and the stem makes a "U" shape.
2. Squeeze and release the bulb several times, so that the pipette is completely filled with water. There should be no air bubbles in the bulb and no water in the stem.
3. Unbend the pipette and hold it with the stem pointed down and squeeze out a drop of water.
4. Gently release pressure on the bulb and see if there is any water the stem.
5. If there is still water in the stem, squeeze out one drop at a time until the stem has no water in it and the bulb has no air.
6. If you get an air bubble stuck between the bulb and the stem, squeeze the bubble out into the liquid and refill it.

<u>Setting up the scale</u>

Now my pipette is ready to weigh. But first, I need to turn on my scale and make sure it's ready to use.

[Instructions for setting up your scales may be different. For the proper procedure, please consult your instruction manual.]

1. Push the "on/off" button on the scale. "8888" will appear on the screen. In about 5 seconds, this will change to "0.0"
2. There is a list of units of weight on the right side of the screen. Make sure the tiny arrow is pointing to "g" for "grams." If it is pointing to something else, press the "unit" key until the tiny arrow on the screen points to "g".
3. Now the screen reads "0.0" and the scale is ready to use.

Weighing the full pipette

1. Place the pipette on the small scale. Make sure the pipette stem is not touching anything other than the scale.
2. Read the weight on the screen. Notice the decimal point (dot)—it's important!
3. Write down the weight on your data sheet. Be sure that you write it in the correct space.

Show the worksheet and explain where to enter the data.

We're going to start with our standards: water and the four sugar solutions. You can do these in any order. After everyone has completed the standards, we'll stop and check our results together. Then we can test some different drinks.

Does anyone have any questions on the procedures? I will be available to help you while you work.

Circulate around the room, helping visitors fill the pipettes, weigh them, and record their data. After most visitors have finished with the standards, call for everyone's attention.

Now that you've all had a change to try all or most of the standards, let's share our results.

Take a look at your data sheets. As the amount of sugar increased in our solutions, did the pipettes weigh more or less? *More.*

Good. That means our method is working. We can compare the weights of different drinks to see how much sugar they contain.

Now, we're going to continue our experiment. If you're not done with the standards, you can finish those up first.

If you're ready to move on to testing different drinks, you can use the same method to see how much sugar they contain. Be sure to write down which drinks you're testing on your data sheet, so you don't forget.

You can compare the weight of different drinks to the weight of the standards, to get an idea of how much sugar they contain.

Before you weigh each drink, try predicting how much sugar it will contain. You can take two drinks at a time—like juice and soda—and try to predict which one will have more sugar.

Circulate and assist visitors. When most pairs have completed a few drinks, call for the group's attention.

Now it's time to share our results. Sharing results is one of the most important things that scientists do.

Who wants to share an interesting or surprising result? Tell us how much sugar one of your test drinks contains.

Let several visitors share one result, until most of the drinks have been covered. Many visitors will be able to compare the weights of the test drinks to the weights of the standards, and figure out about how much sugar the test drinks contain. You might need to assist others as they share their results.

Great! It sounds like everyone was able to learn something from this experiment.

What do you think about these results? *Responses will vary.*

What will you choose to drink next time you're thirsty? *Responses will vary.*

Is that a good choice for all the time, or just once in awhile?

Thank you for coming to our program. I'd be happy to answer any questions.

Clean Up

All the solutions used in this experiment can be poured down the drain.

Tips and Troubleshooting

Problem: The bulb isn't filling completely.
Solution: Make sure visitors are holding the pipette in a "U" shape, and the tip of it is below the surface of the liquid. Have them squeeze several times. They will eventually squeeze some liquid back out (not just air) and then the pipette will fill completely.

Problem: The bulb gets a stubborn bubble in it that won't come out.
Solution: Squeeze all the liquid and the air bubble out of the pipette, then start refilling it. Make sure visitors are holding the pipette in a "U" shape, and the tip of it is below the surface of the liquid.

Problem: Some visitors just can't get the pipette filled perfectly despite numerous tries and assistance.
Solution: Check their results to see if the problem is going to affect their results. The imperfect technique may not affect the overall pattern of results. It's more important that they see the big picture than that they get perfectly accurate results. If their overall results are being compromised, you or an assistant can work with them. If that's not possible, let them continue as best they can and explain that the procedure is tricky, that everyone is getting slightly different results, and that we'll all going to compare results at the end to figure out which drinks really have the most sugar.

Question: Why don't we need to worry about how much the pipette weighs?
Answer: Because we're comparing the drinks, not trying to find out exactly how much each one weighs. Every time we weigh a drink, we're using the same pipette, so the pipette adds the same amount of weight to every drink.

Starch Test

Use iodine to test for starch!

Activity Guide

Try This!

SAFETY: Iodine is toxic. Do not ingest it.

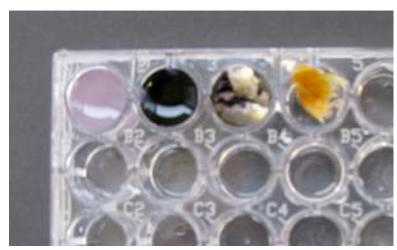
(It will also stain your skin and clothes, although this is not harmful.)

1. Place a tiny sample of cooked cornstarch in one well of the well plate.
2. Place a tiny sample of uncooked cornstarch into a second well of the well plate.
3. Put a few drops of iodine on top of the samples. What happens?
4. Now place a tiny sample of each of the remaining food and paper samples in wells of the plate.
5. Put a few drops of iodine on top of each of the remaining samples. Do they react in the same way?
6. If you like, put a corn or wheat puff in your mouth and let it absorb saliva. Then, put it in a well and see what happens when you drop iodine on it.

What's Going On?

Starch reacts with iodine, turning a blue color. The more starch there is in a sample, the darker blue it will turn.

- High-starch samples turn dark blue:
  - o Cooked cornstarch
  - o Cooked macaroni
  - o Rice puff
  - o Wheat puff
  - o Some papers



- Low-starch samples turn lighter blue, or don't change color:
  - o Uncooked cornstarch
  - o Uncooked macaroni
  - o Wheat puff been soaked in saliva
  - o Some papers

The cooked food samples turned a darker blue than the uncooked samples because cooking helps to break down the cell walls, releasing the starch.

A regular wheat puff turns dark blue, but a wheat puff soaked in saliva doesn't. That's because saliva contains an enzyme called *amylase* that converts starch to sugar. Enzymes are complex proteins that act as catalysts to speed up reactions.

Most paper products are made from the wood of trees, which contains cellulose. When some papers are manufactured, they go through a chemical process that breaks down the cellulose into starch. Those papers will react with iodine and turn blue. Other papers (especially rough papers) are manufactured differently, so the cellulose remains. Those papers won't react with iodine.

Learning Objectives

- Starch reacts with iodine, turning a blue color.
- Cooked food samples turn darker blue than uncooked samples, because cooking helps to break down cell walls and releases starch.

Materials

Each visitor will need:
- 24-well plate
- Labeled cup of uncooked white rice
- Labeled cup of cooked white rice
- Labeled cup of uncooked macaroni
- Labeled cup of cooked macaroni
- Labeled cup of corn puffs
- Labeled cup of wheat puffs
- Labeled cup of uncooked cornstarch in water *(Requires advance preparation; see below)*
- Labeled cup of cooked cornstarch in water *(Requires advance preparation; see below)*
- Labeled dropping bottle with diluted iodine *(Requires advance preparation; see below)*
- Small pieces of different kinds of paper, napkins, or paper towels
- Measuring spoons
- Glass measuring cup

Advance Preparation

SAFETY: Be careful when cooking the rice, macaroni, and cornstarch.

Uncooked cornstarch mixture
1. Put ½ teaspoon cornstarch in a glass-measuring cup.
2. Slowly stir in ¼ to ½ cup water. The mixture should be thick and cloudy.

Cooked cornstarch mixture
1. Put ½ teaspoon cornstarch in a glass-measuring cup.
2. Slowly stir in ¼ to ½ cup water.
3. Cook the mixture in a microwave for one minute.
4. Stir, and cook for another 30 seconds. The heated mixture should be thick and clear.

Diluted iodine
- Combine water and iodine in approximately equal quantities, to make a light brown liquid.

See Vitamin C

Which foods have vitamin C?

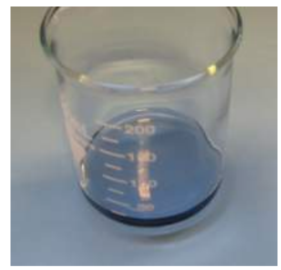
Activity Guide

Try This!

1. Put two tablespoons of the blue indicator solution into a small glass container.
2. Using a pipette, add a drop of vitamin C solution to the indicator solution. Swirl the solution. It should turn clear. If the blue color doesn't disappear right away, add another drop of vitamin C and swirl again.

What's Going On?

The indicator solution turns from blue to clear when you add a drop or two of vitamin C. This positive test shows you how the indicator solution works: if the blue disappears, your liquid contains vitamin C.



This procedure is called a *titration.* When the color of the indicator solution changes, that's the *end point* of the titration.

Now Try This!

1. Put two tablespoons of the blue indicator solution into a small glass container.
2. Using the pipette, add a drop of lemon juice to the indicator solution. Swirl the solution. Keep adding drops and swirling the solution. Does the blue color disappear?
3. Now repeat steps 1 and 2 using vinegar. Does the blue color disappear?
4. Optional: Test fruit juices and other liquids to find out if they contain vitamin C. You can also try heating these liquids, to see if you get different results.

What's Going On?

Lemon juice contains vitamin C, so the indicator solution turns from blue to clear. You probably found that it took more than one drop of lemon juice to turn the indicator clear. Lemon juice doesn't contain as much vitamin C as the solution you made with the tablet, so it takes more drops of lemon juice to reach the end point of the titration.

The blue indicator doesn't turn clear when you add vinegar. That's because the vinegar doesn't contain vitamin C. This test shows that it's the vitamin C and not the acidity of the lemon juice that makes the indicator turn clear. (Vinegar and lemon juice are both acids.)

If you keep testing, you'll find that Vitamin C is present in citrus juices, cranberry juice, potatoes, and other foods. Heat breaks down vitamin C, so cooked foods contain less vitamin C than raw foods.

Vitamin C is an important nutrient and antioxidant. It's important in many processes. For example, it helps our bodies to create the collagen in our cell walls and also prevents scurvy, a disease that causes abnormalities in bones and teeth.

Learning Objective

- An indicator solution of cornstarch and iodine can test whether vitamin C is present in different foods.

Materials

- Indicator solution *(Requires advance preparation; see below.)*
- Vitamin C solution *(Requires advance preparation; see below.)*
- Lemon juice
- Vinegar
- Water
- Measuring cup
- Measuring spoons
- Glass jars
- Thin-stem pipette or medicine dropper
- Microwave oven
- Fruit juices, milk, soda pop, broth and other liquids (optional)

SAFETY: Iodine is toxic. Do not ingest it.

(It will also stain your skin and clothes, although this is not harmful.)

Advance preparation

Indicator solution
- Cornstarch
- Iodine

1. Measure ½ teaspoon cornstarch into a large glass-measuring cup.
2. Add one-cup water and stir.
3. Heat in the microwave for 30 seconds.
4. Stir. If the cornstarch hasn't completely dissolved and the mixture is still cloudy, heat for another 20 seconds.
5. Measure one cup of water into a clean glass jar. Add one teaspoon of the cornstarch solution and four drops of iodine to the plain water. It will turn blue. This will be your indicator solution.

Vitamin C solution
- Vitamin C tablet (250 milligram)

1. Measure one-cup water into a jar.
2. Dissolve the vitamin C tablet in the water.

Magnetic Cereal

Attract iron-fortified cereal with a magnet!

Activity Guide

Try This!

SAFETY: Magnets can pinch! Take care when using strong magnets.

Total Cereal

7. Fill a cereal bowl with water.
8. Float a few flakes of cereal on the water.
9. Use the magnet to pull a cereal flake across the water.
   Why do you think the cereal is attracted to the magnet?

Farina Cereal

1. Pour the cereal into a mixing bowl.
2. Put the magnet inside a sandwich bag.
3. Hold one end of the baggie-wrapped magnet, and use it to stir the cereal. Stir for a minute or two.
4. Remove the baggie-wrapped magnet, and hold it over the sheet of cardstock.
5. Take the magnet out of the bag, and shake the bag gently over the cardstock.
6. Tiny gray particles should fall on the paper.
7. Carefully lift the cardstock. Put the magnet underneath it and move it around under the particles. Are the particles attracted to the magnet?

What's Going On?

Believe it or not, many breakfast cereals contain pure iron—basically the same thing that is used to make the nails you might use to build a house!

Iron is an essential nutritional element. It's added to cereals to make them more nutritious. Hydrochloric acid and other chemicals in your digestive tract change the tiny particles of iron in the cereal into a form that your body can absorb.

Red blood cells contain a compound called hemoglobin that carries oxygen. (Hemoglobin is what makes blood red.) Hemoglobin molecules are made up of iron and other elements. Lack of iron can cause fatigue, reduced resistance to sickness and disease, and an increased heart and respiratory rate.

Learning Objectives

- Some cereals are fortified with iron to make them more nutritious.
- Our bodies need iron (a common metal) so that hemoglobin in our red blood cells can carry oxygen.

Materials

- Total® or other flake breakfast cereal with a high iron content
- Farina® wheat cereal or other finely-milled, iron-fortified breakfast cereal
- Magnet
- Fold-top sandwich bag
- Cereal bowl
- Mixing bowl
- Water
- Sheet of white cardstock

Bounce an Egg

Can you drop an egg without breaking it?

Activity Guide

Try This!

1. Put the hard-boiled egg in the bottom of one glass.
2. Put the raw egg in the bottom of the other glass.
3. Fill the glasses with enough vinegar to cover the eggs. Watch the glasses. What do you see?
4. Leave the eggs in the vinegar overnight.
5. Remove the eggs, and try dropping them gently in the bowl. (Keep track of which is which.)

What's Going On?

The eggs bounce instead of breaking, because the acid of the vinegar breaks down the calcium carbonate of the eggshell. The bubbles you noticed when you added the eggs to the vinegar were carbon dioxide, released by the reaction of the vinegar and calcium carbonate. When all the carbon has come out of the eggshells, they're no longer hard—they're soft and bouncy.

Now Try This!

4. Dump the vinegar down the sink.
5. Clean and dry the glasses.
6. Put the hard-boiled egg in a clean, dry glass.
7. Leave it sitting out for a day, then feel it again.
8. Put the raw egg in a glass, and cover it with water.
9. Leave it sitting in the water for a day, then check to see what has happened.

What's Going On?

The hard-boiled egg got hard again! It absorbed the carbon from the carbon dioxide that's in the air we breathe.

The raw egg absorbed water via *osmosis,* expanding until the soft shell burst. If you put the raw egg in salt water, it would shrink because it would lose fresh water through osmosis.

> ***Osmosis** is the diffusion of water through a semi-permeable membrane.*

Learning Objectives

- Eggshells are made of calcium carbonate.
- Eggshells dissolve in acid and produce carbon dioxide.
- The air we breathe contains carbon dioxide.
- Water moves through the semi-permeable eggshell membrane via osmosis.

Materials

- Raw egg
- Hard-boiled egg
- Vinegar
- Two drinking glasses or glass jars, one labeled “raw” and one labeled “hard-boiled”
- Mixing bowl

Credits
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