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Note to the Project Helper

Congratulations! A 4-H member has asked you to serve as a project helper. You may be a parent, relative, project leader, friend, club advisor, or another individual important in the 4-H member’s life. Your duties begin with helping the youth create and carry out a project plan, as outlined in the Member Project Guide. This is followed by helping the youth focus on each experiment, providing support and feedback, and determining what was done well, what could have been done differently, and where to go next.

As a project helper, it is up to you to encourage, guide, and assist the 4-H member. How you choose to be involved helps to shape the 4-H member's life skills and knowledge of the importance of food science.

Your Role as Project Helper

- Guide the youth and provide support in setting goals and completing this project.
- Encourage the youth to apply knowledge from this project book.
- Serve as a resource person.
- Encourage the youth to go beyond the scope of this 4-H project book to learn more about food science.

What You Should Know About Experiential Learning

The information and experiments in this book are arranged in a unique, experiential fashion (see model). In this way, youth are introduced to a particular practice, idea, or piece of information through an opening (1) experience. The results of the experiment are then recorded in the accompanying pages. Youth then take the opportunity to (2) share what they did with their project helper, (3) process the experience through a series of questions that allow the learner to (4) generalize and (5) apply the new knowledge and skill.

What You Can Do

- Review the learning outcomes (project skill, life skill, educational standard, and success indicator) for each experiment to understand the learning taking place. See the inside back cover for a summary of the learning outcomes.
- Become familiar with each experiment and the related background information. Stay ahead of the learner by trying out experiments beforehand.
- Begin the project by helping the learner establish a plan for the project. This is accomplished by reviewing the Member Project Guide.
- After each experiment, conduct a debriefing session that allows the learner to answer the review questions and share results. This important step improves understanding from an experiential learning perspective.
- Help the learner celebrate what was done well and to see what could be done differently. Allow the learner to become better at assessing his or her own work.
- In the Member Project Guide, date and initial the experiments that have been completed.
Member Project Guide

Welcome to *Science Fun with Kitchen Chemistry*! This project is designed for 4-H members with beginning-level skills with science experiments. After completing this project, you are encouraged to explore other Science, Technology, Engineering, and Math (STEM) and Food and Nutrition books.

Check your county’s project guidelines (if any) for completion requirements in addition to the ones below, especially if you plan to participate in county project judging or plan to prepare an exhibit for the fair.

**Project Guidelines**

**Step 1:** Complete all 11 experiments.
**Step 2:** Take part in at least two learning experiences.
**Step 3:** Become involved in at least two leadership/citizenship activities.
**Step 4:** Complete a project review.

**Step 1: Experiments**

Complete all 11 experiments. Private Proton’s Challenges are optional, but may bring you closer to finding a strong alien defense method. Take good notes and record your experiment results. When you finish an experiment, review your work with your project helper, and ask them to initial and date your findings.

<table>
<thead>
<tr>
<th>Experiments</th>
<th>Date Completed</th>
<th>Project Helper Initials</th>
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<tr>
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<tr>
<td>1. What’s the Matter?</td>
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<td>3. Acids and Bases</td>
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<td>4. Put Out the Fire!</td>
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<td>5. Orange Float</td>
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<td>Debriefing and Background</td>
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<tr>
<td><strong>Project Area 3: Resist with Reactions</strong></td>
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<td>6. Let’s Chill!</td>
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<td>7. Fizzy Foam Fun</td>
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<td>8. Shiny Penny</td>
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<td>Debriefing and Background</td>
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<td><strong>Project Area 4: Shield Yourself with Scientific Testing</strong></td>
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<td>9. Colorful Chromatography</td>
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<tr>
<td>Debriefing and Background</td>
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**Step 2: Learning Experiences**

Learning experiences are meant to complement experiments, providing you with a chance to investigate Kitchen Chemistry more in-depth. What are some learning experiences you could do to show the interesting things you are discovering about Kitchen Chemistry? Here are some ideas:

- Attend a clinic, workshop, demonstration, or speech related to chemistry.
- Help organize a club meeting based on one of the experiments.
- Go on a related field trip or tour a business that uses chemistry to make a product.
- Host a workshop to share tips about Kitchen Chemistry.
- Prepare your own demonstration, illustrated talk, or project exhibit.
- Participate in county judging.

Once you have a few ideas, record them here. Complete **at least two** learning experiences. Then, describe what you did in more detail. Ask your project helper to date and initial in the appropriate spaces below.

<table>
<thead>
<tr>
<th>Plan to Do</th>
<th>What I Did</th>
<th>Date Completed</th>
<th>Project Helper Initials</th>
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<tbody>
<tr>
<td>Example: Demonstration</td>
<td>Showed club members how to make CO₂</td>
<td>5/5/YR</td>
<td>K.B.</td>
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Step 3: Leadership and Citizenship Activities

Choose **at least two** leadership/citizenship activities from the list below (or create your own) and write them in the table below. Record your progress by asking your project helper to initial next to the date each one is completed. You may add to or change these activities at any time. Here are some examples of leadership/citizenship activities:

- Teach someone about the different phases of matter.
- Help another member prepare for his or her project judging.
- Help organize a club field trip to a local science center.
- Organize an event in your area.
- Encourage someone to enroll in *Science Fun with Kitchen Chemistry*.
- Arrange for a chemist to speak at your club.
- Plan your own leadership/citizenship activity.

<table>
<thead>
<tr>
<th>Leadership/Citizenship Activity</th>
<th>Date Completed</th>
<th>Project Helper Initials</th>
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</thead>
<tbody>
<tr>
<td>Example: Organized a club field trip to a local science center.</td>
<td>5/12/YR</td>
<td>K.B.</td>
</tr>
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**Step 4: Project Review**

Completing a project review helps you assess your personal growth and evaluate what you have learned.

Use this space to write a brief summary of your project experience. Be sure to include a statement about the skills you have learned and how they may be valuable to you in the future.

Now, set up a project evaluation. You can do this with your project helper, club leader, or another knowledgeable adult. It can be part of a club evaluation or it can be part of your county’s project judging.
Welcome to the Terrestrial Alien Defense Academy, Cadet!

Kitchen Chemistry Defense Guide
You are under attack! Aliens have been sighted in your neighborhood. Major Molecule, leader of the Terrestrial Alien Defense Academy (TADA), offers this guide to defend against alien invasion in your home. As you try each experiment to combat the aliens, you will use the “Kitchen Chemistry Defense” with common household items.

Searching through information collected from all branches of our military, we have discovered that aliens fear changes in matter. As you explore these changes, you will determine the best defense method to use when standard alien defense weapons fail.

This series of experiments has never been field tested before. Your mission: Attempt each experiment at least once, make careful observations, and record your results for future use. Everything you learn can be applied to new defense methods for the sake of humankind and our planet.

The world is depending on you. Good luck, Cadet!

Research Fact from Admiral Atom
Chemistry is the study of matter and the changes to its different forms—solid, gas, liquid. There are even two more, plasma and the Bose-Einstein condensate or BEC, but we’ll focus on the three most familiar states as we explore these various defense methods.

Neutron Helper Note
Words in bold throughout this book are defined in the glossary.

Ensign Electron Says Be Safe!
Do not taste any experiment unless it specifically states that you can. You will be mixing different items together and not all of them are suitable for drinking or eating.
Project Area 1: Fortify with Changing Forms

Before you can begin the experiments, you need to understand what matter is and how it can change from one form to another. Aliens have been known to shape shift, just like matter. Use the next couple of experiments to learn how Kitchen Chemistry can help you thwart an alien attack.

Experiment 1: What’s the Matter?

Introduction

Matter can exist in many phases as solids, liquids, or gases. Some, however, can behave like more than one of these at a time. In this experiment you will make some slime that is considered a non-Newtonian fluid. Liquids typically flow, but if you put pressure on a non-Newtonian fluid, it acts more like a solid.

Supplies

- large bowl
- 1 cup cornstarch
- about ½ cup water
- spoon
- aluminum pie pan
- kitchen scale

What to Do

Time needed: 15 minutes. Weigh the cornstarch and water, record the two measurements, and add them up. Write this answer in your observation notes. Now, pour the cornstarch into the bowl. Add the water slowly and stir carefully. It will be very thick but still feel like a liquid. Stir it fast and then very slowly. What happens? Squeeze some of the mixture in your hand. How does it feel? Try to roll it in a ball in your hands and then let it flow through your fingers. Pour some of it into the pie pan and hit it hard with your fist or the back of your spoon. What does it look like? Weigh the slime and compare your answer to the first measurement. Are they the same or different?

Record your observations here:

Neutron Helper Note

If you add too much water, just add a bit more cornstarch to thicken.
Explanation

A non-Newtonian fluid can act like both a solid and a liquid. It reacts to stress, or pressure, with an increased **viscosity** or resistance to flow. The slime is made up of tiny solid **particles** of cornstarch that are suspended in water. Chemists call this type of mixture a colloid (CAH-loid). Colloids like this behave strangely—putting pressure on them makes them act more like a solid. If you try to stir them quickly, they resist! Other examples of colloids are milk, fog, and ketchup. The weight of the cornstarch and water before they were mixed will be the same as the slime combination. The **mass** of individual parts remains the same even when combined.

**Source:** This experiment is cited in numerous science books and online science resources.

---

**Neutron Helper Notes**

- This material is easily cleaned up by letting the water evaporate and then vacuuming up the cornstarch. Adding food coloring is OK but the cleanup is much harder for spills!

- Slime can be saved in a plastic bag for a few days to be played with again; however, it will get moldy after a few days and should be thrown out.

---

**Admiral Atom Did you know?**

Chemistry has several “laws” that help scientists predict how matter will react. The most basic law is Conservation of Mass—matter can neither be created nor destroyed, though it can be rearranged.

**Source:** chemistry.about.com/od/generalchemistry/a/chemistrylaws.htm

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**Private Proton’s Challenge**

Test the freezing rate of different liquids. Pour liquids such as water, lemon juice, milk, salt water, rubbing alcohol, whatever you would like to experiment with, into an ice cube tray. Make predictions about which liquids will freeze first. Check the tray every 15 minutes and record your results. Were your predictions right?

**Source:** brainpopjr.com/science/matter/changingstatesofmatter/grownups.weml
Experiment 2: Bubble Transporters

Introduction

You have probably heard the statement that “oil and water don’t mix.” In this experiment you will see that the oil is less dense than water, so the oil floats on top of the water. Add some carbon dioxide bubbles though, and you will see something very interesting!

Supplies

- clear baby food jar (or other small jar)
- water
- food coloring
- spoon
- baby oil
- effervescent antacid tablet (fizzing)
What to Do

*Time needed: 10 minutes.* Fill the jar about one-fourth of the way full with water. Add a couple of drops of food coloring and mix well. Pour the baby oil into the jar, leaving an inch or so of room at the top. Break the antacid tablet into three or four pieces and drop them into the jar. Watch what happens.

Record your observations here:

______________________________
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______________________________

Explanation

As the antacid *dissolves* in water, it releases carbon dioxide (CO₂) bubbles. The CO₂ gas rises to the top of the jar with molecules of colored water attached. At the surface, the bubbles burst releasing the CO₂ into the air. The colored water sinks back to the bottom, traveling through the less dense oil layer to get there. Oil and water don’t mix because of *intermolecular polarity*. Bring that up at the dinner table to impress your parents! Basically, oil molecules prefer to stick to other oil molecules and the same goes for water. They are difficult to mix together and to keep them mixed together.

Private Proton’s Extra Challenge

Want to see raisins act crazy? Pour a clear soda into a tall glass and drop in three or four raisins. Watch what happens. What is going on? Raisins are more dense than soda, so they sink. The raisin surface is rough and as CO₂ gas floats up, the bubbles stick to the raisin, lifting it to the top of the glass. Once the gas is released at the surface, the raisins fall back down. This will continue until all the gas is released, making the soda “flat.”

Admiral Atom Did you know?

Dry ice is the solid form of carbon dioxide, CO₂.

Source: chemistry.about.com/od/chemistryforkids/a/Fun-And-Interesting-Chemistry-Facts.htm
Debriefing

**SHARE** What surprised you about the slime mixture? ____________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

**REFLECT** How long do you think the color blobs would keep rising to the top of the jar in the Bubble Transporter experiment? Does the temperature of the water matter?

__________________________________________________________________________

__________________________________________________________________________

**GENERALIZE** The antacid releases bubbles of CO₂ when dissolved in water. There is also CO₂ in popular cold drinks. Can you think of a beverage that has bubbles when you pour it in a glass?

__________________________________________________________________________

__________________________________________________________________________

**APPLY** Knowing that ketchup is a colloid like your slime, what do you think is the best way to get it out of a glass bottle?

__________________________________________________________________________

__________________________________________________________________________

**Background**

Matter surrounds us. In each state, the molecules in matter have different shapes and forms. Tightly packed molecules give solid matter a definite shape, like a chair or book. Liquids have molecules that are a bit farther apart, giving them a fluid and changing shape that molds to the container in which you put them. The molecules in gases, like carbon dioxide, are spread far apart and move about freely in an excited manner since there is so much space for them to move around unless you contain the gas in something like a can.

Let’s use water as an example. When it’s in a liquid form, it flows and pours easily. When you freeze water it expands and becomes ice, which is less dense, allowing it to float. When you boil water, the steam you see is the gas form, floating freely in the air. It is water in every form. The physical state of water changes, but not its chemical form, H₂O—two hydrogen atoms and one oxygen atom. With a chemical reaction, you change the original chemical components and create a new one.
Project Area 2: Protect with Chemical Properties

Matter can be a solid, liquid, or gas and sometimes more than one form at a time. In this next section, we’ll explore the different properties of matter, using some household items to determine the best possible protection against alien invasion. We’ll also identify matter as an acid or base, learn more about the elements, and even make a gas work to your advantage. Try these experiments, record your results, and watch the aliens flee. We’re counting on you, Cadet!

Experiment 3: Acids and Bases

**Learning Outcomes**

**Project skill:** Testing household liquids for pH level

**Life skill:** Using scientific methods

**Educational standard:** Ohio Physical Science—Substances are classified according to their properties, such as metals and acids.

**Success indicator:** Identifies the acids, bases, or neutrals in a group of liquids

**Introduction**

Substances can be described as acidic, neutral, or basic. Stronger acids make your mouth pucker and taste sour. The opposite of acids are bases, which have a bitter taste and feel somewhat slippery, like soap. How can you tell if a material is an acid or a base? Make an indicator to test different household substances.

**Supplies**

- red cabbage, chopped
- large saucepan
- distilled water
- 9 baby food jars, for testing substances (one per substance)
- medicine/eye dropper
- baking soda mixed in a small amount of water
- milk
- lemon juice
- white vinegar
- cream of tartar mixed in a small amount of water
- shampoo
- effervescent antacid tablet dissolved in water
- soda pop
- hand soap
What to Do

Time needed: 35 minutes (including soak time for cabbage solution). Ask a parent or your project helper to help you finely chop a head of red cabbage and place about 4 cups of it in a saucepan and cover completely with boiling water. Let it sit for 15 minutes so that the color comes out of the leaves into the water. Pour off the liquid into a bowl, filtering out the cabbage leaves. This reddish-purple liquid is your indicator and it will tell us if other substances are acids or bases. Fill each baby food jar about one-third full of the indicator liquid. Add the various substances listed (only one per container) using the eye dropper until you observe a color change. Record your findings below. What materials are bases? Which are acids? What color are the bases and acids? Record your observations here:

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Neutron Helper Note

Remember to rinse the eye dropper out with clean water each time you finish with one test solution.

Explanation

Red cabbage juice is a great indicator—it always turns pink in the presence of an acid and blue (bluish-green) in the presence of a base. Cabbage contains a pigment molecule that is an anthocyanin. This molecule is responsible for the color change.


Admiral Atom

Did you know?

The pH scale, created by Svante Arrhenius, measures the degree of the acidic or basic nature of a liquid. Have more fun learning more about pH at the Alien Juice Bar here: static.lawrencehallofscience.org/scienceview/scienceview.berkeley.edu/html/showcase/flash/juicebar.html.
Experiment 4: Put Out the Fire!

Introduction
For this next experiment, you will produce carbon dioxide (CO₂) gas and put it to work for you by making a fire extinguisher. One property of oxygen makes this experiment very effective. You might need an assistant for this one. Calling Helper Neutron!

Supplies
- 24-ounce bottle, rinsed out and dry
- 2 tablespoons baking soda
- 1/3 cup white vinegar
- 1 tissue
- fishing line or fine string
- scissors
- small ball of clay, enough to stopper the bottle
- bendable drinking straw
- pencil
- small candle in a holder
- matches
- safety goggles

What to Do
Time needed: 30 minutes. Work the clay into a small ball that will completely cover the bottle opening. Use the pencil to make a hole through the clay and insert the straw with the bendable nozzle at the top. Make sure the clay fits up tightly to the straw but doesn’t crush the straw. Set aside. This will be put in the bottle opening when you are ready to start the reaction.
Pour the vinegar into the bottle. Lay the tissue out flat and put the baking soda down the center of it, about one inch from each end. Roll the tissue into a tube that will fit through the bottle opening. Tie each end tightly with fishing line, leaving one end with a long string to insert the tube in the bottle. Tie the tissue in the middle also. Insert the tube with the one long string hanging out the bottle opening to suspend the tube so that the tissue just touches the vinegar.

Put the clay stopper with the straw nozzle on the top of the bottle and seal tightly. Put on your safety goggles and make sure your project helper is present from this point on. Light the candle and place it next to the kitchen sink or some other area that is easy to clean. Gently swirl the vinegar into the tissue. Be patient as the baking soda starts to mix with the vinegar. Too much pressure can cause liquid to come out the straw along with the CO$_2$ gas. After the reaction gets going, aim the nozzle at the flame being careful not to touch the flame with the straw.

Record your observations here:


Explanation

The element oxygen is flammable. A fire needs oxygen to burn. One way to put out a fire is to remove the oxygen it needs to keep going. Carbon dioxide is heavier than oxygen and “robs” the fire of the oxygen needed to keep it burning. In the fire extinguisher you made, you are aiming CO$_2$ at the flame, thus taking away the oxygen by smothering it and making the fire go out.

Experiment 5: Orange Float

Introduction
No, this isn’t a refreshing summertime drink! See if you can make an orange actually float in water. Does it matter if it is peeled? Let’s find out.

Supplies
- large bowl, filled about ¾ of the way with water
- an orange

What to Do
*Time needed: 5 minutes.* Gently place the orange on top of the water in your bowl. Does it sink or float? Remove the orange from the water and peel it. Try floating it again. What happens?

Record your observations here:
**Explanation**

Does it make sense that the unpeeled orange floats and the peeled orange (which you took material away from) sinks? By peeling the orange you have removed its outer, very porous rind. The rind contains lots of air in tiny pockets, which give the fruit extra buoyancy that allows it to float, similar to life jackets used for canoeing or boating. When you remove that less dense rind, the heavier inside has nothing to help it stay afloat and it sinks.

*Source:* This is a basic experiment listed in many elementary science books.

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**Project Area 2: Protect with Chemical Properties**

**Debriefing**

**SHARE** What surprised you the most when you tested different solutions in the cabbage juice?

---

**REFLECT** In Experiment 5, you discovered that an orange with its peel can float. Name another fruit that might float with its peel on, and explain your reasoning.

---

**GENERALIZE** Can you think of other ways CO₂ might be useful?

---

**APPLY** What are some physical and chemical changes you might find in your house? Examples: crushing a soda can is a physical change, or mold growing on bread is a chemical and physical change. List a few more.
Background

Properties are the characteristics of matter. A blanket may be fuzzy. A helium balloon floats. A rubber band is flexible. These properties are measurable and observable without changing the identity of the matter. We call these physical properties. Matter can have mass, **volume**, length, shape, color, taste, and **density**. Matter can also have chemical properties, but you can’t tell what those are by touching or looking at it. Chemical properties can be determined when matter reacts to other substances, changing its identity.

In our Kitchen Chemistry experiments, you explored the physical properties of an orange. The orange had a dense, porous rind that helped it float. In the Acids and Bases experiment, you discovered the chemical properties of various liquids when you added them to the cabbage juice indicator. The liquid changed color, indicating the pH of the liquid—a chemical property.

Elements are the most basic form of matter. Each element has a specific pattern of atoms that makes it unique. And how those atoms are arranged determines the properties of that element. Elements are pure substances. You can’t put two substances together to make an element.

Learn more about properties at: [sciencekids.co.nz/gamesactivities/materialproperties.html](http://sciencekids.co.nz/gamesactivities/materialproperties.html).
Project Area 3: Resist with Reactions

The aliens are still here. Time to make some big changes. The third project area involves chemical reactions. You can change matter by mixing two chemicals together. The reaction changes the original ingredients into something new. You will certainly get a reaction from aliens using these experiments as you change matter into different forms and make a shiny discovery.

Experiment 6: Let’s Chill!

Introduction

Normally you don’t taste your science experiments but this is one you can! In this experiment, you will lower the freezing temperature of water with salt to make milk products freeze. Good thing aliens don’t like ice cream!

Supplies

- quart-size freezer zip-close bags (2 bags)
- gallon-size freezer zip-close bag (1 bag)
- about 4 cups ice
- 3 tablespoons coarse ice cream salt
- ½ cup whole milk
- ¼ cup half and half
- 1 tablespoon sugar
- ¼ teaspoon vanilla
- winter gloves
- spoon

Neutron Helper Notes

- Chocolate milk can be used but make sure it is whole milk (most chocolate milk sold in stores is actually only 1%).

- Double bagging the ingredients helps to make sure the ice/salt mixture doesn’t contaminate the ice cream. Freezer bags are recommended as they are thicker and less likely to get holes in them.

- For those who are lactose intolerant or would just prefer a different treat, try using a cup of orange juice in the inner bag instead of the milk mixture. It will turn into an orange slushy!
What to Do

*Time needed: 20 minutes.* In one small zip-close bag, put the whole milk, half and half, sugar, and vanilla. Mix gently by squeezing on the sides of the bag. Seal the bag completely closed making sure to get as much air out as possible. Put this entire bag inside another small bag and seal tightly, again getting as much air out as you can. In the large bag, place the ice and salt and then add the small bag of ice cream mix. Close tightly and, wearing gloves, shake the bag for at least 5 minutes until the ice cream becomes firm. When done, take the small bag out of the ice/water mixture and rinse quickly under cold running water. This will remove any salt, which will make your ice cream taste bad if it gets in it. Now take the inner bag out, open it, and enjoy your treat!

**Explanation**

Salt mixed with ice makes the ice melt, much like what happens when salt trucks spread salt on icy roads in the wintertime. When salt is added to ice, the freezing point of the ice is lowered. Ice absorbs energy in order to melt, changing from a solid to a liquid. When you use ice to cool the ingredients for ice cream, the energy is absorbed from the ingredients and from the air (and your hands!). The reaction is **endothermic**—it takes heat from the milk mixture to melt the ice—making the milk mixture colder so it then freezes.

How much the freezing point is lowered depends on the amount of salt added. The more salt you add, the lower the temperature will be before the salt-water solution freezes.

**Source:** This experiment is cited in numerous science books and online science resources.
Experiment 7: Fizzy Foam Fun

Introduction
Chemical reactions are sometimes fast and sometimes slow. But we can make them go faster by using a catalyst—a material that speeds up reactions but doesn’t react itself. In this experiment you will produce lots of oxygen bubbles using yeast as the catalyst.

Supplies
- 24-ounce bottle, rinsed out and dry
- ½ cup hydrogen peroxide, 3% or 6% solution
- dishwashing liquid
- food coloring
- 1 packet active dry yeast
- about ¼ cup water, very warm
- small bowl
- funnel
- large rectangular baking pan
What to Do

*Time needed: 10 minutes.* Pour the water into the bowl and stir in the yeast. Set it aside. Put the bottle in the baking pan (or you could do the experiment in the sink—it will get messy!). Using the funnel, pour the hydrogen peroxide into the bottle. Add a few drops of food coloring and a couple of squirts of dish soap. Use the funnel again to pour the yeast/water mixture into the bottle. Take out the funnel quickly and stand back!

Record your observations here:

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Ensign Electron Says Be Safe!

Make sure you wash your hands when you are finished with this experiment.

*Source:* This experiment is in many science workbooks as well as the Internet. Sometimes it is called “Elephant Toothpaste” in reference to the large amount of foam created.

Explanation

Hydrogen peroxide breaks down slowly over time into water and oxygen. But the yeast—a catalyst—makes the hydrogen peroxide break down very quickly. The oxygen that is released combines with the dish soap to make lots of bubbles. The hydrogen peroxide commonly available at pharmacies is a 3% solution. Beauty supply stores have 6% hydrogen peroxide and will make even more foam. Don’t use any concentration over 6% because it can be too dangerous.

This is also an example of an *exothermic* reaction—a reaction that gives off heat. If you touch the bottle or the foam after the reaction starts you will find it gets warmer than it was when you started. (In Experiment 6, the reaction was *endothermic*. The ice absorbed the heat from the milk mixture.)
Experiment 8: Shiny Penny

Introduction
Gather a few pennies from your house. Notice how some are shiny and some are very dull? You can change their appearance through chemistry with the following experiment.

Supplies
- 5 or 6 dull (not shiny) pennies
- ¼ cup white vinegar
- 1 teaspoon salt
- glass or plastic (non-metal) bowl
- paper towels
What to Do

**Time needed: 5 minutes.** Pour the vinegar into your non-metal bowl. Add the salt and stir. Now add the pennies. Count to 10 slowly and watch what happens. Record your results below. Now take the pennies out of the vinegar solution, rinse them off, dry them with a paper towel, and admire your new shiny pennies.

Record your observations here:


Explanation

It is easy to see what pennies are made of when you see a new one. When copper is new, it is bright and shiny. As pennies age, the copper in the penny reacts with air molecules and oxidizes. During this process, a shiny penny turns dull as the copper oxide develops. Copper oxide is easy to remove. When vinegar, an acid, is mixed with salt, the chemical reaction removes the copper oxide making your penny shiny again.

Private Proton’s Challenge

Try the shiny penny experiment again. This time, after 10 seconds, add more pennies to the vinegar solution and wait 10 more seconds. Don’t dry your pennies off. Just put them on the paper towel and watch. What happens? The greenish-blue color developing on your pennies is a green mineral called malachite.

**One More Challenge:** Take the pennies out of the vinegar solution and put in a few nuts and bolts. The vinegar removed copper from your pennies. Now, the nuts and bolts will attract those copper molecules. What do you see?

**Source:** This experiment is cited in numerous science books and online science resources.
Debriefing

**SHARE** How long did it take to see a reaction in Fizzy Foam Fun?

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**REFLECT** Are there other chemicals you can add to the ice/water bag around the milk to lower the freezing point of water besides salt?

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**GENERALIZE** Why does hydrogen peroxide come in a dark brown bottle or container?

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**APPLY** Do you think the shiny penny cleaning method would work on other coins? Why or why not?

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Background

Physical changes in matter are all about changes in states—from liquid to solid to gas—and energy. You can apply energy, such as heat or force, to make matter change. Crushing a can, cooking an egg, or boiling water are all physical changes. Chemical changes happen at different speeds. We can see these changes easily.

Basic elements are made up of one type of atom. Atoms bond with other atoms to make molecules. Molecules connect to other molecules to make the matter we see around us. Based on their atomic makeup, molecules can be attracted to other molecules. (In Experiment 2: Bubble Transporters we learned that oil molecules stick with other oil molecules and the same for the water molecules.) Some atoms are chemically bonded within the molecules and are much harder to break apart. These changes take place on a much smaller scale. You can’t see these changes without a microscope, and often not even with a microscope!

When you break the bond holding atoms together, you release energy. The atoms are free to join up with other atoms, creating a new chemical. The energy created from the reaction in Experiment 6: Let’s Chill was absorbed. This caused the temperature to drop and melt the ice. This is called an endothermic reaction. In the Fizzy Foam Fun experiment, you created an exothermic reaction that released energy into the surrounding area, which you can feel as heat. Reactions can happen quickly or slowly over time, like oxygen reacting with metal to create rust. Catalysts speed up the process of a normally slow reaction.
Project Area 4: Shield Yourself with Scientific Testing

You've discovered that matter can change shape chemically, by using force, and by applying energy, in the form of heating or cooling. Now we're ready for our final tactics. Our research is conclusive on this fact: aliens do NOT like tests. If your research results have not repelled the aliens around your home, the following experiments will most likely be your best line of defense. Proceed with caution. Test a way to separate a mixture, stir up a solution, and send those aliens back home!

Experiment 9: Colorful Chromatography

Learning Outcomes

Project skill: Separating dye color molecules through absorption

Life skill: Processing information

Educational standard: Ohio Physical Science—All matter is made of atoms, which are particles that are too small to be seen.

Success indicator: Identifies heavy and light color molecules through capillary action

Introduction

Chromatography is a process that scientists use to separate the parts of a mixture by seeing how they absorb at different rates. Test this theory with this experiment.

Supplies

- large bowl
- water
- coffee filter paper or blotting paper
- scissors
- ruler
- household tape
- water-soluble markers in several colors (try black, for sure!)
What to Do

*Time needed: 10 minutes.* Cut the coffee filter paper into strips about 4½ inches by ½ inch.

Number them so you can record your observations. Using the markers, put a small dot of a single color (about ¼ inch in diameter) about 1 inch from the bottom of a strip. Repeat with other colors, one to a strip. Tape each of the strips to the ruler so that they are side by side but not touching. Fill the bowl about halfway with water and lay the ruler across the bowl so that the bottom of the strips just touch the top surface of the water.

Let the water soak into the strips and move upward. Take the ruler out of the bowl when the water is about 1 inch from the ruler. Record what you see on each strip below.

Record your observations here:

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**Explanation**

Capillary action moves the water up the strips of filter paper, taking the color dyes with it. The dyes are mixtures of colors. These mixtures are made up of different sizes and weights of particles. When they move along the paper, the heaviest particles stop first and the lightest particles move the greatest distance. When the particles are separated like this you can see all of the different colors that make up the marker color.


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**Admiral Atom Did you know?**

Liquid oxygen is blue.
Experiment 10: Color Splash

**Introduction**

Have you ever tie-dyed a T-shirt? It takes a long time and is often very messy. Here is a way to decorate your shirt easily with lots of colors while you test a solvent and learn about diffusion.

**Supplies**

- white or light-colored cotton T-shirt, bandana, socks, or other clothing item
- colored permanent markers
- large piece of cardboard, if desired
- large plastic cup
- rubber band
- spray bottle
- 70% (or 90%) isopropyl alcohol

**What to Do**

*Time needed: about 20 minutes, not including drying time.* Use markers to color a small area of your garment with lots of bright colors for the best effect. If you are decorating a T-shirt, you may want to put a piece of cardboard between the front and back of the shirt while you are decorating so the colors do not bleed through. Place the area you want to “splash” over the cup, and rubber band the shirt to the cup. When you are finished, fill the spray bottle with the alcohol and spray the garment where you want the colors to move and blend. This is best done outside or in a large sink. You can decide how much or how little to make the colors change with how much you spray. What happens to the marker colors? When you are finished, let the item dry completely.
**Explanation**

The ink in a permanent marker is “permanent” because it does not dissolve in water. It does, however, dissolve in alcohol. That means it is **hydrophobic**. As the garment absorbs the alcohol, the alcohol dissolves the ink and diffuses (moves) it through the cloth. The ink moves from areas of high concentration to areas of low concentration. As the colors spread out, they will also mix with each other and form new colors.

**Neutron Helper Note**

To set the colors, put the garment in a hot clothes dryer for about 15 minutes. After this, the item can be washed with your other clothes.

Experiment 11: Make Your Own Rock Candy Crystals

Introduction

A super sweet treat on a stick—what could be more menacing to aliens? You’ll learn about supersaturated solutions in this next experiment.

Supplies
- small saucepan
- 1 cup water
- 2–3 cups sugar
- 1 wooden skewer or chopstick
- tall narrow glass or container
- clothespin

What to Do

Time needed: 30 minutes (plus 3–7 days for crystals to form). Clip the clothespin onto the wooden skewer and adjust until the skewer is about 1 inch from the bottom of the glass, on the inside. Make sure the clothespin rests on the top of the glass opening. Set aside.

Make sure your project helper is present from this point on. Place the cup of water in a saucepan and bring to a boil. Add ½ cup sugar and stir until dissolved. Keep adding the rest of the sugar slowly and stirring each time. This is a slow process, but keep stirring until you can’t get any more sugar to dissolve. Then, turn off the heat and let the mixture cool for 20 minutes. Have a helper pour the cooled mixture into the glass about 1 inch from the top, then place your skewer in carefully, making sure it is in the middle of the glass and not touching the sides. Allow the glass to fully cool. Set the glass in a safe place and watch your crystals grow in 3–7 days.

Record your observations here:
Neutron Helper Note

**Optional**—If you’d like colored rock candy, add several drops of food coloring to your water sugar mixture. To “seed” your sugar crystals, dip the wooden skewer into the sugar mixture and allow to cool slightly. Roll the skewer in sugar and dry. Place the “seeded” skewer into the cooled sugar mixture.

**Explanation**

Heat energy is often used to change matter from one state to another. A larger amount of sugar molecules can be held in solution in hot water than in cold. As you add more and more sugar to the water, you created a supersaturated solution. Once the water starts to cool, it can no longer hold the sugar molecules and the sugar is released to re-form onto the wooden skewer.

**Sources:**
Science Bob at sciencebob.com/experiments/rockcandy.php.

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**Project Area 4: Shield Yourself with Scientific Testing**

**Debriefing**

**SHARE** How long did it take the sugar crystals to appear on the wooden skewer in the Make Your Own Rock Candy Crystals experiment?

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**REFLECT** Why won’t permanent markers work in the Colorful Chromatography experiment?

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**GENERALIZE** Since water-based markers are soluble in water (meaning they dissolve in water), could you use the color splash method to decorate any item that you plan to wash? Would this be a good idea or not, and why?

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**APPLY** We used a coffee filter in the Colorful Chromatography experiment. What else could be used to get the same effect?
Background

To better understand mixtures and solutions, let’s examine some foods you eat and drink. Trail mix is a mixture of peanuts, cereal, raisins, and candy-coated chocolate candies. The separate parts of the trail mix could be picked out and regrouped into another food. The same is true of mixtures in chemistry. When you mix different compounds together, the individual molecules do not join together, so they are easily separated.

Here are a few ways to separate mixtures.

- **Filtration**—uses a material to filter a solid from a liquid. An example is placing yogurt on a cheese cloth so the liquid drains out, leaving the solids on top.

- **Sedimentation**—letting a mixture sit undisturbed so the heavier items settle to the bottom. You may have seen Italian salad dressing separate into oil and vinegar when it hasn’t been shaken.

- **Evaporation**—when a liquid turns into a vapor or a gas. If you wanted to separate salt from sea water, you might use evaporation. Wait long enough and the molecules in water slowly change to gas and release into the air. All that is left is the salt. To speed up the process, you can apply energy in the form of heat. As the water changes to steam, the salt is left behind.

Solutions are like mixtures, except they are more homogenous—meaning they mix evenly and it’s harder to get the different parts to separate. Think of hot chocolate. You mix the powder with milk and make hot chocolate. It is possible to separate the two, but it would take some work.

The TADA field tests were a success. Now you have begun to understand the forms of matter, discover different properties, and learn ways to defend our planet through chemical and physical changes in matter. Thanks to your quick thinking, superior research skills, and “Kitchen Chemistry Defense” knowledge, you have updated our research database and we are safe once again.

Yours in Service,

*Major Molecule*
Glossary

**acid.** A compound that reacts with a base. Acids are corrosive and taste sour.

**atom.** The smallest part of matter.

**base.** A chemical compound that reacts with acids. It tastes bitter.

**catalyst.** A compound or element that can increase the rate of a chemical reaction; catalysts can help a reaction proceed faster and with less energy.

**chromatography.** A process in which a chemical mixture carried by a liquid or gas is separated into components as they flow around or over a stationary liquid or solid.

**density.** A measure of how much matter a unit of a substance contains, relative to the volume of the substance.

**dissolve.** Mixing a liquid with something else to form a solution.

**electron.** A very small particle that spins around the center of an atom; electrons have a negative charge.

**endothermic.** A chemical reaction that absorbs thermal (heat) energy.

**evaporation.** The molecular phase change of a liquid to a gas or vapor.

**exothermic.** A term used to describe a reaction or process that releases energy in the form of heat.

**flammable.** Capable of burning quickly or being easily ignited.

**hydrophobic.** A property of matter that causes it to repel water. Also describes portions of molecules that do not dissolve well in water molecules.

**indicator.** A substance such as litmus or anthocyanin that shows the presence of or concentration of an acid or base.

**intermolecular polarity.** The attraction between molecules that causes like molecules to cling together as they repel any molecule without a similar structure.

**mass.** How much a material weighs without gravity; mass is the amount of matter in an object, measured in grams.

**matter.** The material substance of the universe that has mass, weight, and occupies space.

**molecules.** The smallest physical unit of a compound, consisting of one or more atoms held together by chemical bonds.

**neutral.** Neither acid nor alkaline (base).

**neutron.** One of the particles found in an atom; unlike protons and electrons, neutrons have no electrical charge.

**non-Newtonian.** A fluid whose flow properties are not described by a single constant value of viscosity.

**oxide.** A compound produced when oxygen combines with another element.

**oxidize.** To combine with oxygen; to remove hydrogen from matter especially by the action of oxygen.

**particle.** A basic unit of matter, such as a molecule or atom.

**proton.** A particle found in the center of an atom; protons have a positive charge and are almost equal in size to a neutron. Electrons are much smaller than protons.

**solvent.** Liquid in which a solid dissolves to form a solution.

**supersaturated.** The state of a chemical solution containing a greater amount of solute than normally possible, often as a result of heating, and then careful cooling.

**viscosity.** The property of a fluid that resists the force tending to cause the fluid to flow.

**volume.** The space within or space occupied by a substance.
Kitchen Chemistry Supplies List

Plan to have the following items on hand

- 1-cup liquid measurer
- baking powder
- baking soda
- dishwashing liquid
- granulated sugar
- measuring cups
- measuring spoons
- small and large glass bowls
- small and large saucepans
- paper towels
- pencil
- table salt
- scissors

Project Area 1

- cornstarch
- aluminum pie pan
- kitchen scale
- clear baby food jar or other small jar
- food coloring*
- baby oil
- effervescent antacid tablet*

Project Area 2

- red cabbage
- distilled water
- 9 baby food jars
- medicine/eye dropper
- milk
- lemon juice
- white vinegar
- cream of tartar
- shampoo
- soda pop
- hand soap
- 24-ounce bottle (rinsed out and dry)*
- tissues
- fishing line
- clay or Play-Doh™
- bendable drinking straw
- small candle in a holder
- matches
- safety goggles
- an orange with a thick rind

* item used in more than one experiment

Project Area 3

- quart-size freezer zip-close bags, 2
- gallon-size freezer zip-close bag, 1
- coarse ice cream salt
- whole milk (¼ cup)
- half and half (¼ cup)
- vanilla extract
- winter gloves
- 3% or 6% hydrogen peroxide
- active dry yeast, 1 packet
- funnel
- large rectangular baking pan (optional)
- dull pennies, 5 or 6
- non-metal bowl

Project Area 4

- coffee filter paper or blotting paper
- ruler
- household tape
- water-soluble markers in several colors, including black
- white or light-colored cotton T-shirt, bandana, socks, or other clothing item
- color permanent markers
- large piece of cardboard (optional)
- large plastic cup
- rubber band
- spray bottle
- 70% (or 90%) isopropyl alcohol
- wooden skewer or chopstick
- tall narrow glass or container
- clothespin
### Summary of Learning Outcomes

<table>
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<tr>
<th>Experiment</th>
<th>Project Skill</th>
<th>Life Skill</th>
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<th>Success Indicator</th>
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</table>
| 1. What’s the Matter?           | Mixing a liquid and a solid to create a new product                          | Reasoning           | Strand: Physical Science, Grade 3  
Topic: Matter and Forms of Energy  
Content Statement: All objects and substances in the natural world are composed of matter. | Recognizes and understands the various phases of matter                           |
| 2. Bubble Transporters          | Testing the effects of intermolecular polarity                               | Processing information | Strand: Physical Science, Grade 6  
Topic: Matter and Motion  
Content Statement: Molecules are the combination of two or more atoms that are joined together chemically. | Identifies the properties in CO₂ gas that can lift color molecules through water and oil molecules |
| 3. Acids and Bases              | Testing household liquids for pH level                                       | Using scientific methods | Strand: Physical Science, Grade 7  
Topic: Conservation of Mass and Energy  
Content Statement: Substances are classified according to their properties, such as metals and acids. | Identifies the acids, bases, or neutrals in a group of liquids                  |
| 4. Put Out the Fire!            | Combining ingredients to create a natural form of CO₂                         | Understanding systems | Strand: Physical Science, Grade 3  
Topic: Matter and Forms of Energy  
Content Statement: Matter has specific properties and is found in all substances on Earth. | Recognizes properties of CO₂ gas capable of extinguishing flames                |
| 5. Orange Float                 | Learning about the physical properties of an orange                          | Reasoning           | Strand: Earth and Space Science, Grade 3  
Topic: Interconnections within Systems Matter and Forms of Energy  
Content Statement: Earth’s nonliving resources have specific properties. | Identifies buoyant properties of oranges with and without a rind in water         |
| 6. Let’s Chill!                 | Chemically lowering the freezing temperature of water to freeze milk         | Planning and organizing | Strand: Physical Science, Grade 3  
Topic: Matter and Forms of Energy  
Content Statement: One way to change matter from one state to another is by heating or cooling. | Transfers heat energy to freeze milk and create ice cream                        |
| 7. Fizzy Foam Fun               | Using a catalyst to speed up a chemical reaction                             | Using scientific methods | Strand: Physical Science, Grade 6  
Topic: Matter and Motion  
Content Statement: Thermal energy is a measure of the motion of the atoms and molecules in a substance. | Discovers how different chemical components affect chemical reactions            |
| 8. Shiny Penny                  | Creating a chemical reaction to remove oxidation from a penny               | Thinking critically | Strand: Earth and Space Science, Grade 6  
Topic: Rocks, Minerals, and Soil  
Content Statement: Minerals form in specific environments. | Removes oxidation residue from a coin to reveal a shiny penny                    |
| 9. Colorful Chromatography      | Separating dye color molecules through absorption                           | Processing information | Strand: Physical Science, Grade 6  
Topic: Matter and Motion  
Content Statement: All matter is made of atoms, which are particles that are too small to be seen. | Identifies heavy and light color molecules through capillary action              |
| 10. Color Splash                | Exploring matter diffusion through dye and solvents                          | Managing resources  | Strand: Physical Science, Grade 3  
Topic: Matter and Forms of Energy  
Content Statement: Liquids and gases flow easily, but solids do not flow easily. | Recognizes properties of ink through diffusion to create wearable art            |
| 11. Make Your Own Rock Candy Crystals | Mixing a supersaturated solution to create an edible treat                 | Managing resources  | Strand: Physical Science, Grade 4  
Topic: Electricity, Heat, and Matter  
Content Statement: The total amount of matter is conserved when it undergoes a change. | Follows instructions to grow sugar crystals on a wooden skewer                   |

*These standards are from the Ohio Department of Education’s Science Revised Standards and Model Curriculum—Grades PreK–8 made available in 2011. Only those standards reflected in the experiments are cited. They are available in their entirety at ode.state.oh.us.
The Ohio Department of Education’s Academic Content Standards focus on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry. All experiments in Science Fun with Kitchen Chemistry have employed one or more of the scientific processes listed under Scientific Inquiry and Application for the Science Model Curriculum.
I pledge
My head to clearer thinking,
My heart to greater loyalty,
My hands to larger service, and
My health to better living,
For my club, my community, my country, and my world.

Additional copies of this book and other Ohio State University Extension, 4-H Youth Development publications are available through local OSU Extension offices and online at extensionpubs.osu.edu. Ohio residents get the best price when they order and pick up their purchases through local Extension offices.