Everyday

STEM®

teacher workshop

Steve Spangler's

Hands-on Science Workshop for Teachers

How to Keep Your Students Really Excited about Science

... as if you need to get kids excited about science. Hey, kids love science... it's the teachers who have a problem with science because most of us had a science teacher in school that was as exciting and dynamic as a brick wall. Let's be honest, this workshop is about getting YOU excited about teaching something that can make a difference in the life of a child... and make the world a better place to live... and increase the number of times you laugh each day.

Contact Information for Steve Spangler

Just in case you need to find this guy again, here are a few ways you can track him down by phone, social media, email, website or homing pigeon (if you have one)...

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Connect with Steve on social...

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INTRODUCTION

IT'S NOT ABOUT THE SCIENCE . . . **IT'S ABOUT THE EXPERIENCE**

I've worked in television for many years, but not as the evening anchor or sports guy or even the weatherman. When the little red light comes on, it's my job to teach viewers how to do amazing things using ordinary stuff found around the house. What type of amazing things, you ask? Oh, things like how to make a high-powered potato launcher out of pencils and straws or how to make a 2-liter bottle of soda erupt into a 12-foot-high fountain of fun. That's right, you guessed it—when the red light comes on, I become the science guy—a modern-day "Mr. Wizard," so to speak.

My first job, however, was not in television. Fresh out of college with a teaching certificate in hand, I found a job in an elementary school teaching science. It didn't take

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long for me to discover that my style of teaching was somewhat different from that of my colleagues, who spent most of their time running off worksheets in the copy room. My kids laughed a lot (almost too much at times), and this soon caught the attention of neighboring teachers and their kids who were more than a little curious. One colleague asked, "How can your students be learning when they're laughing so much?" Hmmm . . . I wonder if laughter and learning go hand in hand? The answer is yes!

I have to attribute most of my success as a teacher to my first class of third graders. Over the course of 9 months, they taught me the importance of using humor to create experiences that transcend the four walls of the classroom and somehow make it to the dinner table as a topic of conversation.

"What did you do in school today?"

"Not much. Oh . . . I remember something . . . Mr. Spangler made us get into a big circle and hold hands . . . then he shocked us with 50,000 volts to teach us about electricity."

> "OH . . . I REMEMBER SOMETHING . . . MR. SPANGLER MADE US GET INTO A BIG CIRCLE AND HOLD HANDS . . . **THEN HE SHOCKED US WITH 50,000 VOLTS** TO TEACH US ABOUT ELECTRICITY."

I got lots of calls from parents that first year of teaching, and it didn't take long for word to spread that things were a little different in the new teacher's class. One of those parents just happened to work for the local NBC television affiliate in Denver. She invited me to come down to the station someday after school and asked if I would bring along a few science experiments from my class, including that shocking machine. In no time, I had a group of television executives making slime, shooting potatoes, and holding hands in a big circle while I delivered the shock. That one commanding performance opened the door for me into a much bigger classroom. I went from twenty-three kids to over a million viewers each week as the host of a nationally syndicated children's program called *News for Kids*.

My executive producer spelled out my mission in the clearest terms possible: "Your job is not to teach science. Your job is to grab the viewer's attention and show them that learning is fun. Make them laugh and the learning will follow." These marching orders soon became my mantra and the advice that I give to parents and teachers today.

3-2-1 **BLAST OFF!**

As part of a promotional tour for the television show, I found myself on the road, visiting children in schools across the country with my bag of cool gadgets and science demonstrations. Let's just say that there's nothing terribly glamorous about doing school assemblies. The best-case scenario is that a bunch of kids are crammed into

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the cafeteria and forced to sit on the floor, while the guest speaker is forced to shout because the P.E. teacher is using the microphone as a doorstop. On this particular occasion, the setting was an elementary school in the heart of Salt Lake City. Nearly seven hundred children squeezed their way into the cafeteria, and the principal's introduction was nothing short of inspirational.

"Hey kids . . . listen up. There's a guy here who wants to show you something and I want you to be good for a change. If I catch anyone throwing stuff at the speaker like you did last time, I'm shutting this circus down." He turned to me. "Okay . . . they're all yours."

With an introduction like that, things could only get better. Up to this point, I had never really taught kindergartners, but I soon learned that these little people have a tendency to grab onto you as a sign of affection! I did most of the show with a five-year-old latched onto my leg. Thankfully, the kids liked the demos and I survived my first of two presentations. As the sea of children started to file out of the room, I noticed that one of the kindergartners was not ready to leave. In fact, he wanted to talk to me. As he approached, I could tell that he was a little nervous. He pulled at his pant leg and squirmed as if it might be time to find a bathroom. As I kneeled down, he began to talk.

"Ummm . . . hey guy. Guess what?"

THEN THE LIGHTBULB IN MY HEAD WENT ON. BEHIND EVERY FUNNY KINDERGARTNER **THERE'S A FUNNIER PERSON CALLED A TEACHER.**

"What?"

"I like rockets."

"Me, too!"

"And you know what else?" he said. "I know how to make a rocket . . . and some day I will make a rocket that can fly to the sun!"

Well, here's a tough fork in the road. I can't tell him "no" because I would crush his dream, and I can't say "great" because I would be lying. They just don't teach you this stuff in college. I looked him right in the eyes, and with compassion in my voice I said, "I like your idea, but if your rocket gets too close to the sun, it will melt."

He looked at me the way only a kindergartner could and said, "I'm doing it at night, duh!" It was as if I had swallowed the bait and he was reeling in the catch of the day. The best part is that I had heard someone tell me the same joke years before, but I had never heard it told by a kindergartner!

Then the lightbulb in my head went on. Behind every funny kindergartner there's a funnier person called a teacher. I immediately looked over the sea of kids to find his kindergarten teacher looking right at me with a huge grin as she

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mouthed the phrase, “Gotcha!” I turned my attention back to the little comedian and said, “You are so funny!” His reply was phrased with a sense of apprehension, “I don’t know why everyone thinks that joke is so funny.”

What? Didn’t the kid get it? Then it hit me like a ton of bricks. This little boy still *believed*. In his way of thinking, *all things are possible*. What was so funny to me and to his teacher offered little in the way of humor to him because his world was filled with limitless possibilities.

Maybe this belief is my real reason for writing this book. You don’t have to understand that a rocket can’t travel to the sun. You don’t have to know what osmosis is or be able to quote Newton’s First Law of Motion. The science behind the activities doesn’t really matter (okay, the science is important), what truly matters is the experience.

THE FIRST TIME YOU TRY ONE OF THE ACTIVITIES YOU’LL DISCOVER THAT THERE’S AN INFECTIOUS, ALMOST VIRAL QUALITY THAT TRANSFORMS THE “COOL ACTIVITY” **INTO AN UNFORGETTABLE LEARNING EXPERIENCE.**

To the casual observer, this book represents a collection of cool science activities that might be considered *geek chic*. There’s just something cool about learning how to remove an egg’s shell to reveal a naked egg, or how to use a bar of soap to whip up a soap soufflé in your friend’s microwave oven.

The first time you try one of the activities, however, you’ll discover that there’s an infectious, almost viral quality that transforms the “cool activity” into an unforgettable learning experience. When you read about the science behind making a bottle of soda erupt into a geyser using Mentos, you’ll be compelled to try it yourself. But it doesn’t stop there. The next thing you know, you’re sharing what you just experienced with a friend . . . and then it hits you . . . you’ve caught the bug.

What is the bug? It is a renewed sense of wonder. You can’t stop asking questions, wondering “What would happen if . . . ?” and trying new variations on the activities. Your enthusiasm is contagious and your friends “catch it” too.

This is my hope as you read this book. Catch the bug. Wonder. Ask questions. Share your discoveries. Make these activities unforgettable learning experiences. And more than anything else, believe that the possibilities are endless.

—Steve

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A WORD ABOUT **SAFETY**

By their very nature, science experiments fizz, bubble, pop, smoke, erupt, move, change temperature, and sometimes produce unexpected results. That's why science is fun, and that's also why you need to follow the necessary safety precautions when doing any science activity.

Read all the directions before you begin any experiment. If you aren't sure about something, ask!

Take it seriously when the experiments say that they require adult supervision.

Don't put any chemical in or near your mouth, eyes, ears, or nose.

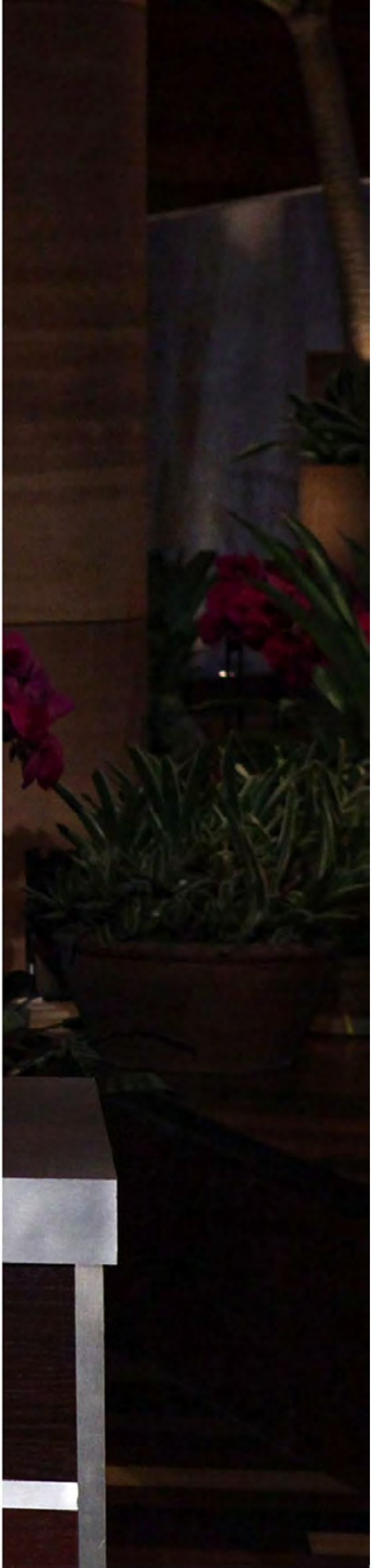
Wear safety glasses.

Wear protective gloves and use tongs when handling dry ice because it will cause severe burns if it comes in contact with your skin. Never put dry ice into your mouth! Never trap dry ice in a container without a vent.

Wash your hands thoroughly with soap and water after handling raw eggs. Some raw eggs contain salmonella bacteria that can make you really sick.

Aim anything that is going to "shoot" or explode away from yourself and others.

Don't eat your science experiments . . . they don't taste good, and eating in a lab is a bad thing to do.



INTRODUCTION

DON'T TRY THIS **AT HOME . . .**

Let's cut to the chase and be honest . . . science experiments have changed over the years. Okay, maybe the experiments have not changed, but the way they're packaged has. It seems that all of today's science experiments come with a warning that reads, **"Don't try this at home!"** This is especially true when someone breaks out the vinegar and baking soda or anything else that might fizz, bubble, pop, or get a child excited about learning.

What's the first thought that pops into a young scientist's mind when she hears, "Don't try this at home?" That's right . . . "I must do everything possible to try this at home!" The warning issued by the adult becomes a challenge for every kid who hears it.

There's an alternative to the standard warning. Instead of messing up your *own* home, try messing up your *friend's* home. Now the warning reads as follows:

"Don't try this at home . . . try it at a friend's home!"

Here's the good news. This book is filled with great science activities, demonstrations, and science fair project ideas that are easy to do and are guaranteed to get your creative juices flowing. Don't be fooled by the list of simple materials—vinegar, eggs, plastic bags, salt, soap—required for many of the experiments. Even though they're basic ingredients, the "wow" factor of the activities is huge. At the end of each activity, you'll learn the real science behind all of the "gee-whiz." You'll learn not only the *how* but also the *why*. And then something strange will happen. You'll start to ask your own questions and create your own experiments. Don't be surprised if a little voice in your head starts to ask things like, "What would happen if I changed this or tried that?" Curiosity will get the best of you and you'll find yourself doing the experiment again and again with your own changes and ideas.

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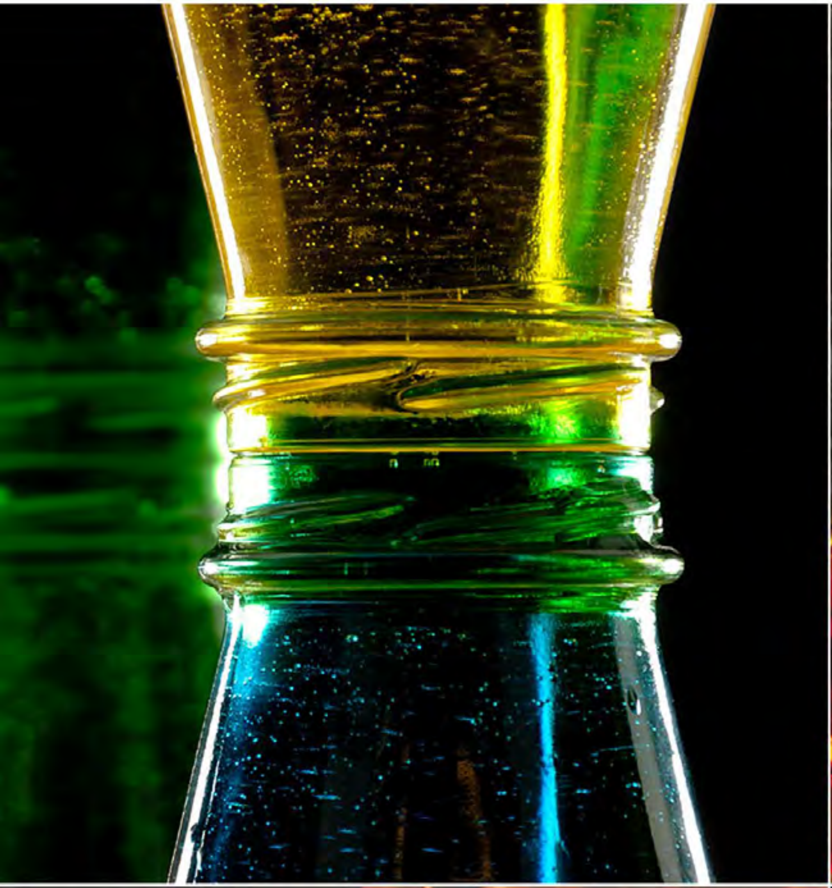



My favorite part of each activity in this book is the section titled "Let's Try It!" It's not a suggestion . . . think of it as a command or your marching orders. Round up the supplies, clear the tabletop, put on those safety glasses, and get to work. What happens next is the best part. Out of the clear blue you'll make a new discovery and uncover your own science secret. You'll feel your heart start to speed up and your mind race with new ideas. You've made a discovery, and that's an amazing feeling.

—Steve Spangler

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BEYOND THE FIZZ: **HOW TO GET KIDS EXCITED ABOUT DOING REAL SCIENCE**

No one cared that it was cold outside. These kids could hardly wait to see what would happen next. Giggles and laughter bounced from child to child as the group of second graders positioned themselves around the 2-liter bottle of diet soda.

In a whispered voice, one boy asked, "Do you really think she's going to do it?"

"Sure . . . she'll do it, but you have to get ready to run," replied the girl standing next to him.

Mrs. Schmidt removed the roll of Mentos from her pocket and loaded them into a small tube attached to the top of the soda bottle. The only thing that kept the mints from falling into the soda was a plastic pin tied to a piece of string.

"Are you ready?" Mrs. Schmidt asked.

"YES!" shouted the students who could hardly contain themselves.

"Three . . . Two . . . One . . . Go!"

It all happened in a fraction of a second. Mrs. Schmidt pulled the string, the Mentos fell into the soda, and a giant soda geyser shot up everywhere. It was raining Diet Coke! As soon as the soda started to spray, the children scattered.

The students screamed, "That was awesome . . . do it again!"

When Mrs. Schmidt finally regained control, she told the children, "This is just a 'one-time' experiment. I don't have any more soda, but wasn't that cool?"

As she walked her students back into the classroom, Mrs. Schmidt knew that she had hit a home run with her exploding soda experiment. It had all of the elements of a great science lesson: it was engaging and the fun factor was huge.

Okay, But Where's the Science?

Like many teachers, Mrs. Schmidt thought that she had presented a great science lesson with her soda geyser activity. In her mind, she was doing an exciting, hands-on activity and her students were having a blast. However, if you look at the activity on a deeper learning level, you'll start to uncover the most important missing element . . . the act of actually doing science! The harsh reality is that Mrs. Schmidt's flying soda activity was cool, but her students were never doing science. The only level of student engagement was running away from the flying soda. The bottom line is that the students watched their teacher perform a cool trick using mints and soda, but calling that science is wrong on many levels.

Missing Elements . . . Wonder, Discovery, and Exploration

The first key to engaging students in doing real science is to understand the difference between a *science demonstration* and a *hands-on science experiment*. Demonstrations are usually performed by the teacher and typically illustrate a science concept. Science experiments, on the other hand, give participants the opportunity to pose *their own* "what if . . ." questions, which inevitably lead to controlling a variable—that is, changing some aspect of the procedure or the materials used to perform the experiment.

In Mrs. Schmidt's case, the students were never given the opportunity to ask questions, make changes, create their hypotheses, or compare the results of the new experiment with the original. When the students yelled, "Do it again," this should have been music to Mrs. Schmidt's ears. The great Mentos Geyser experiment captured her students' interest, and they were, in essence, begging for an opportunity to explore, to ask their own questions, to test changes to the procedure, to formulate new ideas, and to make their own big discoveries.

Instead, Mrs. Schmidt gave a commonly used response when her students wanted to be engaged: "No, this is a 'one-time' experiment." One time? Who can eat just one potato chip? No one ever performs an experiment just once! Demonstrations may be one-time events, but great experiments lead to more questions, which lead to making changes and trying the experiment again. It's a wonderful cycle of critical thinking called scientific inquiry, and you don't need a PhD in rocket science to pull it off.

Great Demonstrations Lead to Greater Questions

One of the attributes of an amazing science teacher is to watch how he or she uses a cool science demonstration to grab the students' attention and stimulate their natural curiosity. Great science teachers use demonstrations in such a way that they invariably precipitate the question, "How did you do that?" Evidence shows that students retain science concepts much longer when they observe an engaging demonstration that provokes an inquisitive response and that challenges them to figure out why. If the science demonstration served its intended purpose, the students will come alive with a stream of questions, and it's the job of a great teacher to help the young scientists turn their questions into an unforgettable learning experience.

GREAT SCIENCE TEACHERS USE DEMONSTRATIONS TO INVARIABLY PRECIPITATE THE QUESTION, **"HOW DID YOU DO THAT?"**

Beyond the Fizz

No one can ever fault Mrs. Schmidt for sharing the Mentos Geyser with her students. If her primary goal was to get her students excited about science, she did it. But I hope she will discover a much more valuable treasure when she gives her students the opportunity to engage in the learning process. In the hands of a great teacher, cool science demonstrations like the Mentos Geyser open the door to an amazing journey filled with wonder, discovery, and exploration. By using the power of inquiry to create unforgettable learning experiences, you rekindle a childlike sense of wonder—in both your students and yourself—right before you turn them into a soaking mess from flying soda. Don't worry . . . they'll be talking about it at the dinner table for years to come.

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WINDBAG **WONDERS**

Here's the challenge ... How many breaths would it take to blow up a 8-foot-long bag? Depending on the size of the person, it may take anywhere from ten to fifty breaths of air. At the end of the challenge, the person is totally out of breath, wondering why she said yes in the first place. Now imagine the look on her face when you are able to inflate the giant bag using only one breath of air. That's right ... one breath and you win! This is one of my all-time favorite science demonstrations, and it's guaranteed to make it into your Top Ten list.

WHAT YOU NEED

Windbag (available at www.SteveSpanglerScience.com)
Or
Diaper Genie® bag

NOTE: The "Windbag" is actually a long plastic bag in the shape of a tube. SteveSpanglerScience.com is your source to purchase the brightly colored Windbags pictured throughout the pages of this activity. There is a real-world version of a Windbag at your local department store. Head to the aisle where baby products are sold and look for a diaper disposal system (commonly referred to as a Diaper Genie). The long plastic bags are sold as refills for the diaper disposal system, and they work very well for this demonstration.

LET'S TRY IT!

1. If you're using one of the Diaper Genie bags, cut off a section of the plastic tube material that is roughly 6 to 8 feet long. A shorter section of bag (4 to 5 feet long) is recommended for younger kid-scientists.
2. Tie a knot in one end of the bag. Invite a friend to blow up the bag, keeping track of the number of breaths it takes. Then, squeeze all of the air out of the bag. Explain to your friend that you can blow up the bag in one breath. Chances are, he or she won't believe you, but that's all part of the surprise.
3. Have your friend assist you by holding onto the closed end of the bag. Hold the open end of the bag approximately 10 inches away from your mouth. Make the opening as wide as you can with the index fingers and thumbs of both hands.

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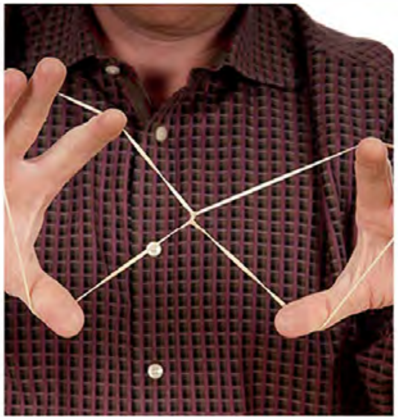
Using only one breath, blow a long, steady stream of air into the bag (just as if you were blowing out candles on a birthday cake). You MUST keep your mouth off of the bag (about 10 inches away from the opening) and keep the opening of the bag as large as possible. As you'll soon see, the secret is actually in the open space between your mouth and the bag.

4. If you do it correctly, you'll see the bag rapidly inflate. The trick is to quickly seal the bag with your hand so that none of the air escapes. Tie a slipknot in the end of the bag or let the air out and try again.

The Ultimate Windbag Challenge

Announce to your audience that they have 5 minutes to work together to build the largest freestanding Windbag structure they possibly can. The structure must be held up only by the Windbags themselves—no one can physically hold up the structure. ***Note: It would help to do this activity in a gym, a large ballroom, or outside.***



Here's a tip: loop two rubber bands together to form a "figure eight." Now hook two Windbags together by slipping the rubber bands over the tied ends of two inflated Windbags. Use more rubber band "figure eights" to connect multiple Windbags and create all kinds of creative structures. It's a great team-building activity for kids and adults alike.

WHAT'S GOING ON HERE?

Here's the quick and simple answer. The long bag quickly inflates because air from the atmosphere is drawn into the bag along with the stream of air from your lungs.

For you science enthusiasts out there, here's a more technical explanation. In 1738, Daniel Bernoulli concluded that a fast-moving stream of air is surrounded by an area of low **atmospheric pressure**. In fact, the faster the stream of air moves, the more the air pressure drops around the moving air. When you blow into the bag, higher-pressure air in the atmosphere forces its way into the area of low pressure created by the stream of air moving into the bag from your lungs. In other words, air in the atmosphere is drawn into the long bag at the same time that you are blowing into it.

The science behind the lifting table can be explained by **Pascal's Law**. His experiments with fluids led him to conclude that the pressure exerted by a confined fluid (and in this case, the air in the bag is a confined fluid) is equal in all directions. In other words, the compressed air is exerting pressure underneath the inverted table equally up, down, and sideways throughout the long Windbag. This same scientific principle is being applied when you pump up a bicycle tire or when an auto mechanic uses an air lift in a garage.

REAL-WORLD APPLICATION

Firefighters use **Bernoulli's Principle** to quickly and efficiently force smoke out of a building. Instead of placing fans up against a doorway or window, a small space is left between the opening of the building and the fan in order to force a greater amount of air through the building. Firefighters call this "positive air flow."

STEVE SPANGLER USES WINDBAGS TO SET **GUINNESS WORLD RECORD**

Steve used Windbags to demonstrate the power of air at the first annual 9News Weather and Science Day at Coors Field in Denver, Colorado, on May 7, 2009. As part of Weather and Science Day, Steve Spangler Science was awarded the Guinness World Record for the Largest Physics Lesson, with 5,401 participants using their own Windbags to perform an independent physics activity. Participants had 2 minutes to inflate their Windbags, and the news helicopter hovering above the stadium captured the colorful scene. Danny Girton Jr., official adjudicator for Guinness World Records, was on hand to verify the record-breaking event and presented Steve Spangler and his team with an official Guinness World Record certificate at the close of the day.


COORS FIELD

THE QUICK-POUR **SODA BOTTLE RACE**

Race to see who can be the first to empty a soda bottle full of water. With a special twist of the hand, you will be able to empty the water in the soda bottle in just a few seconds.

WHAT YOU NEED

- Plastic soda bottle (1-liter bottles work best)
- Pitcher of water
- Stopwatch or watch with a second hand to record your times

LET'S TRY IT!

1. Remove the label from the soda bottle so you have a clear view of the inside. Fill the soda bottle almost to the top with water.
2. Without squeezing the sides of the bottle, turn it over and time how long it takes to empty all of the water. Just hold the bottle upside down. You might want to repeat this several times and average the results. Be sure to use the same amount of water for each trial. Now you're collecting data!
3. Keep a table of the trials and call this the Glug-Glug Method.
4. Refill the bottle almost to the top with the same amount of water as you did before. When you turn it over this time, move the bottle in a tight, clockwise or counterclockwise circular motion as the water pours out.

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5. Keep moving the bottle like this until you see the formation of what looks like a tornado in the bottle. The water begins to swirl, a vortex forms, and water flows out of the bottle very quickly.
6. Time this method as you did before and call it the Vortex Method. Repeat the test several times and average the results. Which method allows the water to exit the bottle more quickly?

TAKE IT FURTHER

See if you can figure out new methods for getting the water out quickly. Time your trials and record them. Get another bottle and challenge your friends to a race. Until they learn the secret, you will win every time.

For a giant tornado, try filling a Deep Rock brand water bottle to the top with water, swirl it quickly in a clockwise or counterclockwise circular motion, and watch the powerful vortex form. Okay, this method is going to take a very strong person to swirl the water . . . and it's going to make a huge mess. Just take it outdoors and enjoy watching the strong person's shoes get drenched!

If you want to create the tornado over and over without having it drain down the sink, try a popular science toy called the Tornado Tube® (available at www.SteveSpanglerScience.com). The Tornado Tube connects two plastic soda bottles together and allows for the water to move from one bottle to the other as the bottles are tipped. Start with all the liquid in one bottle, quickly tip the bottle upside down, and start the swirling motion. The tornado (it's actually a vortex) will form as the liquid moves into the bottom bottle.

If you want the tornado to be more visible, squirt a few drops (no more) of liquid soap into a bottle of water. Connect the bottle to an empty bottle using the Tornado Tube, shake the bottles to make some suds, and swirl the liquid quickly in a circular motion. Look for the vortex in the middle of the bottle. The drops of soap help make it more visible.

Sure, anyone can color the water by adding a few drops of food coloring. Here's a real challenge: how would you go about coloring just the swirling vortex while keeping the surrounding water colorless? I struggled with this self-imposed challenge for months. My initial thought was to try adding a small amount of oil to the water. Of course, it's next to impossible to add coloring to oil, and the thickness (or **viscosity**) of ordinary vegetable oil destroyed the formation of any kind of vortex.

Then I stumbled upon a kind of colored oil at the local hardware store. It's called lamp oil, and it's used in outdoor lanterns or indoor oil lamps. Best of all, lamp oil comes in an assortment of colors. Purchase your favorite color of lamp oil (the red oil makes a really cool colored vortex) and try adding 2 ounces of the oil to the water in the soda bottle. Use the Tornado Tube to connect the two soda bottles and swirl the water using your now famous vortex-forming, swirl-of-the-bottle technique. When the oil and water swirl together, the less dense oil travels down the vortex first and creates a colored tornado effect. Remember, oil and water do not mix because oil is **hydrophobic** (water-fearing). The two liquids are said to be **immiscible**, which means oil and water cannot be mixed or blended. Since the oil is less dense than the water is, it forms a layer that floats on the surface of the water.

As long as you're adding things to the water, go on a scavenger hunt for a few miniature plastic houses from an old Monopoly game, plastic barnyard animals, glitter, beads, and anything else you can think of. Place the items in an empty bottle and fill the bottle three-fourths full of water. Attach the Tornado Tube and the second bottle. Swirl the liquid to create the vortex and watch what happens to the items you put in the bottle. Where were the items before you swirled and where did they go once the tornado formed? Toto, we're not in Kansas anymore!

WHAT'S GOING ON HERE?

"Auntie Em, Auntie Em, it's a twister!" Well, it's *sort of* a twister. If you've ever seen a dust devil on a windy day or watched the water drain from the bathtub, you've seen a **vortex**. A vortex is a type of motion that causes liquids and gases (both are fluids) to travel in spirals around a centerline. A vortex is created when a rotating liquid falls through an opening. Gravity is the force that pulls the liquid into the hole, and the rotation causes a continuous vortex to develop.

Swirling the water in the bottle while pouring it out causes the formation of a vortex that looks like a tornado in the bottle. The formation of the vortex makes it easier for air to come into the bottle and allows the water to pour out faster. If you look carefully, you will be able to see the hole in the middle of the vortex that allows the air to come up inside the bottle. If you do not swirl the water but just allow it to flow out on its own, then the air and water have to take turns passing through the mouth of the bottle (thus the glug-glug sound).

BUBBLING **LAVA BOTTLE**

Learn how to make a wave bottle using oil, water, and a secret ingredient that makes the whole thing fizz, bubble, and erupt.

WHAT YOU NEED

- Clean, plastic soda bottle with a cap (16-ounce size works well)
- Vegetable oil (the cheaper the better)
- Food coloring
- Alka-Seltzer tablet
- Large flashlight
- Water

LET'S TRY IT!

1. Fill the bottle three-quarters full with vegetable oil.
2. Fill the rest of the bottle with water (almost to the top but not overflowing).
3. Add about ten drops of food coloring. Be sure to make the water fairly dark in color. Notice that the food coloring only colors the water and not the oil.
4. Divide the Alka-Seltzer tablet into four pieces.
5. Drop one of the tiny pieces of Alka-Seltzer into the oil and water mixture. Watch what happens. When the bubbling stops, add another chunk of Alka-Seltzer.
6. When you have used up all of the Alka-Seltzer and the bubbling has completely stopped, screw on the soda bottle cap. Tip the bottle back and forth and watch the wave appear. The tiny droplets of liquid join together to make one big wavelike blob.

TAKE IT FURTHER

As you watched the bubbling color blobs rise and fall in the water, you probably thought to yourself, "This is just like a lava lamp . . . without the lamp!" On a side note, if you have no concept of what a lava lamp is, pull out your smart phone and Google it.

How to Make a Lava Lamp

To make a cool looking lava lamp, you'll need a large flashlight like the one in the photograph. Carefully rest the bottle of oil and water directly on the lens of the flashlight and repeat the experiment above with the bright light shining up and through the liquid. Groovy, baby!

WHAT'S GOING ON HERE?

First of all, you confirmed what you already know—oil and water do not mix. Even if you try to shake up the bottle, the oil breaks up into small little drops, but it doesn't mix with the water. Why is it that oil and water are such opposites?

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Alka-Seltzer

Oil and water don't mix because of how their molecules are constructed. Water is what is known as a **polar molecule**. A water molecule is shaped like a V, with an oxygen atom at the bottom point of the V and a hydrogen atom on each of the two top ends. However, there is unequal sharing of electrons between the hydrogen and oxygen atoms. This means that the bottom of the molecule has a negative electrical charge, while the top carries a positive charge.

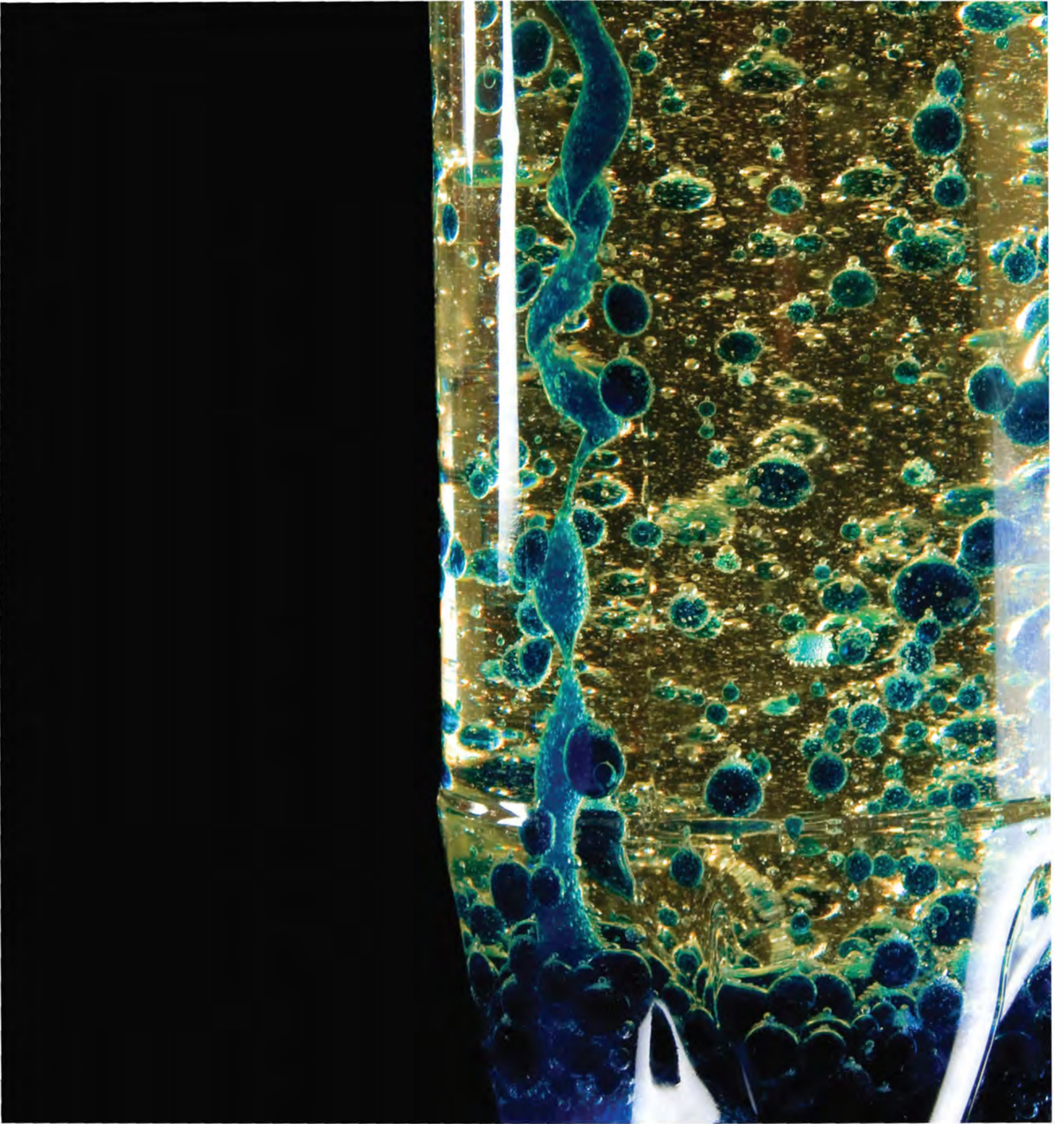
Vegetable oil, on the other hand, is a **nonpolar molecule** made of long chains of hydrocarbons—strings of carbon atoms bonded to hydrogen atoms. Unlike the water molecule, there is equal sharing of electrons between the carbon and hydrogen atoms. This means that the electrical charges of the atoms are not separated, so the molecules don't have opposite positive and negative ends.

If you were to think of molecules like groups of people, the polar molecules hang out with other polar molecules, and the nonpolar molecules with other nonpolar molecules. This brings us back to the reason why oil and water don't mix. Water is a polar molecule, and it just doesn't hang out with nonpolar molecules like oil. Scientists say that oil and water are **immiscible**.

The adage "like dissolves like" will help you remember what will mix with what. Salt and water mix because both molecules are polar—like dissolves like. It's also easy to mix vegetable oil and olive oil, or motor oil and peanut oil . . . but that's gross.

You also noticed that food coloring only mixes with water . . . and now you know why. Food coloring is a polar molecule because it dissolves in water. In other words, food coloring and water are **miscible**. Vegetable oil is not affected by the food coloring because they are polar opposites.

Here's the surprising part . . . the Alka-Seltzer tablet reacts with the water to make tiny bubbles of carbon dioxide. These bubbles attach themselves to the blobs of colored water and cause them to float to the surface. When the bubbles pop, the color blobs sink back to the bottom of the bottle, and the whole thing starts over until the Alka-Seltzer is used up. When the chemical reaction between the Alka-Seltzer and water is over and the bubbling stops, you're left with a cool looking wave bottle that will sit proudly on your desk.



BOUNCING SMOKE **BUBBLES**

There's something magical about a bubble. It's just a little puff of air trapped in a thin film of soap and water, but its precise spherical shape and beautiful swirling colors make it a true wonder of science. Bubbles are cool, but bubbles filled with fog are even cooler. Just imagine the cool factor going up tenfold if you could bounce and play with these bubbles. "Boo Bubbles" are what you get when you fill a bubble with a ghostly carbon dioxide cloud. But Boo Bubbles are truly magical because you can roll them on your hands, bounce them off your sleeve, and pop them to release the burst of fog. It's the combination of science and performance art that will have everyone (even you) ooohing and ahhhing.

WHAT YOU NEED

Boo Bubbles™ Kit (available at www.SteveSpanglerScience.com)
Or
Safety glasses
Knit gloves
Gallon-sized plastic jar
3-foot piece of rubber tubing
Liquid soap (Dawn works best.)
Small plastic container

Dry ice

Thick gloves

Bath towel

Making the Dry Ice Bubble Generator

The Dry Ice Bubble Generator pictured below is available as a kit (called the Boo Bubbles Kit) from www.SteveSpanglerScience.com. It's a no-hassle option for the person who wants to get started immediately. It's also possible to make your own Dry Ice Bubble Generator using items that are commonly found at a department store or the plumbing aisle of your favorite hardware store.

You'll need a gallon-sized plastic jar with a 3-foot long piece of rubber tubing attached to the side. The goal is to attach the tubing to the top part of the jar so that the fog created by mixing dry ice and water blows out of the tube when you cover the top of the jar with the lid. The free end of the rubber tubing is attached to a small funnel or something similar to help blow bubbles when it's dipped into a soapy water solution. The best approach is to start with the plastic jar and spend some time walking through the plumbing aisle of your local hardware store to consider all of the ways to attach a piece of plastic tubing to the jar. It could be as simple as drilling a hole in the jar and attaching the hose with a piece of tape or a dab of caulking or glue. The design is up to you, but be sure to take this book with you so you're prepared when someone asks, "How can I help you?"

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WARNING!
Never trap dry ice in a jar without a vent. In other words, there MUST be a hole in the jar to allow the pressure to escape. Otherwise, the pressure will build up and the jar will explode! This could cause serious harm to you or to someone else.

NOTE: You'll need some thick gloves to handle the dry ice. The knit gloves used later in the activity do not provide enough protection for your hands. Find a good pair of leather gloves to protect your hands against the cold temperature of the dry ice and you're set.

LET'S TRY IT!

1. Start by putting on your attractive safety glasses and thick leather gloves. You might need to use a hammer to break up the dry ice into pieces that will easily fit into the jar.
2. Fill the jar one-half full with warm water. Dry ice produces the best fog when you use warm water. Attach the rubber hose to the side of the jar (if it's not already attached).
3. Drop a few good-sized pieces of dry ice into the jar. Immediately, the fog will roll out of the jar. Practice covering the top of the jar with the lid to control the flow of fog out of the tube. You don't have to screw the lid onto the jar. Just hold it on top of the jar to force more or less fog through the rubber tubing.
4. Make a soapy solution by mixing a squirt (that's a *very* technical term!) of liquid soap with about 4 ounces of water in the small plastic container.
5. Dip the free end of the rubber tubing (either the "naked" tubing or the end of the tube "dressed up" with a small plastic cup, funnel, or fitting from the hardware store) into the bubble solution to wet the end of the tube. Remove the tube from the bubble solution with one hand while covering the jar with the lid in the other hand. This will take a little practice, but it's easy once you get the hang of it. The goal is to blow a bubble filled with fog.
6. When the bubble reaches the perfect size, gently shake it off of the tubing and it will quickly fall to the ground (it's heavier than a normal bubble because it's filled with carbon dioxide gas and water vapor). When the bubble hits the ground, it bursts, and the cloud of fog erupts from the bubble. Very cool!




  

TAKE IT FURTHER

Bouncing Boo Bubbles

This Boo Bubble variation happened accidentally and now it's a must-do whenever you play with Boo Bubbles. A bath towel was stretched out on the table in an effort to make the soapy cleanup just a little easier. To everyone's amazement, some of the fog-filled bubbles bounced on the towel and didn't pop! It just goes to show you that what some people call "play time" is actually high-level research (okay, maybe it's not real *research*, but it is play with a purpose). It's important to mention that not all types of fabric behave the same way. Ponder that for a few minutes before reading about the science of the bouncing bubble in the following pages.

Touchable Boo Bubbles

If fog-filled bubbles will bounce off of a towel, what would happen if you wrapped your hands in fabric and tried to touch or play with the bubbles? You can easily find out by purchasing a pair of inexpensive children's winter gloves. Blow a bubble about the size of a baseball with the Dry Ice Bubble Generator. Bounce the bubble off of your gloves. Try bouncing the bubble off of your shirt or pants. Again, some fabrics work better than others. Try bouncing bubbles on a hand towel or start up a game of volleyball bubbles with another friend who has too much time on her hands.

Giant Boo Bubbles

Regular-sized Boo Bubbles are awesome, but Giant Boo Bubbles are even more awesome! All you need are a few parts and pieces from around the house and you'll be making these giant, fog-filled bubbles in no time. Cover a clean table surface with a thin layer of soap bubble solution and spread it around. Fill the large water bottle with warm water and drop in a few big pieces of dry ice. Again, ***NEVER put any type of lid on the bottle or do anything that would seal the bottle closed. The rapidly expanding gas could result in an explosion.***

Hold the large plastic hose (similar to the kind you'd find on a shop vacuum) over the top of the large water bottle. The carbon dioxide cloud will start flowing out of the hose. Make sure you don't plug the hose so the gas can't escape. That never ends well . . . trust us.

Dip the open end of the hose into the bubble solution and put it down on the soap-covered table. A giant Boo Bubble will start forming on the surface of the table! Keep the nozzle down and your bubble will just get bigger and bigger and bigger. When the bubble finally pops, all of that carbon dioxide gas will escape, leaving a ghostly fog behind.

WHAT'S GOING ON HERE?

While blowing bubbles indoors, you might have noticed the occasional bubble that fell to the carpet but didn't pop. Regular bubbles burst when they come in contact with just about anything. Why? A bubble's worst enemies are oil and dirt. Soap bubbles will bounce off of a surface if it is free of oil or dirt particles that would normally puncture the soap film. They break when they hit the ground, but they don't break if they land on a softer fabric like gloves or a towel.

Dry ice is frozen carbon dioxide (CO_2) Under normal atmospheric conditions, CO_2 is a gas. Only about 0.035% of our atmosphere is made up of carbon dioxide. Most of the air we breathe is nitrogen (79%) and oxygen (20%). Instead of melting, dry ice turns directly into CO_2 gas. It does not melt like real ice because it skips the liquid stage and goes straight from solid to gas. When you drop a piece of dry ice in a bucket of water, the gas that you see is a combination of carbon dioxide and water vapor. So, the gas is actually a cloud of tiny water droplets.

Dry ice must be handled with care because it is -109.3°F (-78.5°C). It must be handled using gloves or tongs—otherwise, it will cause severe burns if it comes in contact with your skin. Never put dry ice into your mouth!

Grocery stores use dry ice to keep food cold during shipping. Some grocery stores and ice cream shops will sell dry ice to the public (especially around Halloween) for approximately $1 per pound. Dry ice comes in flat square slabs a few inches thick or as cylinders that are about 3 inches long and about half an inch in diameter. Either size will work fine for your dry ice experiments. Remember the science . . . dry ice turns directly from a solid into a gas—a process called **sublimation**. In other words, the dry ice in the grocery bag will literally vanish in about a day! The experts tell us that dry ice will sublimate (turn from a solid into a gas) at a rate of 5 to 10 pounds every 24 hours in a typical vented ice chest. It's best to purchase the dry ice as close to the time you need it as possible. This is the one time when last-minute shopping is necessary.

FLOATING **WATER**

Is it really possible to fill a glass with water and turn it upside down without spilling? This clever science trick is a popular after-dinner science stunt, but make sure there's a bowl close by to catch your mistakes.

WHAT YOU NEED

Plastic cup or drinking glass

Index card or old playing card

Large bowl or sink to practice over

LET'S TRY IT!

1. Before you get started, make sure the index card or playing card is large enough to completely cover the mouth of the glass. Fill the glass or plastic cup to the top with water.
2. Cover the cup with an old playing card, making sure that the card completely covers the mouth of the container.
3. Keep your hand on the card and turn the cup upside down. Hold the cup over the bowl just in case you accidentally spill.
4. The final step takes guts. Slowly take your hand away and the card will stay in place . . . and so should the water (keep your fingers crossed).
5. Don't press your luck too far. Put your hand back on the card and return the cup to its upright position.
6. The temptation is just too great, and you know you're going to do it again. Just make sure the card doesn't become completely soaked and accidentally fall apart. This could be a huge surprise for everyone!

TAKE IT FURTHER

Repeat the experiment but this time change the amount of water in the cup. Does it make any difference? What about if you switch the container? Will a wider cup hold the

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card better than a narrower cup? Does the temperature of the water have any effect on the water staying inside the cup?

Try the experiment using a paper cup or plastic cup but this time, using a thumbtack, poke a small hole in the bottom of the cup. What do you predict will happen if air is allowed to sneak into the cup?

WHAT'S GOING ON HERE?

The secret is right in front of your nose—it's the air that we breathe. Air molecules in the atmosphere exert pressure on everything. Scientists know that at sea level air molecules in the atmosphere exert almost 15 pounds of pressure (okay, 14.7 pounds if you want to be exact) per square inch of surface area. Your body is used to feeling this kind of air pressure, so you don't notice it.

When you first turn the cup upside down, the pressure of the air inside the cup and the air pressure outside the cup are equal. If you look closely, however, you'll notice that just a little water leaks out between the card and the cup. This happens because the force of gravity naturally pulls down on the water. When some of the water escapes, this causes the volume of air (the space above the water inside the cup) to increase slightly. Even though the amount of air above the water stays the same, the volume occupied by the air is now greater and the air pressure inside the cup decreases. The pressure of the air outside the cup is now greater than the pressure inside the cup and the card stays in place. All of this is possible because the water creates an airtight seal between the rim of the cup and the card.

When the seal is broken (even a *tiny* bit), air enters into the cup, equalizes the pressure, and gravity pushes the water out. Poking a thumbtack-size hole in the cup allows air to seep into the cup from the outside. The pressure of the air molecules both inside and outside the cup stays the same, gravity takes over, the card falls, and the water spills. Watch out for the carpet!

MYSTERIOUS **WATER SUSPENSION**

At first glance, you might think that you've seen this science demonstration attempted by a friend. A glass jar is filled with water and covered with an index card. The whole thing is turned upside down and the hand that is supporting the index card is pulled away. The card appears to be stuck to the inverted jar of water. In and of itself, this is a very cool trick, but in this version of the experiment, things get crazy. The inverted jar of water is held over the head of a spectator and the index card is pulled away! The gasps are audible . . . someone screams in anticipation of the water falling from the jar only to drench the poor spectator. To everyone's amazement, the water does not fall. It's suspended in the jar, literally floating above the spectator's head. The card is replaced, the jar is returned to its upright position, and the science magician pours the water back into the pitcher. The only sound you can hear is that of people scratching their heads. Amazing!

WHAT YOU NEED

Mysterious Water Suspension Kit (available at www.SteveSpanglerScience.com)
Or
Mason jar (pint size) with twist-on lid

Plastic screen mesh (This is the stuff used to make a screen for a window.)

Scissors

Index cards

Towels to clean up your mess

LET'S TRY IT!

1. Believe it or not, the secret to this science magic trick was in plain view of the audience the entire time. There's simply a piece of mesh screen that is held in place by the lid of the jar. Unlike a normal jar lid, the Mason jar has a lid that comes in two pieces—the center section and an outer ring called the sealing band. You will only be using the outside ring portion of the lid for this science trick.
2. Place the plastic screen mesh over the opening of the jar and twist on the ring portion of the lid. Using scissors, cut around the lid to trim off the edges of the screen. If you want a more professional look, remove the lid before cutting the screen. You'll see that the lid leaves an indentation in the screen material. Use scissors to cut around the indentation. What you're left with is a screen insert that fits perfectly into the top of the sealing band. Place the screen over the opening of the jar and twist on the lid.

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PERFORMANCE TIP:
This is a great piece of science magic designed to fool and amaze your friends. The cool thing about science magic is that unlike magic tricks performed by magicians, you want your friends to try and guess the secret. However, before you reveal the secret, make sure you've allowed enough time for every person to share his or her predictions (in science lingo, those predictions are called ***hypotheses***).

3. Your first inclination might be to try to hide the screen from your audience, but the truth of the matter is that no one will see it unless they know to be looking for it. Of course, you'll need to have a little distance between you and your audience, but you can casually show the top of the jar in one hand while picking up the pitcher of water in the other and no one will suspect a thing. Go ahead, try it, and you'll be amazed that you got away with flashing the secret right before their eyes! This is called "misdirection" and it fools the audience.
4. When you're ready to perform the trick, fill the jar with water by simply pouring water through the screen.
5. Cover the opening with the index card. Hold the card in place as you turn the card and the jar upside down. Let go of the card. Surprisingly, the card remains attached to the lid of the upside-down jar. Carefully remove the card from the opening and the water mysteriously stays in the jar!
6. Replace the card, turn the whole thing over, remove the card, and pour out the water . . . while enjoying the sounds of ooohs and ahhhs!

TAKE IT FURTHER

Experiment with different screens, some with fine mesh and some with coarse mesh, to observe how surface tension and air pressure work together to accomplish this feat. Ultimately, it's best to use plastic screen material since it will not rust or discolor the jar. Test out different kinds of plastic mesh from produce bags, for example, to see how the size of the mesh affects the surface tension of the water.

If you want to be really tricky, prepare one jar with the screen and one without. Ask a volunteer to join you on stage and have the volunteer use the jar without the screen. While your jar mysteriously holds the water, the volunteer's jar loses its contents every time. After the laughter subsides and before your volunteer's confusion turns to frustration, reveal the secret . . . but make sure you have a towel close at hand.

WHAT'S GOING ON HERE?

This is truly an amazing science magic trick because several scientific principles come into play to make the water appear to be suspended in the jar. **Atmospheric pressure** (the pressure exerted by the surrounding air) is the force that holds the index card in place. The card stays on the upside-down jar because the pressure of the air molecules pushing up on the card is greater than the weight of the water pushing down.

But how does the water stay in the jar when the card is removed? The answer is **surface tension**. The surface of a liquid behaves as if it has a thin membrane


THIS CARD

stretched over it. A force called **cohesion**, which is the attraction of similar molecules to each other, causes this effect. The water stays in the jar even though the card is removed because the molecules of water are joined together (through cohesion) to form a thin membrane between each tiny opening in the screen.

If you tip the jar at all, air will come into the jar and break the seal, causing the water to pour out. Tip the jar sideways and the water falls out of the jar. If you return the jar to its upright position, the air can no longer get into the jar and the rest of the water will stay inside. Now you have a special insight—be careful not to jiggle the jar or touch the screen because you'll break the surface tension and surprise everyone with a gush of water. Okay, maybe that's actually a good idea.

REAL-WORLD APPLICATION

After a rainstorm, you might have noticed that the screens on your windows at home are saturated with water. It's a simple matter of water molecules holding onto the screen (this is called **adhesion**) while holding onto each other and stretching across the tiny openings of the screen mesh (cohesion) to form a thin layer of water. Run your fingers across the screen and what happens? You break the surface tension of the water.

If you've ever gone camping and you had a tent with a screen opening at the top, you might have experienced an accidental rain shower inside your tent. During the night, moisture in the air condenses on the screen, filling each mesh opening with water. Jiggling the tent in the morning knocks the water loose, and you're left with a tent full of unhappy campers. Make sure you try it on someone else's tent!


DO NOT
REMOVE
THIS CARD

DO NOT OPEN BOTTLE

When you receive a package that says "DO NOT OPEN!" what do you want to do? Open it! It's just human nature. Try this tempting experiment for some guaranteed fun.

WHAT YOU NEED

- Clear plastic soda bottle (1 liter with cap)
- Permanent marker, any color
- Sharp pushpin
- Water
- Flashlight
- Towel to clean up your mess

LET'S TRY IT!

1. Clean and dry the 1-liter bottle and remove the label.
2. Fill the bottle to the very top with water and twist on the cap.
3. Use the permanent marker to write "DO NOT OPEN!" in fat letters on the bottom half of the bottle.
4. Carefully, use a sharp pushpin to poke a line of five or six holes about an inch (2.5 cm) from the bottom of the bottle. A small amount of water will squirt out as you poke holes in the bottle, but it's not a big deal. When you're finished, hold the bottle by the cap (don't squeeze the bottle or it will start leaking before you're ready) and give the bottle a gentle wipe down with the towel.
5. Carefully set the bottle on the kitchen counter (word-side out) where someone can see it as they pass by. Stay close enough to watch what happens. Eventually, someone is bound to ask about the bottle. Play dumb with, "I dunno," when they ask about it. Let them unscrew the cap and you'll witness science in action. Water squirts everywhere!
6. As you test out your newly discovered water management skills, you'll quickly notice that it's funnier to watch people just pick up the bottle. Even the slightest squeeze on the sides as they lift the bottle results in water squirting from the holes. Yes, it's childish . . . but it's really fun . . . and it's a great science lesson.

TAKE IT FURTHER

Experiment by poking different numbers of holes in the bottle. Do you get the same result with twenty holes as you did with just five holes? Try poking holes in different areas of the bottle. Do holes in the top of the bottle leak the same amount of water as holes in the bottom of the bottle? Does the size of the hole matter?

Leaking Liquid Light

There's a good use for your DO NOT OPEN bottle. Yes, it's a great practical joke, but there's also some real science waiting to pour out.

Place the bottle on the counter close to the sink so the streams of water flow into the sink. You'll need to get a big, powerful flashlight to shine through the

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bottle of water. Turn on the flashlight and turn off the lights in the room. Now, uncap the lid and let the water begin to flow.

As the light from the flashlight passes through the bottle, the water acts like a pipe for the light. Place your hand under the stream of water and look for the spot of light on the palm of your hand. Amazing!

The light is actually trapped inside the flowing stream of water. The water also helps to reflect the beam of light back into the stream whenever it tries to escape. When the light stream shoots down the stream of water, the waves of light bounce off the sides of the stream, focusing it back toward the middle. This idea of light bouncing around the inside of the stream is called **total internal reflection**.

Why is this important? You might have heard of your telephone company stringing fiber optic cables in place of the traditional metal core wires. Fiber optic cables are made out of glass fibers. A laser beam that carries your telephone conversation is fired into one end of the cable where it bounces off the internal walls and comes out the other end at about the speed of light. Your soda bottle light pipe is a great way to start to understand the physics of fiber optics. If you want to learn more about fiber optics, make a trip to your local library or start your scientific surfing on the Internet.

WHAT'S GOING ON HERE?

Let's start by examining an empty soda bottle. Is the bottle really empty? No. The bottle is filled with air (gotcha!). When you pour water into the bottle, the molecules of air that once occupied the bottle come rushing out of the top. You don't notice this because molecules of air are invisible. When you turn a bottle filled with water upside down, the water pours out (thanks to gravity) and air rushes into the bottle. Think of it as an even exchange of water for air.

You might think that poking a tiny hole in the bottom of a bottle would cause it to leak, and it does if air molecules can sneak into the bottle. When the lid is on the soda bottle, air pressure can't get into the bottle to push on the surface of the water. The tiny holes in the bottom or sides of the bottle are not big enough for the air to sneak in. Believe it or not, the water molecules work together to form a kind of skin to seal the holes—it's called **surface tension**. When the lid is uncapped, air sneaks in through the top of the bottle and pushes down on the water (along with the force of gravity), and the water squirts through the holes in the bottle. So be patient, observe, and wait for the scream. Be prepared to say, "Can't you read? It says, 'Do Not Open!'" Then run to get the towels.


DO
NOT
OPEN


DO
NOT
OPEN


DO
NOT
OPEN

THE **BABY DIAPER** SECRET

If you've ever changed a diaper and noticed what looked like tiny crystals on the baby's skin, you've uncovered the secret of superabsorbent, disposable diapers. Those tiny crystals actually come from the lining of the diaper and are made out of a safe, nontoxic polymer that absorbs moisture away from the baby's skin. This amazing polymer changed the way parents care for their babies, and scientists continue to find new uses for these superabsorbent polymers.

WHAT YOU NEED

- Disposable diapers (several brands)
- Plastic cup (8-ounce size)
- Zipper-lock bag
- Scissors
- Newspaper
- Water

LET'S TRY IT!

1. Place a new (unused is your first choice) diaper on the piece of newspaper. Carefully cut through the inside lining and remove all the cotton-like material. Put all the stuffing material into a clean, zipper-lock bag.
2. Scoop up any of the polymer powder that may have spilled onto the paper and pour it into the bag with the stuffing. Blow a little air into the bag to make it puff up like a pillow, then seal the bag.
3. Shake the bag for a few minutes to remove the powdery polymer from the stuffing. Notice how much (or how little) powder falls to the bottom of the bag.
4. Carefully remove the stuffing from the bag and check out the dry polymer you just extracted from the diaper.
5. Pour the polymer into a plastic cup and fill the cup with about 4 ounces (120 mL) of water. Mix it with your finger until the mixture begins to thicken.
6. Observe the gel that the polymer and water create. Turn the cup upside down and see how it has solidified. Now you know the super, moisture-absorbing secret hiding in the lining of a baby diaper. You just discovered something that has both a cool and a yuck factor!

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TAKE IT FURTHER

Put the pieces of gel back into the cup and smush them down with your fingers. Add a teaspoon of salt, stir it with a spoon, and watch what happens. Salt messes up the gel's water-holding abilities. When you're finished, pour the saltwater goo down the drain.

Grab a new diaper and slowly pour about ¼ cup of warm tap water into the center. Hold the diaper over a large pan or sink and continue to add water, a little at a time, until it will hold no more. Keep track of how much water the diaper can absorb before it reaches its limit.

WHAT'S GOING ON HERE?

The secret, water-absorbing chemical in a diaper is a superabsorbent polymer called sodium polyacrylate. A **polymer** is simply a long chain of repeating molecules. If the prefix "poly" means many, then a polymer is a long chain of molecules made up of many smaller units, called monomers, which are joined together. Some polymers are made up of millions of monomers.

Superabsorbent polymers expand tremendously when they come in contact with water because water is drawn into and held by the molecules of the polymer. They act like giant sponges. Some can soak up as much as 800 times their weight in water. Just imagine how much water a giant diaper could hold (then again, don't . . . that's gross).

The cotton-like fibers you removed from the diaper help to spread out both the polymer and the, uh, "water" so that the baby doesn't have to sit on a mushy lump of water-filled gel. This explanation is getting grosser and grosser! It's easy to see that even a little bit of polymer powder will hold a huge quantity of water, but it does have its limits. At some point, the baby will certainly let you know that the gel is full and it's time for new undies!

In spite of their usefulness, these diapers can be a problem. If you've ever observed a baby in diapers splashing in a wading pool, you know that even one diaper can absorb lots and lots of water. Most public pools won't allow them to be worn in the water because huge globs of gooey gel can leak out and make a mess of the filter system. Also, some folks used to throw them away in toilets—not a good idea unless you're a plumber. For the most part, however, these diapers are a great invention and make for dry, happy babies.

REAL-WORLD APPLICATION

Today, superabsorbent polymers are widely used in such applications as forestry, gardening, and landscaping as a means of conserving water. Imagine using a substance that could store water in the soil and then release it as the plants' roots needed it. While we may consider water-absorbing polymers to be a modern convenience, the impact that such technology is having on parts of the world that are plagued by drought is remarkable.

TACO SAUCE **PENNY CLEANER**

It's one of those things you hear about but wonder if it's true. Can you really use taco sauce to clean the tarnish off of a penny? Surprisingly, taco sauce does a great job of cleaning pennies, but how does it work?

WHAT YOU NEED

- Dirty pennies (try to collect tarnished pennies that all look the same)
- Taco sauce
- Vinegar
- Tomato paste
- Salt
- Water
- Small plates
- Masking tape or sticky note

LET'S TRY IT!

1. Let's start with the hypothesis of this experiment: Taco sauce is a great penny cleaner. If this is true, then we can use the scientific method to determine the science behind this saucy secret.
2. Place several tarnished pennies on a plate and cover them with taco sauce. Use your fingers to smear the taco sauce all over the top surfaces of the pennies. Remember to wash your hands . . . and don't lick your fingers because dirty pennies are gross.
3. Allow the taco sauce to sit on the pennies for at least 2 minutes.
4. Rinse the pennies in the sink and look at the difference between the top sides of the pennies that touched the taco sauce and the bottom sides. It's no myth—taco sauce does the trick.
5. For an easy-to-see comparison, use another tarnished penny and cover only half of the surface of the penny with taco sauce. Don't smear the sauce around with your finger this time—you want a nice dividing line between the two sides. Let the penny and sauce combo sit for a few minutes and rinse. It's a cool half-and-half penny.

Since the hypothesis is true, which of the ingredients in taco sauce is responsible for its cleaning power? Let's find out . . .

1. The list of ingredients on the packet of taco sauce reveals four substances to test: vinegar, tomato paste, salt, and water.
2. Place two equally tarnished pennies on each of four different plates. Use masking tape or a sticky note to mark each plate with the taco sauce ingredient you are testing (vinegar, tomato paste, salt, or water).

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tomato
paste


tomato
paste
Vinegar

3. Cover the pennies with the various ingredients, smear them around with your fingers, and allow the pennies to sit for at least 2 minutes. Be sure to wash your hands.
4. Rinse the pennies from each test plate with water. Which ingredient cleaned the pennies the best?

None of the individual ingredients do a good job of cleaning the dirty pennies. In fact, the results are less than impressive. Maybe two or more of the ingredients work together to react against the copper oxide (the tarnish) on the penny. Let's find out . . .

1. Place two equally tarnished pennies on each of three different plates. Make three signs that say "Tomato Paste + Vinegar," "Salt + Vinegar," and "Tomato Paste + Salt."
2. Cover the pennies with each of the mixtures, smear them around with your fingers, and give the ingredients at least 2 minutes to react. Wash your hands.
3. Rinse the pennies under water. Now what do you notice?
4. And the winner is . . . VINEGAR + SALT! But why?

WHAT'S GOING ON HERE?

The clear winner is the mixture of vinegar and salt. Neither vinegar nor salt by itself cleaned the pennies, but when they were mixed together something happened. The chemistry behind the reaction is somewhat complicated but very interesting. When the salt and the vinegar are mixed together, the salt dissolves in the vinegar solution and breaks down into sodium and chloride ions. The chloride ions then combine with the copper in the penny to remove the tarnish or copper oxide from the surface of the penny. It is also well known that a mixture of lemon juice and salt does a good job of removing tarnish from metals and works very well on pennies. By themselves, the salt and vinegar do very little in the way of removing the coating of copper oxide on the penny, but together these ingredients make a great cleaning agent.

So, the secret in taco sauce is the combination of the ingredients. Someone might argue that tomato paste is slightly acidic and may contribute in a small way to removing the copper oxide coating, but the real "power ingredients" are salt and vinegar.

SCIENCE FAIR CONNECTION

The "Taco Sauce Penny Cleaner" is a great example of a science fair project. First, you ask a question—does taco sauce really clean pennies? You find that it does

and then you ask another question—what is it in the taco sauce that causes it to clean pennies? You run multiple tests and isolate one variable at a time to see if the vinegar, the tomato paste, the salt, or the water is the real cleaning agent for the pennies. Guess what? Nothing cleans the penny. Now what do you do? You ask another question—could a combination of ingredients cause the cleaning action? Again, you isolate the variables and eventually reach the conclusion that a combination of vinegar and salt cleans the pennies.

The “Taco Sauce Penny Cleaner” experiment clearly shows **scientific inquiry** in motion—ask a question, run some tests, ask another question, run some tests, ask another question, run some tests, and eventually come to some conclusions. Good science fair projects should leave you with more questions than they answer. What do you still wonder about? How could you extend the experiment to try to find some more answers? Did this activity cause to you wonder about something else entirely? Could you create a new experiment based on your new questions?


tomato paste
Vinegar


Vinegar
salt


SALT SUPPLIES
NET WT 26 OZ
salt


IN GOD WE TRUST
LIBERTY
1984
LIBERTY
1978

EATING NAILS FOR BREAKFAST

Have you ever taken the time to read the nutritional information on your box of breakfast cereal? You'll find that your cereal contains more than just wheat and corn. In fact, you'll notice that your cereal contains sodium, potassium, calcium, and iron . . . iron? Some nails are made from iron. Could you be eating nails for breakfast? Well, not really, but certain cereals do have a very high iron content. To better explain this, try the following experiment.

WHAT YOU NEED

- Box of iron-fortified breakfast cereal (Total brand works best)
- Measuring cup
- Super strong magnet
- Plastic dinner plate
- Quart-size zipper-lock bag

LET'S TRY IT!

1. Open the box of cereal and pour a small pile of flakes on the plate. Crush them into tiny pieces with your fingers. Spread out the pile so it forms a single layer of crumbs on the plate. Bring the magnet close to the layer of crumbs (but don't touch any) and see if you can get any of the pieces to move. Take your time. If you get a piece to move without touching it, that piece may contain some metallic iron.
2. Firmly press the magnet directly onto the crumbs but don't move it. Lift it up and look underneath to see if anything is clinging to the magnet. Several little pieces may be stuck there. Is it the magnet being attracted to static electricity or just sticky cereal? It could be the iron. Throw away the small pile of cereal and clean off your magnet in order to move on to the next step.
3. Pour a little water onto the plate and float a few large flakes on the surface. Hold the magnet close to (but not touching) a flake and see if the flake moves toward the magnet. (The movement may be very slight, so be patient.) With

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NOTE ABOUT MAGNETS

Note: Magnets come in all shapes, sizes, and strengths. Ask at your local hardware store for a strong magnet for a science experiment. The strongest magnets in the world are called neodymium, or "rare-earth," magnets. They are ten times stronger than standard ceramic magnets and are commonly used in speakers and computer disc drives. It is possible to pull the iron out of cereal using a standard magnet, but you'll get much better results using a neodymium magnet.

practice, you can pull the flakes across the water, spin them, and even link them together in a chain. Hmm . . . there must be something that's responding to the magnet. Could it be metallic iron? In your cereal?

4. It's time to mix up a batch of cereal soup to further investigate the claim of iron in your breakfast cereal. Open a quart-size zipper-lock bag and measure 1 cup of cereal (that's equal to one serving according to the nutritional information on the side of the cereal box) into the empty bag. Fill the bag one-half full with warm water and carefully seal it, leaving an air pocket inside.
5. Give the cereal and water a good mixing by shaking the bag around for a minute or so. After a few minutes, the warm water will start to dissolve the flakes of cereal and the liquid will turn into a brown, soupy mixture. Allow the mixture to sit for at least 20 minutes before moving on to the next step.
6. Make sure the bag is tightly sealed and position it on a flat surface in the palm of your hand. Place the strong magnet on top of the bag. Put your other hand on top of the magnet and flip the whole thing over so the magnet is underneath the bag. Slowly slosh the contents of the bag in a circular motion for 15 or 20 seconds. The idea is to attract any free-moving bits of metallic iron in the cereal to the magnet.
7. Use both hands again and flip the bag and magnet over so the magnet is on top. Gently squeeze the bag to raise the magnet a little above the cereal soup. Don't move the magnet just yet. Look closely at the edges of the magnet where it's touching the bag. You should be able to see tiny black specks on the inside of the bag around the edges of the magnet. That's the iron!
8. Keep one end of the magnet touching the bag and move it in little circles. As you do this, the iron will gather into a bigger clump and become much

easier to see. Few people have ever noticed iron in their food, so you can really impress your friends with this one. When you're finished, simply pour the soup down the drain and rinse the bag.

TAKE IT FURTHER

By this time, your brain should be overflowing with questions. Is that black stuff really iron? Take a trip to the grocery store to investigate the contents of other cereals. What other brands claim to have iron? Conduct the same experiment using other brands of cereal to see if you can find more magnetic black stuff.

WHAT'S GOING ON HERE?

Many breakfast cereals are fortified with food-grade iron (chemical symbol: Fe) as a mineral supplement. Metallic iron is digested in the stomach and eventually absorbed in the small intestine. If all of the iron from your body were extracted, you'd have enough iron to make two small nails.

Iron is found in a very important component of blood called hemoglobin. Hemoglobin is the compound in red blood cells that carries oxygen from the lungs so it can be utilized by the body. It's the iron in the hemoglobin that gives blood its red appearance.

A diet without enough iron can cause you to be tired, catch diseases more easily, and make your heart and breathing rates too fast. Food scientists say that a healthy adult requires about 18 mg of iron each day. As you can see, iron plays a very important part in maintaining a healthy body. Score! Cereal for dinner!

THE **EGG DROP**

The Egg Drop is one of my all-time favorite science demonstrations. It's a combination of strategy and skill . . . and just a little luck. The goal is to get an egg to drop into a glass of water. Sound easy enough? Did I mention that the egg is perched high above the water on a cardboard tube and that a pie pan sits between the tube and the water? Still think it's easy? Sir Isaac Newton does. Once you try it, you'll be hooked!

WHAT YOU NEED

- Large eggs (buy a dozen because you need the practice)
- Cardboard tube from an empty roll of toilet paper
- Metal pie pan
- Pitcher of water
- Large drinking glass
- Oh, you might need a few paper towels to clean up your practice mess!

WARNING! IMPORTANT SAFETY RULES

Always wash your hands well with soap and water after handling raw eggs. Some raw eggs contain salmonella bacteria that can make you really sick!

LET'S TRY IT!

1. Pick a sturdy table or counter surface to perform the demonstration. Fill the drinking glass about three-quarters full with water and center the pie pan on top of the glass. Place the cardboard tube vertically on the pie pan, positioning it directly over the water. Carefully set the egg on top of the cardboard tube.
2. Explain to your audience that the goal is to get the egg into the glass of water, but you're not allowed to touch the egg, the cardboard tube, or the glass of water. The only thing left for you to touch is the pie pan. What would you need to do to move the pie pan and cardboard tube out of the way in order for the egg to fall into the glass of water? That's right . . . you're going to invoke Sir Isaac Newton's First Law of Motion and smack the pie pan out of the way. Don't do it just yet . . . read the next step.
3. Stand directly behind the Egg Drop setup. If you're right handed, hold your right hand straight out like you were going to karate chop something. Position

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your hand about 6 inches away from the edge of the pan. The idea is to hit the edge of the pie pan with enough force to knock the cardboard tube out from under the egg. Gravity will do the rest as the egg falls directly into the glass of water.

4. Shoot both hands up high over your head in celebration of your latest science miracle.

TAKE IT FURTHER

Try testing longer cardboard tubes from a roll of paper towel, different size glasses, or different size eggs. Do small eggs work as well as jumbo eggs?

The true Egg Drop connoisseur will never be content with a single egg falling into a single glass. The temptation is just too great to push the envelope and find a way to position two eggs, side by side, and attempt a drop. When it works (and it will), you'll discover that two eggs just aren't enough. After searching day and night for weeks on end (or maybe you'll just find one lying around the house), you'll find the perfect tray to hold three cardboard tubes and three eggs. It's no longer a science experiment . . . it's an obsession with the law of inertia and gravity. Wake the kids, phone the neighbors—this is going to be something special.

WHAT'S GOING ON HERE?

Credit for this one has to go to Sir Isaac Newton and his **First Law of Motion**. Newton said that objects in motion want to keep moving and objects that are stationary want to stay still—unless an outside force acts on them. So, since the egg is not moving while it sits on top of the tube, that's what it wants to do—not move. You applied enough force to the pie pan to cause it to zip out from under the cardboard tube (there's not much friction between the surface of the pan and the water container). The edge of the pie pan hooked the bottom of the tube, which then sailed off with the pan. Basically, you knocked the support out from under the egg. For a brief nanosecond or so, the egg didn't move because it was already stationary (not moving). But then, as usual, the force of gravity took over and pulled the egg straight down toward the center of the Earth.

Also, according to Mr. Newton's First Law, once the egg began moving, it didn't want to stop. The container of water interrupted the egg's fall, providing a safe place for the egg to stop moving so you could recover it unbroken. The force of gravity on the egg caused the water to splash out, and the audience burst into spontaneous applause.

POP BOTTLE **MUSIC**

A popular Las Vegas musical act uses tubes, bottles, trash cans, and other common items to make some very cool and distinctive sounds. This just proves that banging on pots and pans can lead to a very successful music career. Try your hand at making your own instruments using just a few household items.

WHAT YOU NEED

8 glass bottles (All of the bottles need to be the same.)

Water

Spoon

Good ears

LET'S TRY IT!

1. Fill one bottle full with water and leave a second bottle empty. Use the back of the spoon to gently clink both bottles. How are the sounds different?
2. Fill a third bottle half full with water. Clink all three bottles. The sound of the half-full bottle is about in the middle of the other two sounds.
3. Blow air across the tops of all three bottles. What do you notice?

TAKE IT FURTHER

By varying the amounts of water in each bottle, it's possible to create a musical scale. That's why this activity calls for eight bottles, one for each note of the musical scale. Try it with clinking the bottles and with blowing over the tops of the bottles. What differences do you notice? If you want to really put on a show, use food coloring to color the water in each bottle differently. Of course, the food coloring does nothing to affect the sound, but it does make it look like you really know what you're doing! The ultimate goal is to play a song . . . and then to get people to drop a few bucks into your hat. See, this book is already making you money.

Invite some friends over and present them with this challenge: in 60 seconds, arrange the bottles in such a way that when they are clinked with the spoon, they play a familiar song. Try "Jingle Bells," "Mary Had a Little Lamb," "Twinkle Twinkle Little Star," or "Beethoven's Fifth Symphony"—the song is up to you. The first person to arrange the bottles correctly and play the song wins.

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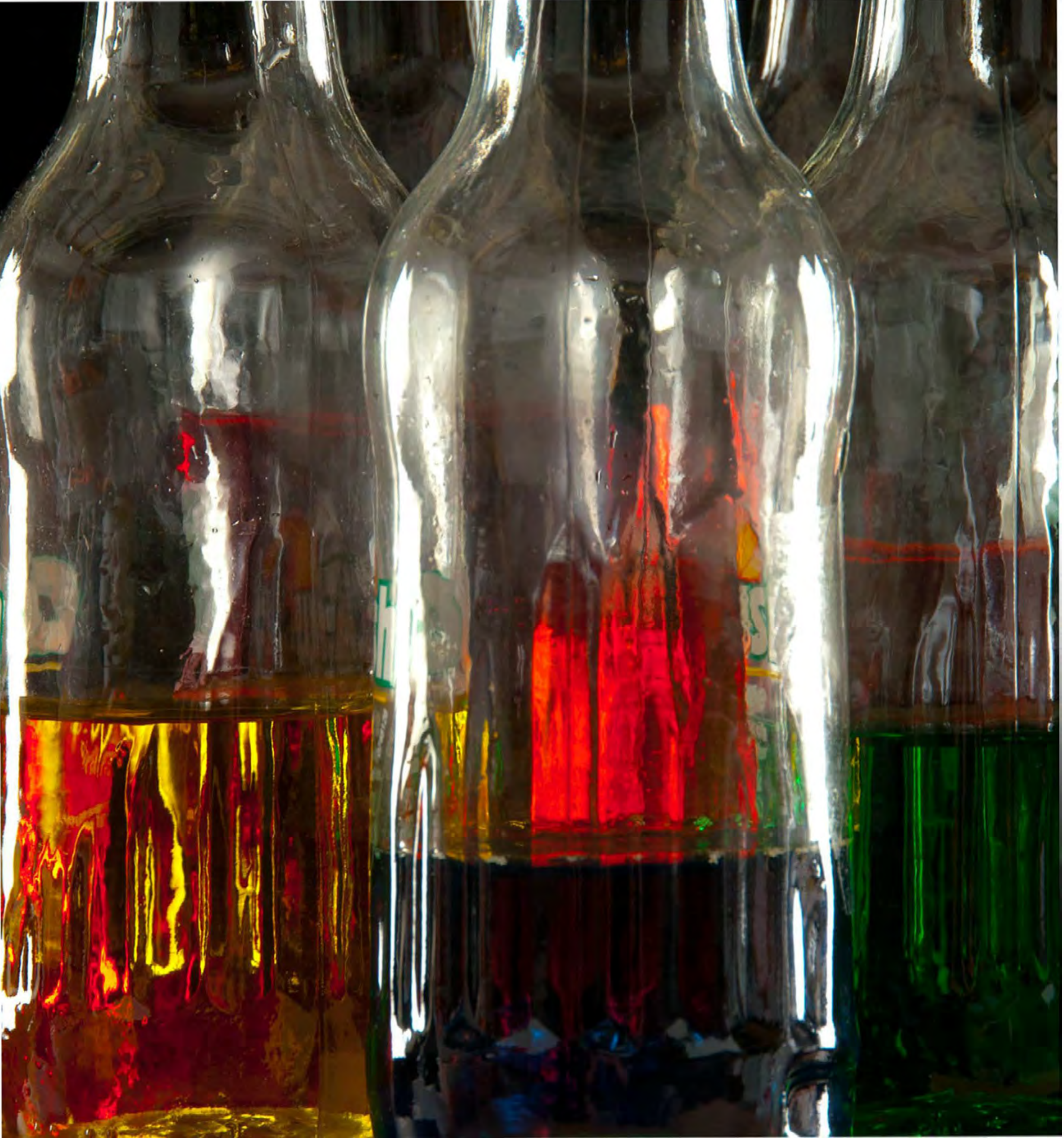
WHAT'S GOING ON HERE?

The science of sound is all about vibrations. When you hit the bottle with the spoon, the glass vibrates, and it's these vibrations that ultimately make the sound. You discovered that tapping an empty bottle produced a higher-pitched sound than tapping a bottle full of water did. Adding water to the bottle dampens the vibrations created by striking the glass with a spoon. The less water in the bottle, the faster the glass vibrates and the higher the pitch. The more water you add to the bottle, the slower the glass vibrates, creating a lower pitch.

The same bottle that makes a low-pitched sound when you tap it with a spoon makes a high-pitched sound when you blow across the top. The same bottle produces opposite sounds! When you blow into the bottle, you are making the *air* vibrate, not the glass. An empty bottle produces a lower pitch because there's lots of air in the bottle to vibrate. Adding water to the bottle decreases the amount of air space, which means there is less air to vibrate. With less air, the vibrations happen more quickly and produce a higher pitch.



POP YOUR TOP

What happens when you have a buildup of gas? Wait, on second thought, don't answer that question. The gas in this experiment is nothing more than bubbles of carbon dioxide and the explosion is nothing short of fun.

WHAT YOU NEED

- Alka-Seltzer tablets
- Film canister with a snap-on lid (Available at www.SteveSpanglerScience.com)
- Empty paper towel roll (the cardboard tube) or a similar-sized tube
- Duct tape
- Construction paper/odds and ends to design a rocket
- Water
- Paper towels for cleanup—you already know that this one is going to be good!
- Watch or timer
- Notebook
- Safety glasses

LET'S TRY IT!

1. Put on your safety glasses.
2. Divide an Alka-Seltzer tablet into four equal pieces.
3. Fill the film canister one-half full with water.
4. Get ready to time the reaction of Alka-Seltzer and water. Place one of the pieces of Alka-Seltzer tablet in the film canister. What happens?
5. Time the reaction and write down the time. How long does the chemical reaction last? In other words, how long does the liquid keep bubbling? Why do you think the liquid stops bubbling? Empty the liquid from the film canister into the trash can.
6. Repeat the experiment, but this time place the lid on the canister right after you drop in the piece of Alka-Seltzer. Remember to start timing the reaction as soon as you drop the piece of Alka-Seltzer into the water. Oh, by the way, stand back! If you're lucky, the lid will pop off and fly into the air at warp speed.

IMPORTANT:
This experiment requires you to wear protective safety glasses.

WARNING!
It's impossible to do this activity just once. It is addicting and habit-forming. Proceed at your own risk! You've been warned.

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7. You should have two pieces of Alka-Seltzer tablet left. Repeat the experiment using one of the pieces of Alka-Seltzer, but this time you decide on the amount of water to put in the film canister. Do you think that will make any difference?
8. Use the last piece of Alka-Seltzer to make up your own experiment. What do you want to find out? How are you going to do it? What are you going to measure?
9. Go ahead and experiment!

TAKE IT FURTHER

If you have another Alka-Seltzer tablet, divide it into four equal pieces. This time you're going to determine if changing the temperature of the water has any effect on the speed of the reaction. Repeat the same procedure as before, but change the temperature of the water in each of the four trials and write down your observations. You may need to experiment with several different film canisters until you find one that really pops. It's important that the film canister has a tight seal or it won't pop very well.

For a real eye-popping demonstration, fill ten or more film canisters one-half full with water and drop small pieces of Alka-Seltzer into each one. Quickly put the lids on the canisters and stand back. Popcorn, anyone?

Alka-Seltzer Rocket

Here's a clever variation of the classic Pop Your Top activity, but this time you launch the bottom of the film canister like a rocket. 3-2-1, blast off!

1. Start by sealing the end of the cardboard tube with several pieces of duct tape or use a plastic tube with one end sealed.
2. Divide an Alka-Seltzer tablet into four equal pieces.
3. Fill the film canister one-half full with water. ***Note: Steps four through six have to take place very quickly or the rocket will blast off before you're ready. Read the next few steps first to make sure you understand what is going to happen.***
4. Place one of the pieces of Alka-Seltzer tablet in the film canister and quickly snap the lid on the container.
5. Turn the film canister upside down and slide it (lid first) into the tube.
6. Point the open end of the tube AWAY from yourself and others and wait for the pop. Instead of the lid flying off, the bottom of the film canister shoots out of the tube and flies across the room. Listen carefully and you'll hear people yelling, "Do it again!"

TAKE IT FURTHER

Once you've mastered the technique, it's time to measure how far the film canister rocket flies across the room. After each trial, write down the amount of water you used in the film canister, the size of the piece of Alka-Seltzer (this should not change), and the distance the film canister traveled. What amount of water mixed with a quarter piece of Alka-Seltzer tablet produces the best rocket fuel? Hmm . . . sounds like a good science fair project!

After you've determined the best amount of water to use, try changing the temperature of the water. How does the temperature affect the speed of the reaction? Does warmer or colder water change the distance that the film canister travels?

If you're really creative, you can use construction paper to turn the bottom part of the film canister into a rocket. Wrap some paper around the canister, add some fins, top the whole thing off with a nose cone, and you've got an Alka-Seltzer powered rocket.

WHAT'S GOING ON HERE?

The secret is actually hiding in the bubbles that you observed. The fizzing you see when you drop an Alka-Seltzer tablet in water is the same sort of fizzing that you see when you mix baking soda and vinegar. If you look at the ingredients of Alka-Seltzer, you will find that it contains citric acid and sodium bicarbonate (baking soda). When you drop the tablet in water, the acid and the baking soda react to produce bubbles of carbon dioxide gas.

Carbon dioxide gas builds up so much pressure inside the closed film canister that the lid pops off. The lid is the path of least resistance for the gas pressure building up inside, so it pops off instead of the stronger sides or bottom of the film canister bursting open.

If you tried the experiment again with different temperatures of water, then you also discovered that temperature plays an important part in the reaction. Warm water speeds up the reaction, while colder water takes longer to build up enough pressure to pop off the lid.

We can thank Sir Isaac Newton for what happens next. When the buildup of carbon dioxide gas is too great and the lid pops off, **Newton's Third Law** explains why the film canister flies across the room: for every action there is an equal and opposite reaction. The lid goes one way and the film canister shoots out of the tube in the opposite direction.

IT PAYS **TO SMILE**

How often do you look at the face of the president pictured on your paper money? What's the facial expression of the president? Happy? Sad? Believe it or not, you can make George Washington's face smile or frown on a dollar bill if you know the secret to this visual foolery.

WHAT YOU NEED

A new, crisp $1 bill

LET'S TRY IT!

The secret is in the way that you fold the dollar bill. Just follow these simple steps.

1. Start with George's portrait facing you.
2. Make a "mountain fold" through the middle of George's left eye. In origami terms, this means to fold the bill away from you.
3. Make a second mountain fold through the middle of his right eye. Make sure that these creases are sharp.
4. Make a "valley fold" between the two previous folds so that the crease is between George's eyes and nose. To make a valley fold, fold the bill toward you. If all of these folds have you confused, check out the photos for clarification.
5. Pull on the ends of the bill slightly so that you can see his entire face, but make sure that the folds are still present.
6. Hold the portrait side of the bill in front of you with the face tilted upward. Notice how George smiles at you!
7. Slowly begin to tilt the bill downward, as if George were looking at the floor. Don't take your eyes off George's face because his smile will magically turn into a frown!

TAKE IT FURTHER

Use different dollar bills ($5, $10, $20, $50, even $100) to see if you can alter the emotions of some other presidents. Is Abe hiding a smile?

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WHAT'S GOING ON HERE?

The George Washington facelift is a great example of an optical illusion. The opposing folds cause the features on the face to bend and contort, depending on how you look at them. Although it's one of the simplest activities in the book, it's the one that you'll find yourself doing over and over again.

During my years as an elementary school teacher, I had the privilege of serving as one of the student council sponsors. Anyone who has ever sponsored an extracurricular activity knows that it can be a real challenge to get kids to show up to school an hour early or stay late unless you have a "hook." In an attempt to get more kids to each meeting, I promised to start each meeting with a science demonstration. Things that fizz, bang, pop, or make kids oooh and ahhh were bound to get everyone to the meetings on time.

Little did I know that these gee-whiz demonstrations would do far more than just coerce kids to participate in student council. The other sponsor and I quickly learned the value of using the demonstration to illustrate a simple lesson in leadership or character building, and the smiling dollar bill illusion fit the bill (pun intended) perfectly.

After teaching the students how to make the George Washington on their own bill smile or frown, we asked them to get into small groups of three or four kids and come up with what leadership lesson they thought we were trying to illustrate using this demonstration. Truth be told, we were just fishing for their answers. Here are a few of their responses.

- **Keep your chin up and share a smile. Cheer up!**
- **Lift your personality—smiles count!**
- **It makes good cents to smile.**
- **People can tell your attitude by looking at your body language.**
- **First impressions are often deceiving.**
- **Things are not always what they seem to be.**
- **It's hard to frown when you keep your chin up.**
- **Keep your eyes and nose pointed in the direction you want to go . . . UP!**
- **Wrinkles can give you a new perspective.**

As you might imagine, the lunch line was a buzz of activity the next day as the student council kids taught their friends how to make George frown and smile. Let's just say the activity went "viral" before anyone knew what the term meant. However, the best part of the experience for us was discovering that our little leadership ambassadors were using the optical illusion to share their own leadership lessons with friends. What started out as just a clever trick to do with an ordinary dollar bill turned out to be an object lesson that truly left a lasting impression.

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2006
WASHINGTON
ONE DOLLAR

MENTOS **GEYSER** EXPERIMENT

It's been called the "vinegar and baking soda" reaction for a new generation. While science teachers have been dropping candies and mints into 2-liter bottles of soda for years in an effort to release all of the dissolved carbon dioxide, the Mentos and Diet Coke reaction became world famous in 2005. Fueled by hundreds of blogs and popular online sharing sites like YouTube, this once obscure reaction became an Internet sensation, and the enthusiasm for dropping Mentos into soda continues to grow. Once you get past the initial gee-whiz factor, there's some amazing science behind a carbonated beverage and a chewy mint.

WHAT YOU NEED

A roll or box of Mentos chewy mints (stick with the standard mint flavor for now)

2-liter bottle of diet soda (either diet or regular soda will work for this experiment, but diet soda is not sticky when you're cleaning it up, and it will usually create a bigger blast)

Sheet of paper to roll into a tube

Steve Spangler's Geyser Tube toy (optional . . . but highly recommended!)

LET'S TRY IT!

1. This activity is probably best done outside in the middle of an abandoned field or on a huge lawn.
2. Carefully open the bottle of diet soda. Again, the choice of diet over regular soda is purely a preference based on the fact that erupting regular soda becomes a sticky mess to clean up because it contains sugar. Diet soda uses artificial sweeteners instead of sugar, and consequently, it's not sticky. Later on in the experiment, you'll be invited to compare the geyser power of diet versus regular soda, but for now we'll start with a 2-liter bottle of diet soda.
3. Position the bottle on the ground so that it will not tip over.
4. Let's start with seven Mentos for our first attempt. The goal is to drop all seven Mentos into the bottle of soda at the same time (which is trickier than you might think). One method for doing this is to roll a piece of paper into a tube just big enough to hold the loose Mentos. Other methods include using a large plastic test tube to hold the Mentos or using my Geyser Tube toy invention,

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Geyser Tube
Nutrition Facts
Total Fat 0g
Sodium 15mg
Total Carbohydrate 0g
Sugars 0g
Protein 0g
2 LITER
(2.1 QT)

which was created to solve this very problem. Assuming that you're using the paper tube method, you'll want to load the seven Mentos into the tube, cover the bottom of the tube with your finger, and position the tube directly over the mouth of the bottle. When you pull your finger out of the way, all seven Mentos should fall into the bottle at the same time.

5. Enough waiting . . . this anticipation is killing me. 3-2-1 drop the Mentos!
6. This final step is very important . . . run away! But don't forget to look back at the amazing eruption of soda.
7. If spectators were watching your exploits, someone is bound to yell out, "Do it again!" and that's exactly what you're going to do.

TAKE IT FURTHER

Simply dropping Mentos into a bottle of soda to make a geyser isn't really science—it's just a fun trick to do in the backyard. The real learning takes place when you start to change one variable at a time to see how it affects the performance of the geyser.

Check out the "Science Fair Connection" on page 149 for great ideas on how to measure the height of the geyser and how to determine the best ingredients to use to make the highest-shooting soda geyser.

WHAT'S GOING ON HERE?

Why do Mentos turn ordinary bottles of diet soda into geysers of fun? The answer is a little more complicated than you might think. Let's start with the soda . . .

Soda pop is made of sugar or artificial sweetener, flavoring, water, and preservatives. The thing that makes soda bubbly is invisible carbon dioxide (CO_2), which is pumped into bottles at the bottling factory using lots of pressure. If you shake a bottle or can of soda, some of the gas comes out of the solution and the bubbles cling to the inside walls of the container (thanks to tiny pits and imperfections on the inside surface of the bottle called **nucleation sites**). When you open the container, the bubbles quickly rise to the top pushing the liquid out of the way. In other words, the liquid sprays everywhere.

Is there another way for the CO_2 to escape? Try this. Drop an object like a raisin or a piece of uncooked pasta into a glass of soda and notice how bubbles immediately form on the surface of the object. These are CO_2 bubbles leaving the soda and attaching themselves to the object. For example, adding salt to soda causes it to foam up because thousands of little bubbles form on the surface of each grain of salt. This bubbling process is called **nucleation**, and the places where the bubbles form, whether on the sides of the can, on an object, or around a tiny grain of salt, are the nucleation sites.

Why are Mentos so special?

The reason why Mentos work so well is twofold—tiny pits on the surface of the mint, and the weight of the Mentos itself. Each Mentos mint has thousands of tiny pits all over the surface. These tiny pits act as nucleation sites—perfect places for CO_2 bubbles to form. As soon as the Mentos hit the soda, bubbles form all over the surfaces of the candies and then quickly rise to the surface of the liquid. Couple this with the fact that the Mentos candies are heavy and sink to the bottom of the bottle and you've got a double whammy. The gas released by the Mentos literally pushes all of the liquid up and out of the bottle in an incredible soda blast.

Science Fair Connection

You might be asking yourself, "Can I use the Mentos Geyser for my science fair project?" The answer is YES, but you'll need to learn how to turn a cool science activity into a real science experiment. The secret is to turn your attention away from the spraying soda and concentrate on setting up an experiment where you isolate a single variable and observe the results.

To get the best results in a science experiment you need to standardize the test conditions as much as possible. The biggest challenge in the Mentos Geyser experiment is finding a consistent way to drop the Mentos into the soda every time. The original reason I invented the Geyser Tube toy was to find a way to standardize the actual drop of the Mentos. If you're not using the Geyser Tube, make sure to come up with your own method for dropping the Mentos into the soda the same way each time.

Measuring the Height of the Geyser

To make any of these tests meaningful, you need to find a way to measure the height of the eruption. A friend or parent with a video camera is a great way to watch and document the results of your experiment, but you'll also need some specific measurements or data. Try placing the soda bottle next to the wall of a brick building (after getting permission from the building's owner). Measure the height of the geyser by counting the number of bricks that are wet once the geyser stops. If you want a more specific measurement, use chalk to mark off 1-foot increments on the brick wall before you drop the Mentos into the bottle of soda. Make comparisons, create a chart with your data, and draw some conclusions. Be sure to thank the building's owner and to hose off the wall of the building when you are finished!

Measuring the Volume of the Geyser

If you want to examine the volume of the geyser instead of the height, make note of the volume of a full bottle of soda before you drop the Mentos into it. (Okay, it's a trick question because a 2-liter bottle of soda holds . . . 2 liters!) Once the geyser stops, pour out the remaining contents of the bottle and measure how much liquid is left. You could use a beaker or a graduated cylinder to measure the remaining liquid in milliliters. Remember that 1 liter is equivalent to 1000 mL. Subtract the remaining amount of liquid from the original volume of the bottle to calculate the volume of the geyser. Then make comparisons, create a chart with your data, and draw some conclusions.

How Many Mentos Work Best?

This has to be the number one question everyone asks about this experiment. What is the best number of Mentos to use to make the highest-shooting geyser? This is a great topic for a science project—you'll need lots of soda and Mentos, and a few friends to help record all of the data.

Be sure that the soda bottles are all the same brand and type. It's also important that all of the test bottles are stored in the same place so that the liquid in each bottle is the same temperature.

Line up a row of ten 2-liter bottles against a brick wall (see "Measuring the Height of the Geyser"). Each bottle will receive a different number of Mentos. Drop one Mentos into the first bottle and record the height by counting the wet bricks (or set up your own scale behind each soda bottle). Drop two Mentos into the second bottle, and so on until you've completed all ten bottles.

Of course, this could go on forever, but you'll start to see a trend in your data that shows the maximum height of the geyser for a certain number of Mentos. Many soda geyser-ologists believe that seven Mentos produce the highest-shooting geyser. Using any more than seven Mentos is just a waste, according to these soda-soaked science enthusiasts. What do your results reveal about the effect of the number of Mentos on the height of the geyser?

The Brand Test

You guessed it . . . it's time to put your favorite soda to the test. Does one brand produce higher-flying geysers? How does generic soda stack up against the big name brands? If you're doing a science fair project, your initial question might be, "What is the effect of the brand of soda on the height of the geyser?"

Use your data from the previous test to determine the standard number of Mentos to use for this test. The only variable you'll change in this test is the brand of soda while everything else remains the same (the number of Mentos and the amount of soda). Again, make sure all of the soda is at the same temperature because temperature plays an important role in the reaction. The brand of soda is the only thing that changes (the variable).

Just think . . . your results could help determine the next Mentos Geyser craze!

The Temperature Test

What is the effect of temperature on the height of the geyser? Does warm soda shoot up higher than cold soda? The key is to keep every launch fair and to make sure the only variable is the temperature of the soda. You'll need a thermometer to record the temperature of the soda just before you launch it.

To enforce the fairness factor, you must stick with one brand of soda for the entire test. Let's use Diet Coke in this example. You'll want to purchase three bottles of Diet Coke and two rolls of Mentos. You're going to set up three tests warm soda, room temperature soda, and cold soda. Place one bottle of Diet Coke in the refrigerator and let it sit overnight. Place the second bottle in a place where it can reach room temperature overnight. There are two safe ways to warm the other bottle of soda. The simplest method is to let the unopened bottle sit in the sun for several hours. You can also place the bottle of unopened soda in a bucket of warm water. Never use a stove or microwave to heat a bottle of soda.

It's time to return to your launching site. Check to make sure your measuring scale is in place (counting bricks or using an alternative scale against the wall). Let's start with the bottle of cold Diet Coke. Open the bottle and dip the thermometer down into the soda. Record the temperature. Load seven Mentos into your paper roll and drop them into the soda. Immediately record the data for the cold soda test. Repeat the same procedure for the bottle of soda at room temperature and for the bottle of warm soda. It's important to use the same number of Mentos for each test and to drop them the same way.

No matter which brand of soda you tested, the warm bottle probably produced the highest-shooting geyser. Warm soda tends to fizz much more than cold soda. Why? The answer lies in the solubility of gases in liquids. The warmer the liquid, the less gas can be dissolved in that liquid. The colder the liquid, the more gas can be dissolved in that liquid. This is because as the liquid is heated, the gas within that liquid is also heated, causing the gas molecules to move faster and faster. As the molecules move faster, they diffuse out of the liquid, leaving less gas dissolved in that liquid. In colder liquids the gas molecules move very slowly, causing them to diffuse out of the solution much more slowly. More gas tends to stay in solution when the liquid is cold. This is why at the bottling plant CO_2 is pumped into the cans or bottles when the fluid is just above freezing—around 35° F. This low temperature allows the maximum amount of CO_2 to dissolve in the soda, keeping the carbonation levels as high as possible.

The Big Blast

After completing all of these tests, you've become somewhat of a Mentos Geyser expert who has the research to support the answer to the question, "How can you make the highest-shooting Mentos geyser?" Each test isolated an independent variable, and combining all of the information you discovered into one launch is a great way to wrap up your science fair project. For example, based on your individual test results, you might have arrived at this recipe for the best Mentos Geyser:

Use a bottle of Diet Coke

Make sure the soda is at least 85°F

Drop seven Mentos into the soda all at the same time

By using the scientific method and some critical thinking skills, you've successfully turned a great gee-whiz science trick into a research-based science fair project.

Mentos Geyser History—From Obscurity to Instant Celebrity

As strange as it might sound, the Mentos Geyser never actually started out using Mentos chewy mints. This science demonstration was popular among chemistry teachers back in the 1980s using a roll of Wintergreen LifeSavers and a pipe cleaner. Teachers threaded the roll of Wintergreen LifeSavers onto a pipe cleaner as an easy way to drop all of the LifeSavers into the soda at the same time. Within seconds of dropping the candies into the soda, a huge geyser would erupt from the bottle.

However, by the end of the 1990s, the manufacturer of Wintergreen LifeSavers increased the size of the mints (no one was ever certain why this happened), making the diameter of the candy too large to fit into the mouth of the soda bottle. Science teachers started experimenting (as they like to do) with other candies and mints that would have the same effect when dropped into a bottle of soda. As luck would have it, the solution to the problem was within arm's reach of the Wintergreen LifeSavers in the candy aisle—it was Mentos chewy mints.

Because Mentos mints didn't have holes in the middle like LifeSavers, getting them into the bottle was tricky. Everyone found their own method of quickly dropping the Mentos into the soda. Some people fashioned a tube out of paper while others used a piece of plastic tubing to load the Mentos. At the time, my solution was to load the Mentos candies into something called a Baby Soda Bottle—a test tube–like container that held an entire roll of Mentos perfectly. Oddly enough, this container was actually a "pre-form" or 2-liter soda bottle before it was blown up into a big bottle. That's why it's called a Baby Soda Bottle.

However, I must admit that even with the Baby Soda Bottle method, the results were not very consistent and it was challenging to get away from the bottle before it exploded. So, I solicited help from our creative team at Steve Spangler Science to come up with a Geyser Tube—a better, more consistent way to drop the Mentos into the bottle. Better yet, if we could trigger the drop of the Mentos from a distance, we wouldn't get as wet.

The next few months were spent building trigger devices ranging from plastic tubes with sliding doors to magnets that held metal stoppers in place to an elaborate battery-operated switch that was triggered by a motion detector. We even played with ways of using the Geyser Tube to trigger multiple soda geysers in a method similar to a Rube Goldberg machine. But the bottom line was that we needed to find a way to standardize the drop of the Mentos.

As they say, the simplest design usually turns out to be the best and most elegant solution to the problem. The winning Geyser Tube design was a clear plastic tube with a special fitting that twisted onto any soda bottle.

The trigger pin at the bottom of the tube prevented the Mentos from falling into the bottle until you pulled the string attached to the pin. The moment the pin was pulled, a slider ring resting above the pin fell into place and covered the holes where the trigger pin once was, and the Mentos dropped into the soda. But there was one added bonus . . . the restricted hole at the top of the plastic tube helped to build up more pressure in the bottle and launched the soda 30 feet into the air.

Fortunately, the maker of Mentos (Perfetti Van Melle) also liked the design, and we launched the Mentos Geyser Tube toy at the New York Toy Fair in February 2007. The Geyser Tube toy is currently available in toy stores and mass-market retailers throughout the country thanks to our distributor, Be Amazing Toys!

The Mentos Geyser became one of my featured demonstrations both on television and during my live stage presentations. While I had performed variations of the Mentos Geyser experiment on television many times from 2001 to 2004, my performance of the demo in September of 2005 in the backyard of NBC affiliate KUSA-TV in Denver proved to be the tipping point as the demo went from relative obscurity to Internet sensation.

My cohost for the KUSA-TV science segment was the lovely Kim Christiansen. During the commercial break, I told Kim what was going to happen and reminded her to

pull her hand out of the way of the erupting geyser and to run backward. Unfortunately, Kim got so caught up in the fun that she forgot to do both . . . and got soaked in Diet Coke on live television. To add insult to injury, she did it two more times, each time getting covered in more soda, until her once pink dress was more Coke-colored than pink.

KUSA-TV News posted that original video on their website along with my blog post titled, "News Anchor Gets Soaked!" Within a few weeks, links to the video and my blog entry numbered in the thousands. I also posted the video on a new online video sharing site called YouTube (YouTube was only 7 months old at the time), and as they say, the rest is history. Within the next 12 months, over 800 Mentos Geyser-related videos were posted on YouTube, making the demo one of the most popular pop-culture science experiments in recent history.

You know the Mentos Geyser is a popular experiment when a producer from ABC's *Who Wants to Be a Millionaire* calls for help writing a question. Here's the question we came up with:

In an experiment popularized online, what candy creates an explosive geyser when dropped into a 2-liter Diet Coke bottle?

A) Skittles
B) Mint Mentos
C) Atomic Fireballs
D) Lemon Heads

The question was asked on a special College Week episode of *Who Wants to Be a Millionaire*. The participant got it right for $8,000, saying: "I saw it on TV and I bought Mentos and a 2-liter bottle of Diet Coke . . . so I'm going to go with Mentos. That's my final answer." The contestant ended up doing really well, going all the way to the $250,000 question, but he walked away with $125,000.

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