CHEMISTRY 1

PARENT/TEACHER'S GUIDE

A comprehensive course that teaches the fundamental ideas behind chemistry. Students will discover how to create the four states of matter, grow crystal farms, experiment with phase shifts, crosslink polymers, shake up rainbow solutions, and stew up a chemical matrix of heat and ice reactions.

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This curriculum is aligned with the California State Standards and STEM for Science.

Introduction to the Unit

Greetings and welcome to the unit on Chemistry! I hope you will find this helpful in preparing to teach your students, exhaustively thorough in content and a whole lot of fun because that's when students and teachers do their best work.

This curriculum course has been prepared to be completed over several weeks, completing 1-2 lessons per week. You will find that there are 20 lessons outlined to take you from an introduction of atoms and molecules on through several advanced topics such complex enough to win a prize at the science fair. If you complete this course and send your kids off, you'll find their high school teachers entirely blown away by their mastery of the subject, and then they will really be able to fly with them. Each lesson has a Teacher Page and a Student Worksheet.

The following features on each set of the Teacher Pages:

- Overview: This is the main goal of the lesson.
- Suggested Time: Make sure you have enough for completing this lesson.
- Objectives : These are the core principles covered with this lesson.
- Materials: Gather these before you start.
- Lab Preparation: This outlines any preparation you need to do ahead of time.
- Lesson: This outlines how to present the topic to the students, stirs up interest and gets the students motivated to learn the topic.
- Lab Time & Worksheets: This includes activities, experiments, and projects that reinforce the concepts and really brings them to life. You'll also find worksheets that make up their Scientific Journal.
- Background Lesson Reading: This is optional additional reading material you can utilize ahead of time to help you feel confident when the students ask questions during the Lab Time. I don't recommend giving this reading to the kids beforehand. If you must share it with them, then do so *after* the students have gotten a chance to roll around with the activities. By doing this, it teaches kids to ask their own questions by getting curious about the concepts through the experiments, the way real scientists do in the real world.
- Exercises & Answer Key: How well did you teach? How well did they learn? Time to find out.
- Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Immediately following the Teacher Pages are "Student Worksheets" for each of the activities. Each set of student worksheets has the following sections:

- Overview
- What to Learn
- Materials
- Lab Time & Worksheets
- Exercise

In addition to the lessons, we have also prepared the following items you'll find useful:

- Scientific Method Guide
- Master Materials and Equipment List
- Lab Safety Sheet
- Written Quizzes (with Answer Key)
- Lab Practical Tests (with Answer Key)

Master Materials List for All Labs

This is a brief list of the materials that you will need to do *all* of the activities, experiments and projects in each section. The set of materials listed below is just for one lab group. If you have a class of ten lab groups, you'll need to get ten sets of the materials listed below. For ten lab groups, an easy way to keep track of your materials is to give each group a number from one to ten, and make up ten separate lab kits using small plastic tubs or baskets. Put one number on each item and fill each tub with the materials listed below. Label the tubs with the section name, like *Chemistry Study Kit* and you will have an easy way to keep track of the materials and build accountability into the program for the kids. Copy these lists and stick them in the bin for easy tracking. Feel free to reuse items between lessons and unit sections. Most materials are reusable year after year.

Chemistry Materials

Materials for Labs

aluminum foil
ammonium nitrate (single-use disposable cold pack)
baking soda
balloon
borax (laundry whitener)
calcium chloride ("Ice Melt")
chalk
cherry tomato
citric acid (spice section, used for preserving and pickling)
corn syrup
cornstarch (3 cups)
disposable cups (about 20)
distilled white vinegar
ethyl alcohol (70%)
fiber (psyllium fiber like Metamucil)
fire extinguisher
food coloring
glass jar (pickle, jam, mayo…)
glue (clear or white)
grapes (green, red or black)
guar gum (grocery store)
hard-boiled egg
honey
hydrogen peroxide
ice cubes
index card
isopropyl alcohol (91%)
kitchen scale (or other scale to measure small masses)
knife (with adult help)
lighter (with adult help)
liquid dish soap (colored)
measuring cups and spoons
microwave
molasses
old pot or saucepan
paper (black and white)
pennies (50)
pipe cleaners
plate
popsicle sticks
red cabbage
rubber gloves
ruler
salt
sand
scissors
small Ziploc bags
soap ("Ivory" brand works best)
sodium carbonate ("washing soda" in the laundry aisle)
sodium silicate*
spoon
string
sugar (9 cups)
tape
towel
vegetable oil (3 cups)
wooden skewers (3)
yellow highlighter

*Order from www.ScienceComany.com

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Unit Prep

This is a short list of things that you may want to consider as you prepare for this unit.

Student Lab Books: If you're the kind of teacher who likes to prepare lab books for your kids, now is a good time to do this. You can copy the *Introduction for Kids* and the *Student Worksheets* for each of the experiments, 3-hole punch them, and stick it in a binder. You'll want one binder per student.

Science Journals: One of the best things you can do with your students is to teach them how to take notes in a journal as you go along. This is the same way scientists document their own findings, and it's a lot of fun to look back at the splattered pages later on and see how far you've come. I always jot down my questions that didn't get answered with the experiment across the top of the page so I can research these topics more.

Master Set of Materials: If you plan on doing all the labs in this unit, you'll want to start gathering your materials together. There's a master materials list so you'll have everything you need when you need it.

Test Copies: Students will take two tests at the end of each section. There are quizzes and lab practical tests you can copy and stash away for when you need them.

Classroom Design: As you progress through the units, you'll be making demos of the experiments and kids will be making posters. You can hang these up on your bulletin boards, string them from the ceiling, or display them in a unique way. I always like to snap photos of the kids doing their experiments and hang those up along with their best labs so they can see their progress as we go along.

Lab Safety

Goggles should be worn when working with chemicals, heat, fire, or projectiles. This protects your eyes from chemical splatter, explosions, and tiny fast-moving objects aimed at the eyes. If you wear glasses, you can find goggles that fit over them. Don't substitute eyeglasses for goggles, because of the lack of side protection.

Clean up Messes: Your lab area should be neat, organized, and spotless before you start, during your experiment, and when you leave. Scientists waste more time hunting for lost papers, pieces of an experiment, and trying to reposition sensitive equipment… all of which could have easily been avoided had they been taught these skills from the start.

Dispose of Poisons: If a poisonous substance was used, created, or produced during your experiment, you must follow the proper handling procedures for disposal. You'll find details for this in experiments as appropriate.

No Eating or Drinking in Lab: All foods and drinks are banned from your classroom during science experimentation. When you eat or drink, you run the very real risk of ingesting part of your experiment. For electricity and magnetism labs, always wash your hands after the lab is over to rinse off the lead from the electrical components.

No Horse Play: When you goof around, accidents happen, which means chemicals spill, circuits short, and all kinds of hazards can occur that you weren't expecting. Never throw anything to another person and be careful where you put your hands – it could be in the middle of a sensitive experiment, especially with magnetism and electricity. You don't want to run the risk of getting shocked or electrified when it's not part of your experiment.

Fire: If you think there's a fire in the room (even if you're not sure), let your teacher know right away. If they are not around (they always should be), smother the fire with a fire blanket or use a fire extinguisher and send someone to find an adult. Stop, drop, and roll!

Questions: If you're not sure about something stop and ask, no matter what it's about. If you don't know how to properly handle a chemical, do part of an experiment, ask! If you're not comfortable doing part of the experiment, then don't do it.

Teaching Science Right

These activities and experiments will give you a taste of how science can be totally cool AND educational. But teaching science isn't always easy. There's a lot more to it than most traditional science books and programs accomplish. If your students don't remember the science they learned last year, you have a problem.

What do kids really need to know when it comes to science? Kids who have a solid science and technology background are better equipped to go to college, and will have many more choices once they get out into the real world.

Learning science isn't just a matter of memorizing facts and theories. On the contrary, it's developing a deep curiosity about the world around us, AND having a set of tools that let kids explore that curiosity to answer their questions. Teaching science in this kind of way isn't just a matter of putting together a textbook with a few science experiments and kits.

Science education is a three-step process (and I mean teaching science in a way that your students will really understand and remember). Here are the steps:

1. Get kids genuinely interested and excited about a topic.
2. Give them hands-on activities and experiments to make the topic meaningful.
3. Teach the supporting academics and theory.

Most science books and curriculum just focus on the third step and may throw in an experiment or two as an afterthought. This just isn't how students learn. When you provide your students with these three keys (in order), you can give them the kind of science education that not only excites them, but that they remember for many years to come.

So what do you do? First, don't worry. It's not something that takes years and years to do. It just takes commitment.

What if you don't have time? What I'm about to describe can take a bit of time as a teacher, but it doesn't have to. There is a way to shortcut the process and get the same results! But I'll tell you more about that in a minute. First, let me tell you how to do it the right way:

Putting It into Action

Step one: Get students genuinely interested and excited about a topic. Start by deciding what topic you want your students to learn. Then, you're going to get them really interested in it. For example, suppose I want my fifth-grade students to learn about aerodynamics. I'll arrange for them to watch a video of what it's like to go up in a small plane, or even find someone who is a pilot and can come talk with the kids. This is the kind of experience that will really excite them.

Step two: Give your students hands-on activities and experiments to make the topic meaningful. This is where I take that excitement and let them explore it. I have flying lesson videos, airplane books, and real pilots interact with my students. I'll also show videos on how pilots plan for a flight. My students will learn about navigation, figuring out how much fuel is needed for the flight, how the weight the plane carries affects the its aerodynamics, and so much more. (And did I just see a spot for a future math lesson also?) I'll use pilot training videos to help us figure this out (short of a live demo, a video is incredibly powerful for learning when used correctly).

My students are incredibly excited at this point about anything that has to do with airplanes and flying. They are all positive they want to be pilots someday and are already wanting flying lessons (remember - they are only fifth-graders!).

Step three: Teach the supporting academics and theory. Now it's time to introduce academics. Honestly, I have my pick of so many topics because flying includes so many different fields. I mean, my students use angles and math in flight planning, mechanics and energy in how the engine works, electricity in all the equipment on board the plane, and of course, aerodynamics in keeping the plane in the air (to name just a few).

I'm going to use this as the foundation to teach the academic side of all the topics that are appropriate. We start with aerodynamics. They learn about lift and drag, make paper and balsa-wood gliders and experiment by changing different parts. They calculate how big the wings need to be to carry more weight (jelly beans) and then try their models with bigger wings. Then we move on to the geometry used in navigation. Instead of drawing angles on a blank sheet of paper, our workspace is made of airplane maps (free from the airport). We're actually planning part of the next flight my students will "take" during their geography lesson. Suddenly, angles are a lot more interesting. In fact, it turns out that we need a bit of trigonometry to figure out some things.

Of course, a 10-year-old can't do trigonometry, right? Wrong! They have no idea that it's usually for high school and learn about cosines and tangents. Throughout this, I'm giving them chances to talk with the pilot in class, share what they've learned with each other, and even plan a real flight. How cool is that to a kid?

The key is to focus on building interest and excitement first, and then the academics are easy to get students to learn. Try starting with the academics and...well, we've all had the experience of trying to get kids do something they don't really want to do.

The Shortcut: Okay, so this might sound like it's time-intensive. If you're thinking "I just don't have the time to do this!" Or maybe "I just don't understand science well enough myself to teach it to my students at that level." If this is you, you're not alone.

The good news is, you don't have to. The shortcut is to find someone who already specializes in the area you want your students to learn about and expose them to the excitement that the person gets from the field. Then, instead of you being the one to invent an entirely new curriculum of hands-on activities and the academics, use a solid science program or curriculum (live videos, not cartoons). This will provide them with both the hands-on experiments and the academic background they need.

If you use a program that is self-guided (that is, it guides you and your students through it step-by-step), you don't need to be hassled with the preparation. That's what this unit is intended to do for you and your students. This program uses these components and matches your educational goals set by state standards.

This unit implements the three key steps we just talked about and does this for you. My hope is that you now have some new tools in your teaching toolbox to give your students the best start you can. I know it's like a wild roller coaster ride some days, but I also know it's worth it. Have no doubt that that the caring and attention you give to your students' education today will pay off many times over in the future.

Educational Goals

The study of chemistry is particularly exciting because students have the opportunity to do and see with their own eyes most of what they are expected to learn. What are those strange bubbles? A chemical reaction! Why did I get this glob of goo? I made a polymer! Concepts that would be somewhat foreign in a textbook can come to life as an experiment or demonstration. Students will gain skills at following detailed directions for labs as well as building a strong foundation of important scientific vocabulary. They will be asked to reflect on what they have learned and experimented with, then challenged to take that learning to the next level.

<u>Here are the scientific concepts:</u>

Crystals, Atoms, Molecules, Polymers, Chemical Reactions, and States of Matter

- Structure of atoms and molecules
- Crystals are organized grouping of atoms or molecules that form specific patterns
- Supersaturated solid solutions
- Physical verses chemical change
- Indicators of a chemical change
- Molecules join together to form polymers
- States of matter: solids, liquids, gases, and plasma
- Non-Newtonian fluids
- Sublimation is the process by which a solid goes directly to a gas
- Explanation of fire

Temperature, the Electromagnetic Spectrum, and Density

- Evaporation and condensation of molecules
- How skin senses temperature
- Radiation
- Electromagnetic spectrum
- Density is a measure of how tightly packed the molecules are, or density = mass ÷ volume
- Factors that affect density

<u>By the end of the labs in this unit, students will be able to:</u>

- Design and build a working scale.
- Know how to demonstrate the process by which a polymer is formed; how crystals are formed; how to create a supersaturated solid solution; how to determine if a substance contains carbon dioxide.
- Understand how to determine if something is a chemical or physical reaction; what state of matter is observed; how to find density.
- Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
- Measure and estimate the weight, length and volume of objects.
- Formulate and justify predictions based on cause-and-effect relationships.

- Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
- Construct and interpret data tables from measurements and experimental data.
- Follow a set of written instructions for a scientific investigation.

Lesson #1: Chemical Matrix of Acids and Bases

Teacher Section

Overview: The first lesson in chemistry is a fun lab to get the wiggles out. Students will create their very own mad science lab. Solids and liquids will be mixed together, allowing students to witness the difference between acids and bases, as well as physical and chemical changes. We'll go deeper into the science behind the reactions later – this lab is just to warm them up.

Suggested Time: 30-45 minutes

Objectives: Students will learn that a physical change happens when the molecules stay the same, but the volume and/or shape change, like wadding up tissue. A chemical change rearranges the molecules and atoms to create new molecular combinations, like lighting the tissue on fire. In addition, students will understand an indicator may be used to determine if a substance is an acid or base.

Materials (per lab group)

- muffin tin or disposable cups
- popsicle sticks for stirring and mixing
- tablecloths (one for the table, another for the floor)
- isopropyl rubbing alcohol
- hydrogen peroxide
- water
- acetic acid (distilled white vinegar)
- liquid dish soap (add to water)
- head of red cabbage (indicator)
- calcium chloride (AKA "DriEz" or "Ice Melt")
- citric acid (spice section, used for preserving and pickling)
- sodium tetraborate (borax, laundry aisle)
- sodium carbonate (washing soda, laundry aisle)
- sodium bicarbonate (baking soda, baking aisle)
- ammonium nitrate (single-use disposable cold pack)

Lab Preparation

Although not lethal, alcohol and peroxide vapors can irritate, so it is recommended to perform this experiment OUTSIDE. Always wear goggles and gloves, and have a hose handy in case of spills. Although these chemicals are not harmful to the skin, they can cause it to dry out and itch. If you're not sure about an experiment or chemical, just don't do it. Skip the peroxide and cold pack if you have small kids.

1. Prepare the indicator by coarsely chopping the head of red cabbage and boiling the pieces for five minutes in a pot full of water. Carefully strain out all the pieces with a fine-mesh strainer; the reserved liquid is your indicator, and should be blue or purple.
2. Have your indicator in a bottle by itself. An old soy sauce bottle with a built-in regulator that keeps the pouring to a drip is perfect. You can also use a bowl with a bulb syringe, but cross-contamination could be a

problem. Or it could not be — depending on whether you want your students to see the effects of cross-contamination during their experiments. The indicator bowl will continually turn different colors throughout the experiment.

3. Cover your lab area, and possibly the floor, with a plastic tablecloth. Place your chemicals on the table. A set of muffin cups make for an excellent chemistry experiment lab. Alternatively, you can use empty plastic ice cube trays.
4. Set out your liquid chemicals in easy-to-pour containers, such as water bottles. Be sure to label them, as they all will look the same: alcohol, hydrogen peroxide, water, acetic acid, and dish soap mixed with water. Set out small bowls (or zipper bags if you're doing this with a crowd) of the powders and use the tops of your water bottles as scoopers. The small scoopers regulate the amounts you need for a muffin-sized reaction. Label the powders, as they all look the same.
5. Print out copies of the student worksheets.
6. Read over the Background Lesson Reading before teaching this class.
7. Watch the video for this experiment to prepare for teaching this class. There are two experiments outlined here – one without litmus paper in which the entire solution changes color (which is a lot of fun), and one using litmus paper to test different substances. I've found that the best combination for this lab is when I do the litmus paper experiment as a demonstration, and then let them loose after showing them they have liquid indicator (like a liquid version of litmus paper) in the bottles.

Background Lesson Reading

In a university class, one of the first things you learn in chemistry is the difference between physical and chemical changes. An example of a physical change is when you change the shape of an object, like wadding up a piece of paper. If you light the paper on fire, you now have a chemical change. You are rearranging the atoms that used to be the molecules that made up the paper into other molecules, such as carbon monoxide, carbon dioxide, ash, and so forth.

How can you tell if you have a chemical change? If something changes color; gives off light, such as chemiluminescent light sticks; absorbs heat (gets cold); or produces heat (gets warm), it's a chemical change.

What about physical changes? Some examples of physical changes include tearing cloth, rolling dough, stretching rubber bands, eating a banana, or blowing bubbles.

About this experiment: Your solutions will turn red, orange, yellow, green, blue, purple, hot, cold, bubbling, foaming, rock hard, oozy, and slimy, and they'll crystallize and gel — depending on what you put in and how much!

What's happening with the indicator? An indicator is a compound that changes color when you dip it in different substances, such as vinegar, alcohol, milk, or baking soda mixed with water. Different indicators are affected differently by acids and bases. Some change color only with an acid, or only with a base. Turmeric, for example, is good only for bases. You can prepare a turmeric indicator by mixing 1 teaspoon turmeric with 1 cup rubbing alcohol.

Why does red cabbage work? Red cabbage juice has anthocyanin, which makes it an excellent indicator for these experiments. Anthocyanin is what gives leaves, stems, fruits, and flowers their colors. Did you know that certain flowers, such as hydrangeas, are blue in acidic soil but turn pink when transplanted to a basic soil? In this experiment, you get the anthocyanin out of the cabbage and into a more useful form so you can use it as a liquid indicator.

Lesson

1. Ask your students, “Have you ever had that desire to be a mad scientist? To experiment and mix chemicals and have all kinds of interesting things happen? Well, here’s your chance! You will see solutions turn red, orange, yellow, green, blue, purple, hot, cold, bubbling, foaming, rock hard, oozy, and slimy, and they’ll crystallize and gel — depending on what you put in and how much!”
2. Show students the bottle containing cabbage juice indicator and ask, “Have you ever pulled out those strange purple things from your salad and wondered what in the world you’re being asked to eat? That’s cabbage, and although you may not like to eat it, it makes an excellent science experiment! We can use cabbage to make something called an indicator. An indicator is a compound that changes color when you combine it with different things, such as vinegar, alcohol, milk, or baking soda mixed with water. Different indicators are affected differently by acids and bases. Some change color only with an acid, or only with a base. You will use cabbage juice as an indicator to see an amazing array of colors.”
3. Describe how you made the cabbage juice. Explain that red cabbage juice has anthocyanin, which makes it an excellent indicator. Anthocyanin is what gives leaves, stems, fruits, and flowers their colors. Say, “Did you know that certain flowers, such as hydrangeas, are blue in acidic soil but turn pink when transplanted to a basic soil?”
4. Mention this true fact: “In a university class, one of the first things you learn in chemistry is the difference between physical and chemical changes. A physical change occurs if you change the shape of an object, like wadding up a piece of paper. Who can think of some other physical changes?” (Tearing cloth, rolling dough, stretching rubber bands, mashing a banana, blowing bubbles, etc.). Say, “What about a chemical change? If you light the wad of paper on fire, you now have a chemical change. You are rearranging the atoms that used to be the molecules that made up the paper into other molecules, such as carbon monoxide, carbon dioxide, ash, and so forth. Can you think of other chemical changes? (something that changes color; gives off light, such as the light sticks used around Halloween; absorbs heat, [gets cold, an endothermic reaction]; produces heat [gets warm, an exothermic reaction]).
5. Before you start the lab, go over safety procedures with your students so they are absolutely clear what is expected during the lab.

Lab Time

1. Before breaking the kids into their lab groups, you can optionally do the acid-base demonstration for them using litmus paper.
2. Review the instructions on their worksheets and then break the students into their lab groups.
3. Hand each group their materials and give them time to perform their experiment and write down their observations.
4. Start mixing it up! If there is time, let students have at all the chemicals at once, even the indicator. Of course, this leads to a chaotic mix of everything. When the chaos settles down, and they start asking good questions, reveal a second batch of chemicals they can use. It is handy to have two identical sets of chemicals, knowing that the first set will get used up very quickly.
5. After the initial burst of enthusiasm, your kids will instinctively start asking better questions. They will want to know why their green goo is creeping onto the floor while someone else's just bubbled up hot pink, seemingly mixed from the same stuff. Give them a chance to figure out a more systematic approach, and ask if they need help before you jump in to assist.
6. Encourage students to use the grid provided in the student worksheet to organize their chemicals and make notes about their observations.
7. Note: Periodically hold your hand under the muffin cups to test the temperature. If it feels hot, it's an exothermic reaction which is giving off energy in the form of heat, light, explosions, etc. The chemical-bond energy is converted to thermal energy, or heat, in these experiments. If it feels cold, you've made an endothermic reaction, in which energy was absorbed. Heat from the mixture converts to bond energy. Sometimes you'll find that your mixture is so cold that it condenses the water outside the container, like water drops on the outside of an ice-cold glass of water on a hot day.

Optional Lab Exercises

Red cabbage isn't the only game in town. You can make an indicator out of many other substances, too. Here's how to prepare different indicators:

- Try some of the following as indicators: red cabbage, blueberries, red and green grapes, beets, cherries, and turmeric.
- Follow this procedure for any of the above: Cut the substance into smaller pieces. Boil the chopped pieces for five minutes. Strain out the pieces and reserve the juice. Cap the juice (indicator) in a water bottle, and you're ready to go.
- You can make indicator paper strips using paper towels or coffee filters. Just soak the paper in the indicator, remove and let dry. When you're ready to use one, dip it in partway so you can see the color change and compare it to the color it started out with.
- Use the indicator both before and after you mix up chemicals. You will be surprised and dazzled by the results!

Exercises

1. What is an indicator? (A compound that changes color when you combine it with different things.)

2. What examples of chemical changes did you observe? (Heat, color change, bubbles, foam, gel, ooze, cold, etc.)

3. What types of physical changes did you observe? (None.)

4. Why did some mixtures get hot? What type of reaction was this? (It was an exothermic reaction, which means energy was given off. The chemical-bond energy was converted to thermal energy, or heat.)

5. Why did other mixtures get cold? What type of reaction was this? (It was an endothermic reaction, which absorbs energy. The heat from the mixture was converted to bond energy.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #1: Chemical Matrix of Acids and Bases

Student Worksheet

Name____

Overview: If you love the idea of mixing up chemicals and dream of having your own mad science lab, this one is for you. You are going to mix up solids and liquids in a chemical matrix, and see a lot of cool chemical reactions between acids and bases.

What to Learn: After this experiment you'll understand that an *indicator* can change color when you combine it with different materials. Today we will use a cabbage juice indicator, but there are many different kinds. You will see several *chemical reactions* take place (that means things will bubble, ooze, spit, change color and get hot or cold).

Materials

- muffin tin or disposable cups
- popsicle sticks for stirring and mixing
- tablecloths (one for the table, another for the floor)
- isopropyl rubbing alcohol
- hydrogen peroxide
- water
- acetic acid (distilled white vinegar)
- liquid dish soap (add to water)
- head of red cabbage (indicator)
- calcium chloride (AKA "DriEz" or "Ice Melt")
- citric acid (spice section, used for preserving and pickling)
- sodium tetraborate (borax, laundry aisle)
- sodium carbonate (washing soda, laundry aisle)
- sodium bicarbonate (baking soda, baking aisle)
- ammonium nitrate (single-use disposable cold pack)

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. After receiving all of your chemicals, start mixing it up! Use the grid provided in the student worksheet to organize chemicals and make notes about your observations.
3. Note: Periodically hold your hand under the muffin cups to test the temperature. If it feels hot, it's an exothermic reaction which is giving off energy in the form of heat, light, explosions, etc. The chemical-bond energy is converted to thermal energy, or heat, in these experiments. If it feels cold, you've made an endothermic reaction, in which energy was absorbed. Heat from the mixture converts to bond energy. Sometimes you'll find that your mixture is so cold that it condenses the water outside the container, like water drops on the outside of an ice-cold glass of water on a hot day.

Chemical Matrix of Acids and Bases
Data Table

Describe the chemical reaction observed for each mixture

						Hydrogen Peroxide + Indicator
						Alcohol + Indicator
						Vinegar + Indicator
						Water + Indicator
Sodium Bicarbonate (Baking Soda)	**Citric Acid**	**Ammonium Nitrate (Single-use Cold Pack)**	**Calcium Chloride ("DriEz" or "Ice Melt")**	**Sodium Carbonate (Washing Soda)**	**Sodium Tetraborate (Borax)**	

Exercises Answer the questions below:

1. What is an indicator?

2. What examples of chemical changes did you observe?

3. What types of physical changes did you observe?

4. Why did some mixtures get hot? What type of reaction was this?

5. Why did other mixtures get cold? What type of reaction was this?

Lesson #2: Laundry Soap Crystals

Teacher Section

Overview: Students will use a supersaturated solution of borax laundry whitener to create crystals grown on pipe cleaners.

Suggested Time: 20-30 minutes

Objectives: Students will observe crystal formation and understand that crystals are organized groupings of atoms or molecules that form specific patterns.

Materials (per lab group)

- pipe cleaners
- cleaned out jar or bottle (pickle, jam, or mayo jar)

You'll need to prepare the solution ahead of time using these materials for the entire class:

- old pot
- stove or other heating appliance
- spoon
- borax

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.
5. Prepare the solution in advance so the students can use it during the lab. You'll prepare a small batch as the first part of their lab as a demonstration piece as well.

Background Lesson Reading

Crystals may be observed in the patterns of snowflakes, the ice in your freezer or rocks in your back yard. Quartz crystals are used in electronics like radios and in the inner workings of watches. Some crystals take thousands of years to form, but they may also quickly form with a little water and Borax.

As minerals form in the Earth's crust, they sometimes grow into a regular repeating pattern, also called a crystal. Each geometric shape is the result of the way the atoms come together as the mineral forms. Factors like pressure, temperature, available space and chemical conditions present in the minerals affect the formation of crystals. Crystals are in metals like gold, copper, silver, mercury and iron and in precious stones like diamonds, rubies, sapphires, emeralds and topaz. You'll also see crystals in ice, sugar, snow, sulfur and salt. The outward three-dimensional properties of crystals reflect the internal atomic structure of the molecules that create them.

Crystals form when liquids inside the Earth cool and harden, or when liquids underground flow into cracks and slowly form minerals. As long as the temperature is consistent and the molecules outnumber the liquid, crystals will form. If the molecules cannot join the group, they are reabsorbed back into the liquid. Examples of natural crystal formations are the stalactites and stalagmites in underground caves.

A hot solution of borax and water can hold more borax than a cool solution. As the borax solution cools, crystals of borax "fall out" of solution and deposit on the shape you have placed in the container. This is not a chemical change, however. In a chemical change, bonds are broken and new bonds are formed between different atoms resulting in different substances. A physical change does not involve a change in the substance's chemical identity. The crystals "grow" because the cooled solution cannot continue to hold all the borax that had been placed in it any longer. The pipe cleaner shape you put in the solution provides a home to the borax crystals that are falling out of solution.

Lesson

1. If you have an example of a crystal, show it to the class. If not, ask students if they have any examples of crystals at home, or have seen crystals someplace else. (They may have seen a geode or other rock crystal, a diamond ring, snow, ice, etc.). Ask students to think about the crystals that have been mentioned and try to determine what they all have in common. Discuss in pairs, then as a class come up with a definition (it's a regular, repeating pattern of minerals).
2. Show students the box of borax and ask if anyone has something like this at home. If so, ask the student what the product is used for. If not, explain that borax is a laundry booster. It helps the whitening power in laundry soap so whites get whiter. It also contains a chemical called sodium tetraborate.
3. Explain that they will add borax to some water, and heat it up. Ask, "What is a saturated solution?" (a solution in which the maximum amount of solute, or what you are dissolving, has been dissolved). Say, "OK. What happens if we add heat? When the water is heated, will you be able to add more or less borax?" (allow for guesses, but make sure they get the correct answer, which is more). Explain, "You are going to make something called a supersaturated solution. You will use heat to cause more borax to be mixed into the solution than is normally possible."
4. Think aloud, "I wonder what will happen when the water cools again?" Let them guess, but don't tell them the answer… they'll see it in their experiment.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Use pipe cleaner to create a shape for crystals to cling to (suggestion: cut into 3 lengths and wrap around one another). Curl top pipe cleaner around a pencil, making sure the shape will hang nicely in the container without touching the sides.
4. Add 2 cups of water and 2 cups of borax (sodium tetraborate) into a pot. Heat, stirring continuously for about 5-10 minutes. Do not boil, but only heat until steam rises from the pan.
5. When the borax has dissolved, add more, and continue to do so until there are bits of borax settling on the bottom of the pan that cannot be stirred in (It may be necessary to stop heating and let the solution settle if it gets too cloudy). You'll be adding in a lot of borax! You have now made a supersaturated solution. Make sure your solution is saturated, or your crystals will not grow.

6. Wait until your solution has cooled to about 130ºF (hot to the touch, but not so hot that you yank your hand away). Pour this solution (just the liquid, not the solid bits) into the jar, and add pipe cleaner shape. Make sure the pipe cleaner is submerged in the solution. Put the jar in a place where the crystals can grow undisturbed overnight, or even for a few days. Warmer locations (such as upstairs or on top shelves) are best.
7. NOTE: These crystals are NOT edible! Please keep them away from small children and pets!

Exercises

1. Why did the sodium tetraborate solution need to be supersaturated in order to form crystals? (When the solution cooled, it could not hold as many crystals of borax, so the rest "fell out" of solution onto the pipe cleaner shape)
2. The concentration of a solution is the amount of dissolved substance (borax) in a given volume of solvent (in this case, water!). Was the borate solution more concentrated when it was cool or hot? Why? (Hot, because more borate was dissolved in the same amount of water).
3. Why was it necessary to put a pipe cleaner into the sodium tetraborate solution? (The crystals need something to cling to.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #2: Laundry Soap Crystals

Student Worksheet

Name____

Overview: Can you really make crystals out of soap? You bet! These crystals grow really fast, provided your solution is properly saturated. In only 12 hours, you should have sizable crystals sprouting up.

What to Learn: Today's focus is on crystals and supersaturated solutions. You'll use heat to dissolve more borax (sodium tetraborate) than usual in a pot of water and love the result when it cools!

Materials

- solution your teacher has prepared for you
- pipe cleaners
- cleaned out jar or bottle (pickle, jam, or mayo jar)
- water
- borax

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Use pipe cleaners to create a shape for crystals to cling to (suggestion: cut into 3 lengths and wrap around one another). Curl top pipe cleaner around a pencil, making sure the shape will hang nicely in the container without touching the sides.
3. Add 2 cups of water and 2 cups of borax (sodium tetraborate) into a pot. Heat, stirring continuously for about 5-10 minutes. Do not boil, but only heat until steam rises from the pan.
4. When the Borax has dissolved, add more, and continue to do so until there are bits of Borax settling on the bottom of the pan that cannot be stirred in (It may be necessary to stop heating and let the solution settle if it gets too cloudy). You'll be adding in a lot of borax! You have now made a supersaturated solution. Make sure your solution is saturated, or your crystals will not grow.
5. Wait until your solution has cooled to about 130^{o}F (hot to the touch, but not so hot that you yank your hand away). Pour this solution (just the liquid, not the solid bits) into the jar, and add pipe cleaner shape. Make sure the pipe cleaner is submerged in the solution. Put the jar in a place where the crystals can grow undisturbed overnight, or even for a few days. Warmer locations (such as upstairs or on top shelves) are best.
6. NOTE: These crystals are NOT edible! Please keep them away from small children and pets!

Exercises Answer the questions below:

1. Why did the sodium tetraborate solution need to be supersaturated in order to form crystals?

2. The concentration of a solution is the amount of dissolved substance (borax) in a given volume of solvent (in this case, water!). Was the borate solution more concentrated when it was cool or hot? Why?

3. Why was it necessary to put a pipe cleaner into the sodium tetraborate solution?

Lesson #3: Non-Messy Squishy Slime

Teacher Section

Overview: Sugar, water, and cornstarch by themselves are not very spectacular. Combine them together to observe something completely different. This chemical reaction creates a polymer that's really fun to play with. Two bonus polymer activities will keep students coming back for more.

Suggested Time: 30-45 minutes

Objectives: Students will see that when two or more substances are combined, a new substance may be formed that can have properties that are different from those of the original materials. In this experiment, students will create a polymer, or chain of molecules.

Materials (per lab group)

Part I: Squishy Slime	Part II: Messy Squishy Slime II	Part III: Messy Squishy Slime III
• 1 cup sugar • 3 cups cornstarch • 12 cups water • measuring cup • pan • heat source • spoon for stirring • food coloring • plastic baggie	• 1 tsp fiber (psyllium fiber like Metamucil) • 1 cup water • spoon • heat source • food coloring	• 1 cup cornstarch • 2 2/3 cups vegetable oil • spoon • balloon

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.

Background Lesson Reading

Chemical reactions happen when two or more molecules interact and change to form a new substance with different properties. There are several clues that a chemical change has occurred, including the following:

1. There is a formation of gas which is seen by a fizzing or bubbling.
2. Heat, light, or odor are produced.
3. A color change is produced.
4. A solid is formed.

A physical change, on the other hand, happens when a substance changes physical forms but still retains its original properties. Ice may be melted to water or heated until it steams, but it's still H_2O.

Sugar, water, and cornstarch are common household items that have very useful purposes. But when combined together, they create something completely different. The product of this chemical reaction is a gooey, slimy mess called a polymer. A polymer is a long chain of molecules that can be slippery, stretchy, and in this case very slimy. Some other polymers are Silly Putty, Jell-O, rubber bands, plastic, rubber, and even gum.

Lesson

1. Ask students what would happen if they mixed sugar into water (they'd get sugar water!). Ask, "Did I make something completely new when I made my sugar water? Or did the two things just mix together? (They mixed together but didn't really change.) Say, "I wonder if I could get my sugar back somehow?" (Allow for some discussion about possible ways to retrieve the sugar.).
2. Guide students to the fact that if they boiled the water out of the sugar or allowed it to evaporate, the sugar would be waiting for them on the bottom of the pan, still just as sugary. Say, "That would be an example of the physical change. The water and sugar temporarily mixed together, but it was still just water and just sugar. Nothing was really different about them."
3. Ask, "What about a chemical change? What do you think might happen when there is a chemical change?" Allow students to discuss in groups and come up with some ideas. Write "chemical change" on the board and underneath write any correct ideas they discover which could include color change, fizzing, heat, light, smell, explosions, or changing form (such as two liquids being mixed together to create a solid).
4. Say, "These are all very interesting chemical changes and we'll see one today. We're going to make a chemical reaction that will create something called a polymer."
5. Write "polymer" on the board. Explain that a polymer is a super-long chain of molecules that is kind of like a bowl of spaghetti. The long chains can slip and slide around and sometimes feel squishy. Say, "But don't take my word for it. Let's see if you can create your own polymer and decide for yourself what it's like."

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. **Squishy Slime:** Mix 1 cup sugar, 12 cups water, and 3 cups cornstarch in a saucepan. Stir constantly over medium heat until thickened, about 5 minutes. Place a glop in each of several bowls along with drops of food coloring. Place a dollop of each color into a plastic sandwich bag and zip it shut. Squish and squeeze without getting your hands slimy!
4. **Messy Squishy Slime II:** Mix one teaspoon fiber (psyllium fiber) with one cup cold water. (You can add food dye to of water if you'd like). Heat mixture (use a stove with adult help, or use a microwave for a few minutes) until it looks slimy. Stir once or twice while heating.
5. **Messy Squishy Slime III:** Mix 1 cup cornstarch and 2-2/3 cups cheap vegetable oil together, stirring to combine. Let sit for an hour (if it's a hot day, stick it in the fridge while you wait). Get a friend to rub a balloon on their head (to charge it up) as you slowly tip the slime to pour it into a second container. Bring the balloon close (but not touching) to the slime, and watch the slime react to the balloon! You'll either see the slime wiggle closer, gel up, or break off a piece, depending on the consistency of your slime!

Exercises

1. How could you make the polymer stretchier? (Answers will vary. Ex: add a sticky substance like glue, add more water)
2. Does the amount of cornstarch added change the slime? (Yes, it becomes drier.)
3. Why should the squishy slime polymer be stored in a Ziploc bag? (so it doesn't dry out)
4. Does the amount of water added to the polymer affect the gooeyness of the slime? (Yes, the more water, the gooier it becomes!)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #3: Non-Messy Squishy Slime

Student Worksheet

Name____

Overview: Sugar, water, and cornstarch by themselves are not very exciting, but combine them together and you'll find a gooey, goopy slime! This chemical reaction creates a polymer that's really fun to play with.

What to Learn: You should understand you are working with a chemical reaction, where you add two or more compounds together to get something completely different. You are making something called a polymer, which is an incredibly long chain of molecules.

Materials

Part I: Squishy Slime	**Part II: Messy Squishy Slime II**	**Part III: Messy Squishy Slime III**
• 1 cup sugar • 3 cups cornstarch • 12 cups water • measuring cup • pan • heat source • spoon for stirring • food coloring • plastic baggie	• 1 tsp fiber (psyllium fiber like Metamucil) • 1 cup water • spoon • heat source • food coloring	• 1 cup cornstarch • 2 2/3 cups vegetable oil • spoon • balloon

Lab Time

1. **Squishy Slime:** Mix 1 cup sugar, 12 cups water, and 3 cups cornstarch in a saucepan. Stir constantly over medium heat until thickened, about 5 minutes. Place a glop in each of several bowls along with drops of food coloring. Place a dollop of each color into a plastic sandwich bag and zip it shut. Squish and squeeze without getting your hands slimy!

2. **Messy Squishy Slime II:** Mix one teaspoon fiber (psyllium fiber like Metamucuil) with one cup cold water. (You can add food dye to of water if you'd like.) Heat mixture (use a stove with adult help, or use a microwave for a few minutes) until it looks slimy. Stir once or twice while heating.

3. **Messy Squishy Slime III:** Mix 1 cup cornstarch and 2-2/3 cups cheap vegetable oil together, stirring to combine. Let sit for an hour (if it's a hot day, stick it in the fridge while you wait). Get a friend to rub a balloon on their head (to charge it up) as you slowly tip the slime to pour it into a second container. Bring the balloon close (but not touching) to the slime, and watch the slime react to the balloon! You'll either see the slime wiggle closer, gel up, or break off a piece, depending on the consistency of your slime!

Non-Messy Squishy Slime Observations

Experiment	**Observations** **(Tell about EVERYTHING you see, feel, and hear!)**
Squishy Slime	
Messy Squishy Slime II	
Messy Squishy Slime III	

Exercises Answer the questions below:

1. How could you make the polymer stretchier?

2. Does the amount of cornstarch added change the slime?

3. Why should the squishy slime polymer be stored in a Ziploc bag?

4. Does the amount of water added to the polymer affect the gooeyness of the slime?

Lesson #4: Moon Sand

Teacher Section

Overview: Moon sand is basically clay with a beach twist. Moon sand adds the best properties of clay to the sand for a moldable, sandy texture that's easy to work with, and demonstrates what a non-Newtonian fluid looks and feels like!

Suggested Time: 30-45 minutes

Objectives: Students will experiment with corn starch, water, and sand to create substances with different properties, including a non-Newtonian fluid, which changes viscosity.

Materials (per lab group)

- cornstarch
- water
- sand
- measuring cups and spoons
- popsicle stick for stirring
- food dye (optional)

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.
5. Note: This class is best done outdoors!

Background Lesson Reading

A non-Newtonian fluid is a substance that changes viscosity, such as ketchup. Ever notice how ketchup sticks to the bottom of the bottle one minute and comes sliding out the next?

Think of *viscosity* as the resistance stuff has to being smeared around. Water is "thin" (low viscosity); honey is "thick" (high viscosity). You are about to make a substance that is both low and high viscosity, depending on what ratio you mix up. Feel free to mix up a larger batch than indicated in the video – we've heard from families who have mixed up an entire kiddie pool of this stuff!

Moon sand is basically clay with a beach twist. If you've ever tried making a sand castle, you know the disappointment of having the structure crumble after hours of work. Moon sand adds the best properties of clay to the sand for a moldable, sandy texture that's easy to work with — and it's dirt cheap to mix up your weight in moon sand.

The students' task is to find the perfect ratio of the three ingredients to make this weird substance. If they have too much water, they'll get a substance that is both a liquid and a solid. If there is too much solid, it crumbles.

Lesson

1. Say, "I am going to tell you two different foods, and I want you to quickly tell me one difference between them. Here they are: ketchup and water" (students may say the answer you're going for, which is thick and thin, or they may come up with something different!). Try again with two other foods, possibly gravy and apple juice or syrup and coffee.
2. Explain that all of these foods are liquids, but have different thicknesses. Explain that viscosity is the resistance stuff has to being smeared around. Water is "thin," which means it has low viscosity; honey is "thick," meaning it has high viscosity.
3. Ask students, "Have you ever noticed how ketchup sticks to the bottom of the bottle one minute and comes sliding out the next? Explain this means ketchup is a non-Newtonian fluid, or a substance that changes viscosity. It may be thick or thin all at once. Say, "How in the world is this possible? We'd better find out!"

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. In a cup or bowl, mix together one scoop of corn starch and one scoop of sand.
4. In another cup, add ½ scoop of water and a few drops of food coloring
5. Add the liquids into the solids and stir with a stick or your hands. It may be necessary to add a few drops of water. Mix thoroughly until the mixture feels like clay.
6. Experiment with different amounts of corn starch, clay, or water to make moon sand with different properties!

Troubleshooting: The smaller the grain of sand, the easier it is to form intricate shapes. White sand will make better colors when food dye is added to the mixture. Use a large enough bowl and try to keep one hand clean so you can add more (of whatever you need) as you go along. The ideal mixture is approximately 2 cups sand, 2 cups cornstarch, and 1 cup water, give or take a bit. Notice how adding just a small amount of water turns it into a liquid, and adding a tiny bit more cornstarch (or sand) makes it crumble as if it were solid? Take your time to get this mixture *just* right.

Exercises

1. Name a substance that is very viscous. (Answers may vary. The correct answer will be something thick like syrup or gravy)
2. Why is moon sand called a non-Newtonian fluid? (its viscosity changes)
3. What can you add to corn starch to make it more viscous? (water)
4. If you were going to make gravy and needed it to be thicker, what could you add to it? (corn starch)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #4: Moon Sand

Student Worksheet

Name____

Overview: Moon sand is basically clay with a beach twist. If you've ever tried making a sand castle, you know the disappointment of having the structure crumble after hours of work. Moon sand adds the best properties of clay to the sand for a moldable, sandy texture that's easy to work with, and shows you firsthand what a non-Newtonian fluid looks and feels like!

What to Learn: After today's lesson, you'll know a bit about non-Newtonian fluids and viscosity and how to play with an experiment to get different results.

Materials

- cornstarch
- water
- sand
- measuring cups/spoons, depending on how much moon sand is desired
- Popsicle stick or other stirring apparatus
- food dye (optional)

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. In a cup or bowl, mix together one scoop of corn starch and one scoop of sand.
3. In another cup, add ½ scoop of water and a few drops of food coloring
4. Add the liquids into the solids and stir with a stick or your hands. It may be necessary to add a few drops of water. Mix thoroughly until the mixture feels like clay.
5. Experiment with different amounts of corn starch, clay, or water to make moon sand with different properties!

Troubleshooting: The smaller the grain of sand, the easier it is to form intricate shapes. White sand will make better colors when food dye is added to the mixture. Use a large enough bowl and try to keep one hand clean so you can add more (of whatever you need) as you go along. The ideal mixture is approximately 2 cups sand, 2 cups cornstarch, and 1 cup water, give or take a bit. Notice how adding just a small amount of water turns it into a liquid, and adding a tiny bit more cornstarch (or sand) makes it crumble as if it were solid? Take your time to get this mixture *just* right.

Moon Sand Data Table

Once you have made your moon sand, experiment with adding more of each substance. Record your results on the following chart.

Added Material	Observations	More or Less Viscous?
Cornstarch		
Water		
Sand		

Exercises Answer the questions below:

1. Name a substance that is very viscous.
2. Why is moon sand called a non-Newtonian fluid?
3. What can you add to corn starch to make it more viscous?
4. If you were going to make gravy and needed it to be thicker, what could you add to it?

Lesson #5: Rubber Eggs

Teacher Section

Overview: Students will discover what happens to the shell of a hard-boiled egg when they soak it in a glass of vinegar.

Suggested Time: 30-45 minutes

Objectives: Students will understand that properties of substances can change when the substances are mixed and that a chemical reaction can be detected by the formation of a gas.

Materials (per lab group)

- hard-boiled egg
- glass or clean jar
- distilled white vinegar
- Optional: regular egg
- Optional: chicken bones

Lab Preparation

1. Hard boil enough eggs for each lab group
2. Assemble items above and have them ready for each lab group.
3. Print out copies of the student worksheets.
4. Read over the Background Lesson Reading before teaching this class.
5. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

If you soak chicken bones in acetic acid, or distilled vinegar, you'll get rubbery bones that are soft and pliable because the vinegar reacts with the calcium in the bones. This happens with older folks when they lose more calcium than they can replace in their bones, making the bones brittle and easier to break. Scientists have discovered calcium is replaced more quickly in bodies that exercise and eat calcium-rich foods, like green vegetables.

Egg shells are also made up of calcium in the form of calcium carbonate ($CaCO_3$). This organic compound is also found in limestone, chalk, marble, and coral. It is classified as a base, with a pH below 7.

Vinegar contains acetic acid. Acetic acid is what gives vinegar its awful taste. It's classified as an acid, with a pH above 7.

As calcium carbonate reacts with the vinegar, and the egg shell dissolves, a chemical change occurs and carbon dioxide gas is released in the form of bubbles. These can be clearly seen as the egg shell dissolves. You will also smell vinegar when the bubbles occur, but vinegar is not being given off by the chemical reaction. Vinegar has a very low surface tension, which makes that stink go everywhere.

Lesson

1. Hold up a hard-boiled egg and ask students to predict what will happen if you drop it (you'll hear a "thud" and the shell will crack). If you have an extra egg, demonstrate this. Ask if anyone has a guess as to what the shell is made of. Allow several students to hazard a guess then tell them it has calcium, just like in bones. Say, "Actually, the calcium is part of a compound called calcium carbonate, which is also found in limestone, chalk, marble, and coral. Calcium carbonate is a base.
2. Hold up the bottle of white vinegar. Ask students if they have ever seen or smelled vinegar and what its uses are (answers may vary, but vinegar may be used for cooking, cleaning, gardening, health, and many other things). Allow them to take a quick whiff if they've never smelled it before. Say, "Vinegar is also called acetic acid."
3. Explain that acids and bases, such as acetic acid and calcium carbonate, combine to form a chemical reaction. There are many ways to determine if a chemical reaction is happening, but one way is the formation of a gas. Ask, "How can we tell if a gas forms in a liquid? What might you see?" (bubbles) Explain that in today's experiment, they will witness the effect of acetic acid on the calcium carbonate of an egg, and what an interesting effect it is!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Place a hard-boiled egg into a glass or jar. Fill with enough vinegar to cover the egg and leave alone for 24 hours.
4. If doing this experiment with regular eggs or chicken bones, put each in a separate container and cover with vinegar. Let sit for 24 hours. Check again after 48 hours.

Exercises

1. Describe what the eggshell looked like before the reaction. (Answers may vary but should include details such as color, thickness of shell, what type of surface the shell has, etc.)
2. Describe the acetic acid (answers may vary but should include details such as color, viscosity, smell).
3. The product you witnessed in this chemical reaction was carbon dioxide, a colorless, odorless gas. How can you tell there really was a chemical reaction? (Bubbles formed.)
4. Why did the egg turn to "rubber?" (The vinegar dissolved the calcium of the egg.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #5: Rubber Eggs

Student Worksheet

Name____

Overview: Did you ever think it would be OK to bounce an egg? In science class, anything is possible! Learn how in today's experiment.

What to Learn: After this bouncy experiment, you'll know one way to spot a chemical reaction. You'll also see how solid calcium carbonate and stinky liquid vinegar can combine to produce carbon dioxide gas.

Materials

- hard-boiled egg
- glass or clean jar
- distilled white vinegar
- Optional: regular egg
- Optional: chicken bones

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Place a hard-boiled egg into a glass or jar. Fill with enough vinegar to cover the egg and leave alone for 24 hours.
3. If doing this experiment with regular eggs or chicken bones, put each in a separate container and cover with vinegar. Let sit for 24 hours. Check again after 48 hours.

Rubber Egg Data Table

Item/Object	Detailed Description of Results after 24 hours *(for hard-boiled egg ONLY, include approximately how high it bounced)*	Detailed Description of Results after 48 hours *(for hard-boiled egg ONLY, include approximately how high it bounced)*
Hard Boiled Egg		
Regular Egg (optional)		
Chicken bones (optional)		

Exercises Answer the questions below:

1. Describe what the eggshell looked like before the reaction.

2. Describe the acetic acid

3. The product you witnessed in this chemical reaction was carbon dioxide, a colorless, odorless gas. How can you tell there really was a chemical reaction?

4. Why did the egg turn to “rubber?”

Lesson #6: Microwaving Soap

Teacher Section

This is a homework lab for your students to do on their own. You can demonstrate this lab using the guidelines below and then send them off to complete their Student Worksheet on their own time.

Overview: When you warm up leftovers, have you ever wondered why the microwave heats the food and not the plate? (Well, some plates, anyway.) It has to do with the way microwaves work. Microwaves generate high energy electromagnetic waves that, when aimed at water molecules, make these molecules get super-excited and start bouncing around a lot. Which is why it's dangerous to heat anything not containing water in your microwave, as there's nowhere for that energy to go, since the electromagnetic radiation is tuned to excite water molecules.

Suggested Time: 30-45 minutes

Objectives: Light you can see (visible light like a rainbow) makes up only a tiny bit of the entire electromagnetic spectrum.

Materials (per lab group)

- bar of Ivory Soap
- microwave (not a new or expensive one)
- plate

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Microwaves generate high-energy electromagnetic waves that, when aimed at water molecules, make these molecules get super-excited and start bouncing around a lot.

We see this happen when we heat water in a pot on the stove. When you add energy to the pot (by turning on the stove), the water molecules start vibrating and moving around faster and faster the more heat you add. Eventually, when the pot of water boils, the top layer of molecules are so excited they vibrate free and float up as steam.

When you add more energy to the water molecule, either by using your stove top or your nearest microwave, you cause those water molecules to vibrate faster. We detect these faster vibrations by measuring an increase in the temperature of the water molecules (or in the food containing water). Which is why it's dangerous to heat anything not containing water in your microwave, as there's nowhere for that energy to go, since the electromagnetic radiation is tuned to excite water molecules.

This following experiment is a quick example of this principle using a naked bar of Ivory soap. The trick is to use Ivory, which contains an unusually high amount of air. Since air contains water moisture, Ivory also has water hidden inside the bar of soap. The microwave will excite the water molecules and your kids will never look at the soap the same way again.

Note: Scientists refer to 'light' as the visible part of the electromagnetic spectrum, where radio and microwaves are lower energy and frequency than light (and the height of the wave can be the size of a football field). Gamma rays and X-rays are higher energy and frequency than light (these tend to pass through mirrors rather than bounce off them).

Lesson

1. Say, "I have a question. Does anybody have any idea how a microwave actually works?" (Students may have a number of different ideas. Let them guess!) After they share, say "Let's first think about light. Some light we can see, like rainbows or lasers. But are there lights we cannot see? Can you see the light that goes from the end of the remote control to the TV? (no) How about the light from the sun that gives you a sunburn? (no) Oh, so some light is invisible. That's the kind of light a microwave shoots off. A microwave puts out invisible lights called electromagnetic waves, and they heat up water molecules. But what about my muffin I heated this morning? That wasn't water and it still got hot. What happened there? What must be in my muffin? (The muffin, and other foods, all contain tiny water molecules that the microwave can excite.)
2. Say, "Let's think about what is happening in the teeny tiny atoms of the food we heat in our microwave. Many things we heat are solids. What does that mean? (It takes a certain shape and doesn't change.) Even though we can't see them, inside the solid are little atoms wiggling and jiggling and vibrating all around. But they can't go far unless we do something. When we add heat, what happens to the little atoms? (They move faster.) What do you think could happen to little molecules of water that are trapped in the food? Tell your partner what you think." Allow pairs to discuss and then discuss as a large group. Lead students to understand that the molecules of water heat up and eventually turn to steam.
3. Explain that Ivory soap has more water whipped into it than other soaps, so it's really good for heating up to see what happens to the water molecules. In fact, that's what you're ready to do now!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Open the microwave.
4. Unwrap the bar of Ivory and place it on the plate (be sure it's glass or ceramic).
5. Set the time for 2-3 minutes.
6. Watch it very closely and remove it when it reaches its maximum volume (when it stops expanding).
7. NOTE: the soap may be hot after the experiment, so please be careful! Allow it to cool for a few minutes prior to touching it.
8. You can even use the soap after you're done.

Exercises

1. Now that you have observed this experiment, explain in your own words how microwaves work. (They send out invisible lights called electromagnetic waves which excite water molecules in foods, making them vibrate and heat up)

2. What might happen if you put something in the microwave that doesn't have any water in it? (it would be dangerous, since there would be nowhere for all that energy to go. It could break the microwave, or even start a fire)
3. Name three types of light waves you cannot see (Answers will vary, including sunlight, microwaves, X-rays, radio waves.)
4. What has more energy: ice, water, or steam? (steam)What happens to the water molecules as they get heated up? (They vibrate more and more.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #6: Microwaving Soap

Student Worksheet

Name____

Overview: When you warm up leftovers, have you ever wondered why the microwave heats the food and not the plate? (Well, some plates, anyway.) It has to do with the way microwaves work. Microwaves generate high energy electromagnetic waves that, when aimed at water molecules, make these molecules get super-excited and start bouncing around a lot. Which is why it's dangerous to heat anything not containing water in your microwave, as there's nowhere for that energy to go, since the electromagnetic radiation is tuned to excite water molecules.

What to Learn: Light you can see (visible light like a rainbow) makes up only a tiny bit of the entire electromagnetic spectrum. Microwaves emit "microwaves" that are lower-frequency, lower-energy waves than visible light, but are higher-energy, higher-frequency than radio waves. The soap in this experiment below will show you how a bar of Ivory soap contains air, and that air contains water vapor which will get heated by the microwave radiation and expand.

Materials

- 3 Ivory soap bars
- microwave (not a new or expensive one)
- plate

Lab Time

1. Open the microwave.
2. Unwrap the bar of Ivory soap and place it on the plate (be sure it's glass or ceramic).
3. Set the time for 2-3 minutes.
4. Watch it very closely and remove it when it reaches its maximum volume (when it stops expanding).
5. NOTE: the soap may be hot after the experiment, so please be careful! Allow it to cool for a few minutes prior to touching it.
6. You can even use the soap after you're done.
7. After you have done your experiment once, design an experiment to test a question you have about Ivory soap. This experiment should be designed to answer a specific question, and you'll make a guess (called a hypothesis) as to how things will turn out. After making a guess, perform the experiment and write down what you observed happen. In the last column of your data table, you'll write what you conclude. The first one has been done as an example for you. The question that the sample is answering is: *How does soap bar volume affect how much it puffs up?* You can test all sorts of questions, from what happens if you put more than one bar of soap in, to what if you use lower power for longer, to what if you chill the bar in the freezer overnight first? The questions are endless. Have fun!

Microwaving Soap Data Table

Hypothesis	Experiment	Observation	Conclusion
Half a bar of soap will only puff just as big as a whole bar.	*Put half a bar of soap in microwave for 2.5 minutes and a whole bar in for 2.5 minutes and compare.*	*When compared, the half bar puffed up more than the whole bar!*	*There might be less mass to move out of the way, so the bar puffs up more easily. Needs more testing. Maybe test a quarter of a bar next?*

Exercises Answer the questions below:

1. Now that you have done this experiment, explain in your own words how microwaves work.

2. What might happen if you put something in the microwave that doesn't have any water in it?

3. Name three types of light waves you cannot see

4. What has more energy: ice, water, or steam? What happens to the water molecules as they get heated up?

Lesson #7: Salty Eggs

Teacher Section

Overview: Why is it easier to float in the ocean than a swimming pool? Students will learn the answer using an egg, a glass of water, and some salt.

Suggested Time: 30-45 minutes

Objectives: Students will understand that salt can affect the density of water.

Materials (per lab group)

- hard-boiled egg
- glass
- water
- salt

Lab Preparation

1. Hard-boil enough eggs for each lab group
2. Assemble items above and have them ready for each lab group.
3. Print out copies of the student worksheets.
4. Read over the Background Lesson Reading before teaching this class.
5. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Did you know that most people can't crack an egg with only one hand without whacking it on something? The shell of an egg is quite strong! Challenge your students to try this at home over a sink and see if they can figure out the secret to cracking an egg in the palm of their hand.

How can you tell if an egg is cooked or raw? Simply spin it on the counter and you'll get a quick physics lesson in inertia…although you might not know it. A raw egg is slushy inside, and will spin slow and wobbly. A cooked egg is all one solid chunk, so it spins quickly.

This experiment is all about density. Density is basically how tightly packed atoms are. Mathematically, density is mass divided by volume. In other words, it is how heavy something is, divided by how much space it takes up. If you think about atoms as marbles, then something is denser if its marbles are jammed close together.

For example, take a golf ball and a ping pong ball. Both are about the same size or, in other words, take up the same volume. However, one is much heavier, has more mass, than the other. The golf ball has its atoms much more closely packed together than the ping pong ball and as such the golf ball is denser.

Here's a riddle: Which is heavier, a pound of bricks or a pound of feathers? Well, they both weigh a pound so neither one is heavier! Now, take a look at it this way: Which is denser, a pound of bricks or a pound of feathers? Aha! The pound of bricks is much denser since it takes up much less space. The bricks and the feathers weigh the same but the bricks take up a much smaller volume. The atoms in a brick are much more squished together than the atoms in the feathers.

Have you ever noticed how it is easier to float in the ocean than the lake? If so, then you already know how salt can affect the density of the water. Saltwater is more dense that regular water, and body tissues contains plenty of water, among other things.

Did you know that thinner people are denser than heavier people? For example, championship swimmers will sink and have to work harder to stay afloat, but the couch potato next door will float more easily in the water.

Lesson

1. Begin today's lesson by discussing student's experiences at the ocean versus a swimming pool. If some students have had the experience of swimming in warm salt water, they may remember how much easier this is!
2. Ask, "Why do you think this is? Why is it easier to swim at the ocean than a pool?" (It is salty.) Say, "OK, why does the salt matter? What does it do?"Allow students to discuss in pairs. Don't give them the answer yet but let them know they will find out in today's experiment.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Place a hard-boiled egg in a glass of water (it should sink!)
4. Add a spoonful of salt and stir.
5. Repeat until the egg rises up from the bottom. You may need to wait for the cloudy saltwater to settle in order to see clearly.
6. Experiment further by adding a little water until the egg sinks again. It is possible to make the egg hover in the middle of the cup. This is called the equilibrium point!

Exercises

1. Density measures how tightly packed atoms and molecules are. If you add two substances together, will the denser substance stay on top or sink to the bottom? (sink to the bottom)
2. When the egg was placed in the fresh water, what happened? What was denser, the water or the egg? What was less dense? (The egg sank. The egg was more dense and the water less dense.)
3. When the water got salty enough, what did you observe? What was denser, the salty water or the egg? What was less dense? (The egg floated. The salt water was more dense, and the egg less dense.)
4. Based on your observations, which is denser: salt water or regular water? How do you know? (Since the egg floated only when salt was added, it means the denser salt water must have sunk to the bottom of the container, allowing the egg to float.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #7: Salty Eggs

Student Worksheet

Name____

Overview: Have you ever noticed how much easier it is to float in the ocean than a swimming pool? Why is this? You will discover the answer using an egg, a glass of water, and some salt.

What to Learn: After today you'll know how salt changes the density of water, which affects your ability (and your egg's ability!) to swim in it.

Materials

- hard-boiled egg
- glass
- water
- salt

Lab Time

1. Place a hard-boiled egg in a glass of water (it should sink!)
2. Add a spoonful of salt and stir.
3. Repeat until the egg rises up from the bottom. You may need to wait for the cloudy saltwater to settle in order to see clearly.
4. Experiment further by adding a little water until the egg sinks again. It is possible to make the egg hover in the middle of the cup. This is called the equilibrium point!

Exercises Answer the questions below:

1. Density measures how tightly packed atoms and molecules are. If you add two substances together, will the denser substance stay on top or sink to the bottom?

2. When the egg was placed in the fresh water, what happened? What was denser, the water or the egg? What was less dense?

3. When the water got salty enough, what did you observe? What was denser, the salty water or the egg? What was less dense?

4. Based on your observations, which is denser: salt water or regular water? How do you know?

Lesson #8: Quick and Easy Density

Teacher Section

Overview: Students will do two quick experiments in order to better understand density. One will show the density of different household items, and the other demonstrates the difference in density between hot and cold water.

Suggested Time: 30-45 minutes

Objectives: Students will understand that the denser something is, the tighter its atoms are packed together.

Materials (per lab group)

- large glass jar
- water
- vegetable oil
- liquid dish soap (colored, if possible)
- honey
- corn syrup
- molasses
- rubbing alcohol
- two water bottles
- hot water
- cold water
- red and blue food coloring
- index card or other thick, heavy paper

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.
5. This lab is best done outside (at least for part 2).

Background Lesson Reading

Density is basically how tightly packed atoms are. Mathematically, density is mass divided by volume. If an object has a mass of 20 grams and a volume of 10 milliliters, its density is 20÷10, or 2g/mL. For example, take a golf ball and a ping pong ball. Both are about the same size or, in other words, take up the same volume. However, one is much heavier, meaning it has more mass than the other. The golf ball has its atoms much more closely packed together than the ping pong ball and as such the golf ball is denser. This property can be used in creating a "density jar." A substance that is denser will float to the bottom of a container, while a less dense one will stay near the top.

Lesson

1. Bring out a bunch of different balls (golf, ping pong, whiffle, tennis, bouncy balls, plastic balls….whatever you have on hand) and a bucket of water. Allow students to guess whether each ball will sink or float as you carefully place each into the water. Optional: have a bucket of salt water as well, and see if there is a difference!
2. Tell students that apart from being a fun guessing game, this demonstrates a very important idea in chemistry called density. Ask students to spread themselves throughout the room, and think about how close they are to their friends. Now, change the boundaries to a rug or other smaller area. Ask what feels different (they are more closely packed together). Now, have them get so close together that they can hardly wiggle. Say, "Wow, you are really squished in tightly. I might say you have more density than you did when you were spread all over the room."
3. After students sit down again, explain that density is a measure of how tightly packed atoms are in a molecule. Say, "If the atoms are very tightly packed, it has a greater density. If they are less packed, like you were when you were all over the room, it is less dense."
4. Explain that in today's experiment, they will use more or less dense materials to create a jar full of different layers. Say, "Remember all the balls we dropped into the water? Name a ball that was more dense than the water (answers will vary, but it should be one of the balls that sunk). Good, now how about a ball that is less dense than water? (Again, answers will vary but the ball should float on the water if it is less dense.) OK, so we can see that one ball has its atoms packed tighter than the water, and in the other ball, the atoms were more loosely packed. Let's use that idea of density to create a density jar."

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.

Part I

3. Add a layer of honey to the bottom of a glass jar.
4. Gently add a layer of molasses.
5. Add a layer of soap.
6. Use food coloring to color the water, then add it to the jar.
7. Add a layer of oil.
8. Add a layer of alcohol.

Part II

9. Get out two identical water bottles. Fill one to the brim with warm-hot water. Add 1-2 drops red food coloring.
10. Fill the second bottle with cold water. Add 1-2 drops blue food coloring. Notice how the food coloring flows in the two different temperatures.

11. Place a thick sheet of heavy paper (such as an index card) and use it to cap the blue bottle. Very quickly invert the bottle and stack it mouth-to-mouth with the red bottle. This is the tricky part: When the bottles are carefully lined up, remove the card. Is it different if you invert the red bottle over the blue?

Exercises

1. What material had the highest density? How do you know? (If you used the materials suggested, it was the honey. If not, whatever layer was on the bottom.)
2. What liquid was the least dense? How do you know? (Again, answers may vary according to what materials were used, but alcohol was the least dense of the materials suggested. It should have ended up at the top).
3. What did you observe in the experiment using cold water and hot water? In which one did the food coloring move faster? Why was this? (It moved faster in the hot water, because the water molecules were less dense).
4. What did you observe when you flipped the two jars on top of each other? (answers will vary)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #8: Quick and Easy Density

Student Worksheet

Name____

Overview: Today you'll get to make a layered, colorful density jar and watch some fun effects of hot and cold water. Both will allow you to play while learning about density!

What to Learn: You should know that density means how tightly atoms are packed together in a substance.

Materials

- large glass jar
- water
- vegetable oil
- liquid dish soap (colored if possible)
- honey
- corn syrup
- molasses
- rubbing alcohol
- two identical glasses or jars
- hot water
- cold water
- red and blue food coloring
- index card or other thick, heavy paper

Lab Time

Part I

1. Wear your gloves and put your goggles on. No exceptions!
2. Add a layer of honey to the bottom of a glass jar.
3. Gently add a layer of molasses.
4. Add a layer of soap.
5. Use food coloring to color the water, then add it to the jar.
6. Add a layer of oil.
7. Add a layer of alcohol.

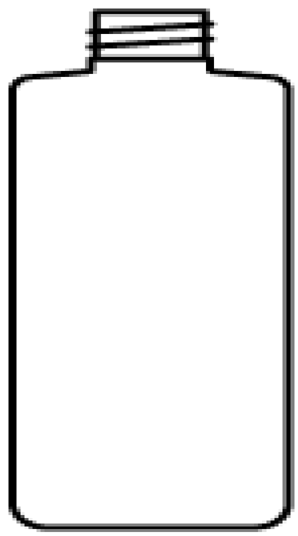
Part II

12. Get out two identical water bottles. Fill one to the brim with warm-hot water. Add 1-2 drops red food coloring.
13. Fill the second bottle with cold water. Add 1-2 drops blue food coloring. Notice how the food coloring flows in the two different temperatures.

14. Place a thick sheet of heavy paper (such as an index card) and use it to cap the blue bottle. Very quickly invert the bottle and stack it mouth-to-mouth with the red bottle. This is the tricky part: When the bottles are carefully lined up, remove the card. Is it different if you invert the red bottle over the blue?

Quick and Easy Density Illustration

Draw, color, and label the layers in your density jar. Label the material with the lowest density and the one with the highest density.



Exercises Answer the questions below:

1. What material had the highest density? How do you know?

2. What liquid was the least dense? How do you know?

3. What did you observe in the experiment using cold water and hot water? In which one did the food coloring move faster? Why was this?

4. What did you observe when you flipped the two jars on top of each other?

Lesson #9: Lava Lamp

Teacher Section

Overview: Students will watch how density works by making a simple lava lamp that doesn't need electricity!

Suggested Time: 30-45 minutes

Objectives: Students will understand that density is a measure of how tightly molecules are packed into a certain space.

Materials (per lab group)

- empty glass jar with straight sides or clean 2 liter soda bottle
- vegetable oil
- salt
- water
- food dye

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Everything is made up of molecules. Density is the measure of how tightly the molecules are packed together in a solid object, liquid or gas. With some materials, such as liquids and gases, the density can be changed. With solid objects, the density can't be changed.

Oil and water are chemically very different from one another. Oil is made up of very long molecules that do not attract other molecules well. Water usually bonds well with other molecules due to its short molecules with positively and negatively charged ends that are very anxious to bond with something, almost anything. Also, oil molecules are very large and water molecules are very small. These differences are the main reasons that oil and water don't mix.

Water birds like ducks and geese are covered with feathers that soak up water like a sponge, but they can swim around in water and not drown. How is that possible? The birds have a gland on their bodies that contains oil. The birds use their beaks to transfer this oil to the feathers that will come in contact with the water. Since water and oil don't mix, the oil makes a barrier that keeps the water off the feathers.

Oil is slippery because of two main reasons. First, oil molecules are long and large. They do not bond easily with anything because they are satisfied with themselves the way they are…not looking for any company, no friends. Secondly, oil molecules have a very high surface tension. It is hard for most substances to break the surface tension of oil, so oil slides around instead of grabbing hold of anything because it….well, it just wants to be alone.

In today's experiment, students will actually be watching the salt itself fall through the oil. However, the oil sticks to the salt to form a larger object. Since the salt is heavier than water, the whole glob sinks to the bottom of the glass. At the bottom of your cup, the oil eventually breaks free of the salt and rises back up.

Lesson

1. Hold up a tissue box full of tissues. Say, "Imagine all these tissues are molecules. I have a certain number of molecules contained in this tissue box. Now, let's say I take some out (remove a handful of tissues). I have the same space, but fewer molecules. My box is now less dense." Give them a moment, then ask, "What if I cram a lot more tissues back in this box?" (It becomes more dense.)
2. Now, ask them to think about two identical backpacks. One backpack has a few papers in it, and one is full of library books. Discuss in pairs which one is more dense and ask students to come up with their own definition of density (The technical definition is mass per unit volume, but their answers will be more student-friendly, such as, "How much you can cram in a certain space?").
3. Say, "OK, here's a third example. Pretend we have a huge swimming pool in the middle of our classroom. What would happen if I threw in a desk? (It would sink.) Why? Is it more dense or less dense than the water?" (more dense) Ask, "What about a piece of Styrofoam? Will it sink or float? (float) So, is it more dense or less dense than water?" (less dense)
4. Ask students if they have ever tried to mix oil and water. Ask what happened (They don't mix!). Ask if anyone has any idea why, and guide answers using the background reading as a resource. Make the following points: Water molecules are small and love to bond, or attach to other molecules; and oil molecules are long, large, and have high surface tension. The two have nothing in common, so they don't mix.
5. Explain that students will use all these differences to make a lava lamp today.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Fill the container halfway with water.
4. Add a layer of oil (fill about 1/3 of the way). Observe the water and oil.
5. Sprinkle salt on top and observe. Salt will combine with the oil and drop down to the bottom. Eventually the oil will break free of the salt and float back to the top
6. Keep sprinkling salt on top.
7. Add food coloring and observe.

Exercises

1. What happened when you mixed the water and oil? (They didn't mix.) Which one was on top? (oil)
2. What is denser: water or oil? How do you know? (water, because it sank to the bottom)
3. Fill in the blanks to determine what happened: When I sprinkled salt on the oil and water mixture, the salt combined with the ____(oil)________ and dropped to the bottom of the container. Eventually the ____(oil)_____ broke free and floated to the top, while the ______(salt)______ stayed at the bottom.
4. What did the food coloring mix with? The oil or the water? (water) Based on what you learned about the differences between oil and water, does this make sense? (Yes, water easily makes bonds, while oil doesn't.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #9: Lava Lamp

Student Worksheet

Name____

Overview: We're going to watch how density works by making a simple lava lamp that doesn't need electricity! If you like to watch blob-type shapes shift and ooze around, then this is something you're going to want to experiment with.

What to Learn: After today's experiment, you'll understand what density is, and know some cool facts about the differences between oil and water

Materials

- empty glass jar with straight sides or clean 2 liter soda bottle
- vegetable oil
- salt
- water
- food dye

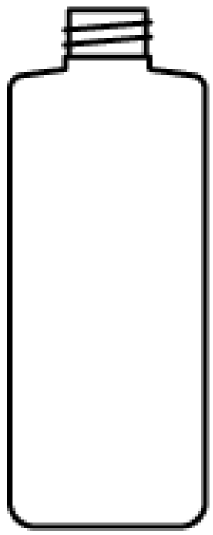
Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Fill the container halfway with water
3. Add a layer of oil (fill about 1/3 of the way). Observe the water and oil.
4. Sprinkle salt on top and observe. Salt will combine with the oil and drop down to the bottom. Eventually the oil will break free of the salt and float back to the top.
5. Keep sprinkling salt on top.
6. Add food coloring and observe.

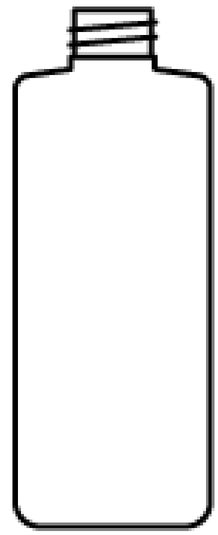
Lava Lamp Illustration

Label on the diagram:

1. Water
2. Oil



Use the following diagram to show what happens when salt is added:



Exercises Answer the questions below:

1. What happened when you mixed the water and oil? Which one was on top?

2. What is denser: water or oil? How do you know?

3. Fill in the blanks to determine what happened: When I sprinkled salt on the oil and water mixture, the salt combined with the ________________and dropped to the bottom of the container. Eventually the ________________ broke free and floated to the top, while the ________________ stayed at the bottom.

4. What did the food coloring mix with? The oil or the water? Based on what you learned about the differences between oil and water, does this make sense?

Lesson #10: Penny Crystal Structure

Teacher Section

Overview: Students will use pennies to see the molecular structure of water when it freezes into ice.

Suggested Time: 20-30 minutes

Objectives: Students will demonstrate knowledge of the structure of atoms and molecules in liquids and solids, and understand what cleavage is in a solid.

Materials (per lab group)

- 50 pennies
- ruler

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Imagine a bunch of folks all stuck to one another by big rubber bands. Each person can wiggle and jiggle but they can't really move anywhere. Atoms in a solid are the same way. Each atom can wiggle and jiggle, but they are stuck together. In science, we say that the molecules have strong bonds between them. Bonds are a way of describing how atoms and molecules are stuck together.

There's nothing physical that actually holds them together (like a tiny rope or something). Like the Earth and Moon are stuck together by gravity forces, atoms and molecules are held together by nuclear and electromagnetic forces. Since the atoms and molecules are so close together, they will often form crystals.

The molecules are pulled so close to one another that they will form patterns, also known as matrices. These patterns are very dependent on the shape of the molecule, so different molecules have a tendency to form different shaped crystals. Salt has a tendency to form a cube shape. Go take a look… and you'll find that they are like little blocks!

Water has a tendency to from triangle or hexagon shapes, which is why snowflakes have six sides. The pennies in this experiment also form a hexagon shape. Solids don't always form crystals, but they are more common than one may think. A solid that's not in a crystalline form is called amorphous.

In this experiment, the penny "crystal" will split in quite a straight line. This is called cleavage. Since crystals form similar patterns, they will tend to break in the same way the pennies break.

Break an ice cube and take a look. You may see many straight sections. This is because the ice molecules "cleave" according to how they formed. The reason you can write with a pencil is due to this concept. The pencil is formed of graphite crystal. The graphite crystal cleaves fairly easily and allows your students to write down their amazing physics discoveries!

Lesson

1. Imagine with your students you are all at a beautiful, open park with lots of room to run and play. Everyone can move in any direction at any time and chances are that nobody will even touch anyone else. Explain this is what it's like to be a molecule of gas.
2. Now, imagine that the park ranger comes and closes off all the grass area because it needs to be mowed. Everyone has to move to the playground area. There's still room to move and play, but there's less room. And they have to stay in the boundaries. Say, "Now you are all molecules in a liquid."
3. Imagine once again that a flash flood comes to the park, and everyone has to move to the one area up high: a platform on the play structure. Now, everyone is stuck together, so tightly packed they can't move much and can't go anywhere. At this moment, they have become a solid.
4. Say, "Atoms in a solid are the same way. Each atom can wiggle and jiggle, but they are stuck together. In science, we say that the molecules have strong bonds between them. Bonds are a way of describing how atoms and molecules are stuck together." Explain that some molecules are shaped in certain ways that cause them for form patterns when they stick together.
5. Salt forms a cube shape (allow students to look at a sample through a magnifying glass if you have one!). Ask, "How many sides does a snowflake usually have?" (six). "I wonder what shape water makes when in freezes?" Direct students to discuss this in pairs, then share as a class. (Water has a tendency to from triangle or hexagon shapes, which is why snowflakes have six sides).
6. Say, "Many molecules form crystals, but some just don't. They are called amorphous. "
7. Explain that although we can't see atoms or individual molecules with our eyes, we can see how they behave as a liquid and a solid using some pennies and a ruler.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.

2. Hand each group their materials and give them time to perform their experiment and write down their observations.

3. Lay about 20-50 pennies on the table so that they are all sitting flat on the table. Now, use the ruler to push the pennies toward one another until there is one big glob of pennies on the table, all touching one another. Don't push so hard that they pile on top of one another.

4. Take a look at the pennies. Do you notice anything? You may notice that the pennies form patterns. How could that happen? You just shoved them together you didn't lay them out in any order. Taa daa! That's what often happens when solids form.

5. Now, place your ruler on the right hand side of your penny blob so that it's touching the bottom half of your pennies.

6. Slowly push the ruler to the left and watch the pennies.

7. You may have noticed that the penny “crystal” split in quite a straight line. This is called cleavage. Since crystals form patterns, they will tend to break in pretty much the same way you saw your pennies break.

Exercises

1. Explain what happened when you pushed the pennies together. (They formed a pattern)
2. Draw a diagram of the structure your pennies formed. (answers will vary but should show a roughly hexagonal pattern)
3. You observed how the pennies broke into a straight line when pushed around with a ruler. What is this called? (Cleavage) Do you think all crystals break into a perfectly straight line? Why or why not? (No, because crystals are made of molecules with different shapes, so they will cleave differently….some very smooth, others fairly rough)
4. Are atoms closer together in a liquid or a solid? (solid)
5. You learned that many solids form into crystalline shapes but that some don’t. What are these called? (amorphous)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #10: Penny Crystal Structure

Student Worksheet

Name____

Overview: What in the world is going on when water freezes? Something is happening to those little H_2O molecules, but what??? You'll find out today using pennies and a ruler.

What to Learn: You will learn what atoms and molecules are up to in their little microscopic world as they go from a liquid to a solid. You will also see what happens when a solid breaks. (Have you ever chipped off a piece of ice? Then you already know what cleavage is!)

Materials

- 50 pennies
- ruler

Lab Time

1. Lay about 20-50 pennies on the table so that they are all sitting flat on the table. Now, use the ruler to push the pennies toward one another until there is one big glob of pennies on the table, all touching one another. Don't push so hard that they pile on top of one another.
2. Take a look at the pennies. Do you notice anything? You may notice that the pennies form patterns. How could that happen? You just shoved them together you didn't lay them out in any order. Taa daa! That's what often happens when solids form.
3. Now, place your ruler on the right hand side of your penny blob so that it's touching the bottom half of your pennies.
4. Slowly push the ruler to the left and watch the pennies.
5. You may have noticed that the penny "crystal" split in quite a straight line. This is called cleavage. Since crystals form patterns, they will tend to break in pretty much the same way you saw your pennies break

Exercises Answer the questions below:

1. Explain what happened when you pushed the pennies together.

2. Draw a diagram of the structure your pennies formed.

3. You observed how the pennies broke into a straight line when pushed around with a ruler. What is this called? Do you think all crystals break into a perfectly straight line? Why or why not?

4. Are atoms closer together in a liquid or a solid?

5. You learned that many solids form into crystalline shapes but that some don't. What are these called?

Lesson #11: Rock Candy Crystals

Teacher Section

Overview: Students will learn how to make a supersaturated solid solution to create rock candy.

Suggested Time: 30-45 minutes

Objectives: Students will understand how to make a supersaturated solid solution and know that crystals form when molecules are pulled very close together to create specific patterns

Materials (per lab group)

- sauce pan
- spoon
- stove or other heating apparatus
- 8 cups granulated sugar
- 3 cups water
- measuring cup
- glass jar (cleaned out pickle, jam or may jars work great)
- aluminum foil
- wooden skewer (string or yarn will also work)
- tape
- food coloring is optional but fun!

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Crystals are formed when atoms line up in patterns and solidify. There are crystals everywhere — in the form of salt, sugar, sand, diamonds, quartz, and many more! To make crystals, you need to make a very special kind of solution called a supersaturated solid solution. This means a solution has been made more concentrated than normally possible.

Think of it this way: If you add salt by the spoonful to a cup of water, you'll reach a point where the salt doesn't disappear (dissolve) anymore and forms a lump at the bottom of the glass. The point at which it begins to form a lump is just past the point of saturation. If you heat up the saltwater, the lump disappears. You can now add more and more salt, until it can't take any more (you'll see another lump starting to form at the bottom). This is now a supersaturated solid solution. Mix in a bit of water to make the lump disappear. Your solution is ready for making crystals. Now, if you add something for the crystals to cling to, like a rock or a stick, crystals can grow. For faster-growing crystals, it is possible to "seed" the rock, stick, string, etc. This means to coat it with the material you formed the solution with, such as salt or sugar.

Making a supersaturated solution can be very difficult. If there is too much salt (or other solid) mixed in, the solution will crystallize all at the same time and form a huge rock that can't be pulled out of the jar. If there is too little salt, then crystals grow agonizingly slowly. To find the right amount takes time and patience.

Lesson

1. Tell students to imagine this scenario: It is a hot summer day, and you come in sweaty and hot and ready for something cool and sweet. You find a tub of Kool-Aid in the cupboard and add a scoop to your glass of nice cool water. You drink, but then get a great idea. What happens if you add another scoop? (Allow students to guess. If they add too much it will just sink to the bottom in a pile). Oh no, not wasted Kool-Aid! Is there anything we can do? Enter Mom, who knows a bit about science. "Hmmmm," she says. "I don't like to waste that Kool-Aid either. I can think of two things we can try. We can add more water or we could try to heat it up and see what happens." At this point you have forgotten how hot you are, and you want to try out Mom's heating idea. You pour the Kool-Aid solution in the pot and heat and stir. Guess what? The Kool-Aid particles disappear! Hooray!
2. Say, "What the mom in our story did was create something called a supersaturated solid solution. Normally, only a certain amount of Kool-Aid can be dissolved in a cup of water. But, if we do something like heat it up, it allows more to dissolve and we say it is now more concentrated." Explain that in today's experiment they will make a supersaturated solution, and then take it a step further.
3. Ask, "What would happen if the Kool-Aid was cooled back down. Would the powder stay mixed in or would it fall out of the solution?" (Fall out of solution.) Explain to students that they will use this information to make rock candy crystals. Crystals are formed when atoms line up in patterns and solidify. There are crystals everywhere — in the form of salt, sugar, sand, diamonds, quartz, and many more. Tell students they will make a supersaturated solution and then observe the pattern of crystal formation of their own rock candy.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Place 3 cups of water in a sauce pan. Add 8 cups of sugar, and stir over medium heat approximately 4-7 minutes. You should be able to get all the sugar to dissolve. You can add more sugar until you start to see undissolved bits at the bottom of the pan. If this happens, just add a bit of water until they disappear. This is called a supersaturated solid solution.
4. Add food coloring to the water if desired.
5. Allow solution to cool to about 130°, and then pour into the jar.
6. Place an aluminum foil "lid" on the jar. Poke a small hole in the middle and place a wooden skewer (or piece of string) through the hole. Make sure the stick doesn't touch the sides or bottom of the jar. Attach skewer in place with a piece of tape. (OPTIONAL: Before placing skewer in jar, "seed" a wet stick by sprinkling sugar over it then inserting up through bottom of aluminum foil lid so sugared end is resting in the solution.)

7. Put the whole thing aside in a warm, quiet place for 2 days to a week. Some crystals will take up to six months for form large structures (as seen in image).

Exercises

1. Why was it necessary to make a supersaturated solid solution to get crystals? (With a normally saturated solution, the sugar crystals would simply dissolve in the water to make hot sugar water. When it cooled, it would make cool sugar water. With a supersaturated solution, the sugar "falls out" of solution as it cools, because it can no longer hold all of the sugar, and crystals are formed)
2. A solute is the material you dissolve. And a solvent is what you dissolve something in. What was the solute in today's experiment? (sugar) What was the solvent? (water)
3. Sometimes when this experiment is done, students end up with a huge chunk of sugar right away. What could have happened? (they dissolved too much sugar in the water)
4. What might be the problem if crystals don't form, or take weeks and weeks to form? (not enough sugar was added; the solution was not supersaturated)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #11: Rock Candy Crystals

Student Worksheet

Name____

Overview: Candy, anyone? That's what you'll make today, and you'll learn about crystals as you go! Yum!

What to Learn: You'll find out how to make a supersaturated solid solution by heating up water and adding more and more sugar. Once your crystals form, you'll see the regular repeating pattern that all crystals have.

Materials

- sauce pan
- spoon
- stove or other heating apparatus
- 8 cups granulated sugar
- 3 cups water
- measuring cup
- glass jar (cleaned out pickle, jam or may jars work great)
- aluminum foil
- wooden skewer (string or yarn will also work)
- tape
- food coloring is optional but fun!

Lab Time

1. Place 3 cups of water in a sauce pan. Add 8 cups of sugar, and stir over medium heat approximately 4-7 minutes. You should be able to get all the sugar to dissolve. You can add more sugar until you start to see undissolved bits at the bottom of the pan. If this happens, just add a bit of water until they disappear. This is called a supersaturated solid solution.
2. Add food coloring to the water, if desired.
3. Allow solution to cool to about 130°, and then pour into the jar.
4. Place an aluminum foil "lid" on the jar. Poke a small hole in the middle and place a wooden skewer (or piece of string) through the hole. Make sure the stick doesn't touch the sides or bottom of the jar. Attach skewer in place with a piece of tape. (OPTIONAL: Before placing skewer in jar, "seed" a wet stick by sprinkling sugar over it then inserting up through bottom of aluminum foil lid so sugared end is resting in the solution.)
5. Put the whole thing aside in a warm, quiet place for 2 days to a week to get started. Some crystals will take up to six months for form large structures (as seen in image).

Exercises: Answer the questions below:

1. Why was it necessary to make a supersaturated solid solution to get crystals?

2. A solute is the material you dissolve. And a solvent is what you dissolve something in. What was the solute in today's experiment? What was the solvent?

3. Sometimes when this experiment is done, students end up with a huge chunk of sugar right away. What could have happened?

4. What might be the problem if crystals don't form, or take weeks and weeks to form?

Lesson #12: Bouncy Putty Slime

Teacher Section

Overview: Time to play with polymers! Polymers are very long chains of molecules that act differently depending on what they are made of and how they're put together. This polymer slime will bounce!

Suggested Time: 30-45 minutes

Objectives: Students will discover that molecules join together to form long chain polymers. When these molecules are linked together, they form a fishnet structure that will bounce.

Materials (per lab group)

- borax (laundry whitener)
- water
- white glue
- disposable cups (2)
- popsicle sticks (2)
- tablespoon
- teaspoon
- optional: food coloring

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

"Poly-" means many and "-mer" means part, or segment. Glue is a polymer, which is a long chain of molecules all hooked together like tangled noodles. When you mix the glue solution with the borax solution, the water molecules start linking the noodles together along the length of each noodle to get more like a fishnet. Scientists call this a *polymetric compound of sodium tetraborate and lactated glue*. We call it bouncy putty.

The property of a polymer will depend on what is happening at the molecular level. Things that are made of polymers look, act, and feel differently based on how the molecules are connected. Some are rubbery, some are gooey, and some are hard.

Lesson

1. Begin today's lesson by building on background knowledge. Ask students, "What does the word poly mean? Where have you heard it before?" Allow students to discuss in pairs before they answer. (There may be a number of correct answers such as polygon, polytechnic, polygraph, polygamy, etc.). Lead students in discovering that the definition of "poly" is many.
2. Explain that the definition of "-mer" is part, or segment. Ask students what word they get when they combine both parts (polymer).
3. Say, "Molecules can be hooked together into very, very long chains called polymers. It's like looking at a bunch of tangled noodles." Ask, "When you think about glue, what descriptions can you think of?" (sticky, thick, etc.) Explain that glue is a type of polymer that will be used in today's experiment.
4. Discuss what will occur in today's experiment, explaining that a glue solution will be combined with a borax solution to form a completely different compound with surprising properties. Say, "When the two solutions are mixed together, they form a kind of fishnet structure as the water molecules link them together. This is what will make them so much fun!"

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Combine 6 tablespoons water with one teaspoon borax in a cup. Stir with a popsicle stick for 10-15 seconds. (Optional: add a few drops of food coloring)
4. In another cup, mix 1 tablespoon white glue and 1 tablespoon water.
5. Pour glue solution into borax solution.
6. Stir for one second with a popsicle stick, then quickly pull the putty out of the cup and play with it until it dries enough to bounce on table (3-5 minutes).
7. Pick up an imprint from a textured surface or print from a newspaper, bounce and watch it stick, snap it apart quickly and ooze apart slowly.
8. Complete the Data Table.

Exercises

1. Think about a ladder. If the glue solution is one side of the ladder and the borax solution is the other side, what is holding the two sides together? (Water molecules.)
2. Is glue a solid or a liquid? (liquid) How about the bouncy ball? (solid)
3. Was this a physical or chemical change? (chemical) How do you know? (it forms a completely new substance)
4. Why does the ball bounce? (The polymer forms a fishnet structure which gives it elasticity)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #12: Bouncy Putty Slime

Student Worksheet

Name____

Overview: Time to play with polymers! Polymers are very long chains of molecules and are super fun because they act differently depending on what they are made of and how they're put together. This polymer slime will even bounce!

What to Learn: In today's experiment you will learn that polymers are long, long chains of molecules that often have very fun and useful properties. You will see that it's possible to play with polymers so they form different structures. The fishnet structure of today's polymer will cause it to bounce.

Materials

- borax (laundry whitener)
- water
- white glue
- disposable cups (2)
- popsicle sticks (2)
- tablespoon
- teaspoon
- optional: food coloring

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Combine 6 tablespoons water with one teaspoon borax in a cup. Stir with a popsicle stick for 10-15 seconds. (Optional: add a few drops of food coloring)
3. In another cup, mix 1 tablespoon white glue and 1 tablespoon water.
4. Pour glue solution into borax solution.
5. Stir for one second with a popsicle stick, then quickly pull the putty out of cup and play with it until it dries enough to bounce on table (3-5 minutes).
6. Pick up an imprint from a textured surface or print from a newspaper, bounce and watch it stick, snap it apart quickly and ooze apart slowly.
7. Complete the Data Table.

Bouncy Putty Slime Data Table

Compound/Object	Detailed Description (what does it look like? How does it act? Is it a solid or a liquid?)
White Glue	
Borax	
Bouncy Putty	

Exercises: Answer the questions below:

1. Think about a ladder. If the glue solution is one side of the ladder and the borax solution is the other side, what is holding the two sides together?

2. Is glue a solid or a liquid? How about the bouncy ball?

3. Was this a physical or chemical change? How do you know?

4. Why does the ball bounce?

Lesson #13: Glowing Slime

Teacher Section

Overview: Any way you picture it, slime is definitely slippery, slithery, and just plain icky — and a perfect forum for learning about polymers. This slime can also be made to glow, which is a terrific introduction to understanding UV light.

Suggested Time: 30-45 minutes

Objectives: Students will discover that polymers are long chains of slippery molecules and that slime can be made by cross-linking these molecules together. In addition, they will understand why some things glow under a black light.

Materials (per lab group)

- water
- popsicle sticks
- disposable cups
- clear glue or white glue
- yellow highlighter
- measuring spoons
- scissors
- borax (laundry whitener)
- Optional: UV fluorescent black light

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Using pliers, pry the end of each highlighter so the kids can get at the felt inside. Leave the cap on loosely until the kids are ready for the lab.
3. Print out copies of the student worksheets.
4. Read over the Background Lesson Reading before teaching this class.
5. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Imagine a plate of spaghetti. The noodles slide around and don't clump together, just like the long chains of molecules (called polymers) that make up slime. They slide around without getting tangled up. The pasta by itself (fresh from the boiling water) doesn't hold together until you put the sauce on. Slime works the same way. Long, spaghetti-like chains of molecules don't clump together until you add the sauce … until you add something to cross-link the molecule strands together.

The sodium-tetraborate-and-water mixture is the "spaghetti" (the long chain of molecules, also known as a polymer), and the "sauce" is the glue-water mixture (the cross-linking agent). You need both in order to create a slime worthy of Hollywood filmmakers.

There are a lot of everyday things that fluoresce, or glow, when placed under a black light. Note that a black light emits high-energy UV light. You can't see this part of the spectrum, just as you can't see infrared light found in the beam emitted from the remote control to the TV. This is why "black lights" were so named. Stuff glows because fluorescent objects absorb the UV light and then spit light back out almost instantaneously. Some of the energy gets lost during that process, which changes the wavelength of the light, which makes this light visible and causes the material to appear to glow

Lesson

1. Tell students to imagine a nice hot plate of freshly cooked spaghetti. Ask them to describe how this spaghetti would look and feel (slippery, slimy, etc,). Now, ask them what happens when you pour on that nice, thick spaghetti sauce (the noodles stick together in a gooey mess). Explain that the same thing happens to long chains of molecules called polymers when they are mixed with a cross-linking agent.
2. Say, "Today, our spaghetti is a laundry whitener called borax, or sodium tetraborate, mixed with glow juice. Our sauce is a mixture of glue and water. When you mix them together you'll see a strikingly different product."
3. Ask students if they have ever seen a use for a black light (they may have seen one at amusement park when things seem to glow; had their hand stamped for re-admission; crime scene shows on TV often use them to detect fingerprints or fluids; can be used to detect counterfeit bills; used in Halloween displays).
4. Explain that many things fluoresce, or glow, when placed under a black light which emits high-energy UV light. These things absorb the UV light and spit out visible light, which appears to glow.
5. Explain that they will make their own glow juice from a highlighter that will fluoresce under UV light, just like at an amusement park.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Remove the end of a highlighter pen with scissors or pliers. Tip pen over until the roll of felt comes out.
4. Slit along the plastic coating covering the felt. Spread the fibers out.
5. Over a large container, douse entire felt with water until it turns white. This is the glow juice.
6. Put 4 tablespoons of glow juice into a disposable cup. Add 1 tablespoon borax (sodium tetraborate). Stir 10 seconds until you dissolve as much sodium tetraborate solution as possible.
7. In a second cup, put 2 tablespoons water and 2 tablespoons clear glue. Mix 20 seconds.
8. Pour glue solution into sodium tetraborate/glow juice solution and stir 1-2 times
9. Pull out slime and play with it until it bounces on table (note: it may be squished back together if it breaks).
10. Place slime under a long wave UV light and it will fluoresce!
11. When you are finished, slime may be stored in the refrigerator or freezer and thawed in a microwave

Exercises

1. What is the "spaghetti" in this experiment? (sodium tetraborate and glow juice mixture) What is the "sauce"? (glue and water mixed together)
2. What are polymers? (long chains of molecules)

3. Is your slime a solid, a liquid, or a bubbly gas? (Answers will vary. The best slimes have all three states of matter simultaneously: solid chunks suspended in a liquid form with gas bubbles trapped inside!)
4. What causes the glow juice to glow? (it absorbs the UV light and spits out visible light, which appears to glow)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #13: Glowing Slime

Student Worksheet

Name____

Overview: When you think of slime, do you imagine slugs, snails, and puppy kisses? Or does the science fiction film The Blob come to mind? Any way you picture it, slime is definitely slippery, slithery, and just plain icky — and a perfect forum for learning about polymers. This slime can also be made to glow, which is a terrific introduction to understanding UV light.

What to Learn: By the time you are finished you will understand that just as spaghetti needs sauce to stick together, polymers need a cross-linking agent. And, you'll learn to make cool luminescent slime you can view with a little help from a black light.

Materials

- water
- popsicle sticks
- disposable cups
- clear glue or white glue
- yellow highlighter
- measuring spoons
- scissors
- borax (laundry whitener)
- Optional: UV fluorescent black light

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Remove the end of a highlighter pen.
3. Tip pen over until the roll of felt comes out.
4. Slit along the plastic coating covering the felt. Spread the fibers out.
5. Over a large container, douse entire felt with water until it turns white. This is the glow juice.
6. Put 4 tablespoons of glow juice into a disposable cup. Add 1 tablespoon borax (sodium tetraborate). Stir 10 seconds until you dissolve as much sodium tetraborate solution as possible.
7. In a second cup, put 2 tablespoons water and 2 tablespoons clear glue. Mix 20 seconds.
8. Pour glue solution into sodium tetraborate/glow juice solution and stir 1-2 times
9. Pull out slime and play with it until it bounces on table (note: it may be squished back together if it breaks).
10. Place slime under a long wave UV light and it will fluoresce!
11. When you are finished, slime may be stored in the refrigerator or freezer and thawed in a microwave

Glowing Slime Data Table

Experiment with adding different amounts of borax or glue to see how each affects your slime. Record in the following table:

Cup #1	Cup #2	Results
4 T Glow Juice + 1 T Borax	2 T water + 2 T clear glue	
4 T Glow Juice + 2 T Borax	2 T water + 2 T clear glue	
4 T Glow Juice + 1 T Borax	2 T water + 3 T clear glue	

Exercises Answer the questions below:

1. What is the "spaghetti" in this experiment? What is the "sauce"?

2. What are polymers?

3. Is your slime a solid, a liquid, or a bubbly gas?

4. What causes the glow juice to glow?

Lesson #14: Bouncy Ball

Teacher Section

Overview: This is one of those "chemistry magic show" types of experiments to wow your friends and family. Here's the scoop: You take a cup of clear liquid, add it to another cup of clear liquid, stir for ten seconds, and you'll see a color change, a state change from liquid to solid, and you can pull a rubber-like bouncy ball right out of the cup.

Suggested Time: 30-45 minutes

Objectives: Students will understand that solids and liquids have different properties and that atoms and molecules form solids by building up repeating patterns, as in long chain polymers.

Materials (per lab group)

- sodium silicate (order from www.ScienceCompany.com)
- ethyl alcohol, also called ethanol (70%)
- beakers or disposable cups (2 per group)
- popsicle sticks (2 per group)
- teaspoon measures (2 per group)
- rubber gloves
- small Ziploc bags

Lab Preparation

1. Each lab station will need the following: sodium silicate, ethyl alcohol, 2 beakers, 2 popsicle sticks, and 2 teaspoons
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Polymers are made up of many molecules all strung together to form really long chains. The sodium silicate is a long polymer chain of alternating silicon and oxygen atoms. When ethanol (ethyl alcohol) is added, it bridges and connects the polymer chains together by cross-linking them.

Think of a rope ladder—the wooden rungs are the cross-linking agents (the ethanol) and the two ropes are the polymer chains (sodium silicate).

Silicones are water repellent, so you'll find that food dye doesn't color your bouncy ball. You'll find silicone in greases, oils, hydraulic fluids, and electrical insulators.

A solid is a kind of matter that has its own shape and does not flow at a given temperature. The molecules that make up a solid are close together and have little movement. Solids can be different colors and textures and have different degrees of malleability. Liquids take the shape of their containers. The molecules in a liquid are further apart and are able to vibrate and move more freely.

Lesson

1. Begin by asking students, "Have you ever played with corn starch and water? What was it like? (Allow for a few answers, focusing on the fact that the mixture was sometimes a liquid and sometimes a solid).
2. Using the background reading, briefly review the difference between a solid and a liquid. Say, "When you combined the cornstarch and water, you made a polymer. Polymers are long chains of molecules. You are going to make a different polymer today."
3. Write the word "silicone" on the board and ask students where they may have seen that word. Give students time to share ideas with a partner and then share as a whole class. Silicones may be found in a variety of places, including greases, oils, hydraulic fluids, electrical insulators, bakeware, kitchen utensils, toys such as silly putty, etc.
4. Explain that in today's experiment they will be combining ethyl alcohol, something found in the drugstore with sodium silicate, a compound also known as water glass, and discovering what will happen.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. In one cup, measure four teaspoons of sodium silicate solution (it should be a liquid). Sodium silicate can be irritating to the skin for some people, so wear rubber gloves when doing this experiment!
4. Measure 1 teaspoon of ethyl alcohol into a second cup. Ethyl alcohol is extremely flammable—cap it and keep out of reach when not in use.
5. Pour the alcohol into the sodium silicate solution and stir with a popsicle stick.
6. You'll see a color change (clear to milky-white) and a state change (liquid to a solid clump.)
7. Using gloves, gather up the polymer ball and firmly squeeze it in your hands.
8. Compress it into the shape you want—is it a sphere, or do you prefer a dodecahedron?
9. Bounce it!
10. Be patient when squeezing the compound together. If it breaks apart and crumbles, gather up the pieces and firmly press together.
11. When finished, seal ball in plastic bag. It will eventually become a bouncy pancake which may be reformed by slowly squeezing the pieces together.
12. Fill out the Bouncy Ball Data Table

Exercises

1. Before the reaction, what was the sodium silicate like? Was it a solid, liquid, or gas? What color was it? Was it slippery, grainy, viscous, etc.? (clear liquid, slippery, viscous)
2. What was the ethanol like before the reaction? (clear liquid, runny)
3. How is the product (the bouncy ball) different from the two chemicals in the beginning? (it forms a temporary ball which bounces, and is white in color)
4. Is the bouncy ball a solid or a liquid? How do you know? (It acts like a solid but is really a liquid because it takes the shape of its container).
5. Was this reaction a physical or chemical change? (chemical change)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #14: Bouncy Ball

Student Worksheet

Name____

Overview: This is one of those "chemistry magic show" types of experiments to wow your friends and family. Here's the scoop: You take a cup of clear liquid, add it to another cup of clear liquid, stir for ten seconds, and you'll see a color change, a state change from liquid to solid, and you can pull a rubber-like bouncy ball right out of the cup.

What to Learn: Solids and liquids have different properties. Polymers are long chains that can be linked together to form silicones which have really cool uses.

Materials

- sodium silicate
- ethyl alcohol, also called ethanol (70%)
- beakers or disposable cups (2 per group)
- popsicle sticks (2 per group)
- teaspoon measures (2 per group)
- rubber gloves
- small Ziploc bags

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. In one cup, measure four teaspoons of sodium silicate solution (it should be a liquid). Sodium silicate can be irritating to the skin for some people, so wear rubber gloves when doing this experiment!
3. Measure 1 teaspoon of ethyl alcohol into a second cup. Ethyl alcohol is extremely flammable—cap it and keep out of reach when not in use.
4. Pour the alcohol into the sodium silicate solution and stir with a popsicle stick.
5. You'll see a color change (clear to milky-white) and a state change (liquid to a solid clump.
6. Using gloves, gather up the polymer ball and firmly squeeze it in your hands.
7. Compress it into the shape you want—is it a sphere, cube, or do you prefer a dodecahedron?
8. Bounce it!
9. Be patient when squeezing the compound together. If it breaks apart and crumbles, gather up the pieces and firmly press together.
10. When finished, seal ball in plastic bag. It will eventually become a bouncy pancake which may be reformed by slowly squeezing the pieces together.
11. Fill out the Bouncy Ball Data Table

Bouncy Ball Data Table

Compound/Object	Detailed Description
Sodium silicate	
Ethyl alcohol	
Bouncy ball	

Exercises Answer the questions below:

1. Before the reaction, what was the sodium silicate like? Was it a solid, liquid, or gas? What color was it? Was it slippery, grainy, viscous, etc.?

2. What was the ethanol like before the reaction?

3. How is the product (the bouncy ball) different from the two chemicals in the beginning?

4. Is the bouncy ball a solid or a liquid? How do you know?

5. Was this reaction a physical or chemical change?

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Lesson #15: Sewer Slime

Teacher Section

Overview: Students will use guar gum and borax to create a gel otherwise known as sewer slime

Suggested Time: 30-45 minutes

Objectives: Students will understand that mixing substances sometimes changes their properties and that this chemical change creates a cross-linked polymer.

Materials (per lab group)

- borax (sodium tetraborate)
- water
- 2 disposable cups
- measuring spoons (tablespoon, ½ teaspoon, ¼ teaspoon)
- popsicle sticks
- powdered guar gum (grocery store)

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Guar gum comes from the guar plant (also called the guaran plant), and people have found a lot of different and interesting uses for it. It's one of the primary substitutes for fat in low-fat and fat-free foods. Some kids call this polymer "fake fat" slime, mostly because it's used in fat-free baking. Cooks like to use guar gum in foods as it has 8 times the thickening power of cornstarch, so much less is needed for the recipe. Ice cream makers use it to keep ice crystals from forming inside the carton. Doctors use it as a laxative for their patients.

Chemically, guar gum is a polysaccharide, meaning it is a carbohydrate that can be broken down into two or more small sugar molecules. Guar gum is made of the sugars galactose and mannose. Either borax or calcium can cross-link guar gum, causing the long polymer strands to stick together, forming a gel. In today's experiment we will use borax to create gooey, messy sewer slime!

Lesson

1. Hold up the package of guar gum. Say, "Look what I found at the health food store! It's used as a substitute for fat in fat-free foods! Doesn't it look cool?" (You may see eye rolling and blank stares, but never fear!)
2. Now, hold up the borax. Say, "Oh, I also found some borax. This is a chemical called sodium tetraborate, and it can make my laundry whiter." Allow students to see what the borax looks like. Say, "OK, I can see you are not impressed. But allow me to change your mind. "
3. Explain that the guar gum, when placed in water, will make super long chains of molecules called polymers. And, there are a few things, including borax, that can link all those chains together to form… well, they'll see for themselves. But this chemical reaction isn't anything to sneeze about!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Fill a cup with 7 tablespoons of cold water.
4. Add ¼ teaspoon of guar gum by first placing the measured amount in your hand then sprinkling into the water. This prevents clumping. Stir with a popsicle stick 10 times and stop, leaving the stick in.
5. Leave it for 2 minutes to thicken. Cautiously dip a pinkie into the cup, and then rub it in your fingers. Does it smell?
6. Meanwhile, in a second cup, mix ½ teaspoon borax (sodium tetraborate) in one tablespoon water.
7. Add ½ teaspoon of the borax solution to the guar solution. Stir observe what you have made!

Exercises

1. Describe your slime using as many details as you can. (answers will vary)
2. The guar gum is a polymer. What does this mean? (It is a long chain of molecules)
3. Why did the borax make it look like slime? (It cross-linked all those chains together)
4. Was this a physical or chemical reaction? How do you know? (chemical because it changed two substances into something completely different)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #15: Sewer Slime

Student Worksheet

Name____

Overview: Get ready to be grossed out as you make a sewer slime that closely resembles snot!

What to Learn: You should understand that the guar gum from today's experiment is a polymer, or long chain of molecules. The borax links all those polymers together in a chemical reaction, forming a gel.

Materials

- borax (sodium tetraborate)
- water
- 2 disposable cups
- measuring spoons (tablespoon, ½ teaspoon, ¼ teaspoon)
- popsicle sticks
- powdered guar gum

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Fill a cup with 7 tablespoons of cold water.
3. Add ¼ teaspoon of guar gum by first placing the measured amount in your hand then sprinkling into the water. This prevents clumping. Stir with a popsicle stick 10 times and stop, leaving the stick in.
4. Leave it for 2 minutes to thicken. Cautiously dip a pinkie into the cup, and then rub it in your fingers. Does it smell?
5. Meanwhile, in a second cup, mix ½ teaspoon borax (sodium tetraborate) in one tablespoon water.
6. Add ½ teaspoon of the borax Solution to the guar gum solution. Stir observe what you have made!

Sewer Slime Data Table

Experiment with adding different amounts of guar gum or Borax to see how each affects your slime. Record in the following table:

Cup #1	Cup #2	Results
7 T water + ¼ tsp guar gum	1 T water + ½ tsp borax	
7 T water + ½ tsp guar gum	1 T water + ½ tsp borax	
7 T water + ¼ tsp guar gum	1 T water + 1 tsp borax	

Exercises Answer the questions below:

1. Describe your slime using as many details as you can.
2. The guar gum is a polymer. What does this mean?
3. Why did the borax make it look like slime?
4. Was this a physical or chemical reaction? How do you know?

Lesson #16: Hidden CO_2

Teacher Section

Overview: Students will experiment to determine where carbon dioxide gas may be hiding in common household items. They will have the opportunity to create their own scale to determine if CO_2 weighs the same as air, more, or less.

Suggested Time: 30-45 minutes

Objectives: Students will explore carbon dioxide gas and learn about sublimation, the process by which a solid goes directly to a gas. Optional: Students will construct a working scale to measure weight of CO_2 compared with air.

Materials (per lab group)

Part I (Hidden CO_2)

- baking soda
- chalk
- distilled white vinegar
- washing soda
- disposable cups (3)
- popsicle sticks (3)
- Optional: Other items to experiment with: flour, baking powder, powdered sugar, or cornstarch (in place of baking soda/chalk/washing soda) and lemon juice, orange juice, or oil (in place of distilled white vinegar)

Part II (Bonus: Making a Scale to Measure CO_2)

- baking soda
- distilled white vinegar
- two disposable cups
- large container
- two water bottles or stacks of books
- two long pencils or skewers
- string

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the videos for this experiment to prepare for teaching this class.
5. If you are doing the optional demonstration, practice it first to be sure you know exactly how long you need to blow through the straw (it's probably longer than you think). I don't let kids blow through it, because if they accidentally inhale it, it's poisonous.

Background Lesson Reading

If you've ever burped, you know that it's a lot easier to do after chugging an entire soda. Now why is that?

Soda is loaded with gas bubbles — carbon dioxide (CO_2), to be specific. And at standard temperature (68˚F) and pressure (14.7 psi), carbon dioxide is a gas. However, if you burped in Antarctica in the wintertime, it would begin to freeze as soon as it left your lips. The freezing temperature of CO_2 is -109˚F, and Antarctic winters can get down to -140˚F. You've actually seen this before, as dry ice (frozen burps!).

Carbon dioxide has no liquid state at low pressures (75 psi or lower), so it goes directly from a block of dry ice to a smoky gas (called sublimation). It's also acidic and will turn cabbage juice indicator from blue to pink. CO_2 is colorless and odorless, just like water, but it can make your mouth taste sour and cause your nose to feel as if it's swarming with wasps if you breathe in too much of it (though we won't get anywhere near that concentration with our experiments).

The triple point of CO_2 (the point at which CO_2 would be a solid, a liquid, and a gas all at the same time) is around five times the pressure of the atmosphere (75 psi) and around -70°F. (What would happen if you burped then?)

What sound does a fresh bottle of soda make when you first crack it open? PSSST! What is that sound? It's the CO_2 (carbon dioxide) bubbles escaping. What is the gas you exhale with every breath? Carbon dioxide. Hmmm … it seems as if the soda is already pre-burped. Interesting.

Lesson

1. Build on background knowledge by asking students what they breathe in when we take a breath (oxygen). Say, "OK, now what do we breathe out?" (carbon dioxide) "Now, what about burping? What do you burp out?" (same thing… carbon dioxide, or CO_2) Get students interested in CO_2 by having a discussion about burps and soda. Ask them to think about why soda makes them burp. Discuss in pairs or groups. (Soda is loaded with CO_2.)
2. Ask students to guess what would happen if they burped in Antarctica, where the temperature can get to negative140^{o}F! Discuss in pairs or groups. (The burp would freeze as soon as it left their lips.) This is called dry ice, and forms at the freezing temperature of carbon dioxide, which is -109^{o}F. Explain that carbon dioxide is an interesting substance because it goes from a gas (burp) to a solid (dry ice), a process called sublimation.
3. Ask students what other materials or objects they think might have carbon dioxide. They may have some ideas, but the blank stares you may get are OK. They are going to find out today!
4. Explain that many common household items actually contain large or small amounts of carbon dioxide. In today's experiment, they will use vinegar, an acid, to detect carbon dioxide gas. Ask, "If something is a gas, what will it look like when in a liquid? (bubbles). Say, "OK, you have enough information to understand today's experiment. Now it's time to find where the carbon dioxide is hiding."

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Fill 3 cups with a few tablespoons of vinegar

4. Put samples into each cup: chalk, sprinkle of baking soda, sprinkle of washing soda. Observe and fill out data sheet.

   To continue with Bonus experiment (Making a Scale to Measure CO_2)

5. Construct a scale by following these steps:
   a. Suspend a long dowel (pencil, skewer, etc) between two water bottles and attach with tape.
   b. Use string to suspend two small disposable cups from either end of a second dowel.
   c. Attach second dowel as a cross-piece across the first suspended dowel. Make sure the scale can go up and down very freely and easily and cups are balanced evenly.
6. In a large container, sprinkle baking soda to cover the bottom.
7. Add distilled vinegar just until bubbles reach the top of the container.
8. Wait a few minutes for the bubbles to completely pop. The container is now full of carbon dioxide gas.
9. Pour gas into one of the cups and observe.

Exercises

1. How do you know carbon dioxide was inside the chalk, baking soda, and washing soda? (When combined with vinegar, carbon dioxide bubbles were produced.)
2. When the carbon dioxide bubbles popped, where did the carbon dioxide go? (It stayed in the cup as an invisible gas.)
3. What would happen to the chalk if you left it in the vinegar? (It would eventually dissolve.)
4. What is sublimation? (when a substance goes from a gas to a solid)
5. If you completed the bonus experiment, did carbon dioxide weigh more or less than air? How do you know? (Carbon dioxide weighs more because when poured onto the scale it caused that side to lower.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #16: Hidden CO_2

Student Worksheet

Name____

Overview: If you've ever burped, you know that it's a lot easier to do after chugging an entire soda. Now why is that? Soda is loaded with gas bubbles — carbon dioxide (CO_2), to be specific. You will experiment to determine where carbon dioxide gas may be hiding in other household items. You'll also create your own scale to determine if CO_2 weighs the same as air, more, or less.

What to Learn: Focus on carbon dioxide for today's experiment. Where is it? How do you know? What does carbon dioxide look like as a solid?

Materials

Part I (Hidden CO_2)

- baking soda
- chalk
- distilled white vinegar
- washing soda
- disposable cups (3)
- popsicle sticks (3)
- Optional: Other items to experiment with: flour, baking powder, powdered sugar, or cornstarch (in place of baking soda/chalk/washing soda) and lemon juice, orange juice, or oil (in place of distilled white vinegar)

Part II (Bonus: Making a Scale to Measure CO_2)

- baking soda
- distilled white vinegar
- two disposable cups
- large container
- two water bottles or stacks of books
- two long pencils or skewers
- string

Lab Time

1. Wear your gloves and put your goggles on. No exceptions!
2. Fill 3 cups with a few tablespoons of vinegar.
3. Put samples into each cup: chalk, sprinkle of baking soda, sprinkle of washing soda. Observe and fill out data sheet.

<u>To continue with Bonus experiment (Making a Scale to Measure CO_2):</u>

4. Construct a scale by following these steps:

   a. Suspend a long dowel (pencil, skewer, etc) between two water bottles and attach with tape.
   b. Use string to suspend two small disposable cups from either end of a second dowel.
   c. Attach second dowel as a cross-piece across the first suspended dowel. Make sure the scale can go up and down very freely and easily and cups are balanced evenly.
5. In a large container, sprinkle baking soda to cover the bottom.
6. Add distilled vinegar just until bubbles reach the top of the container.
7. Wait a few minutes for the bubbles to completely pop. The container is now full of carbon dioxide gas
8. Pour gas into one of the cups and observe.

Hidden CO_2 Data Table

Mixture	Description of Reaction	Speed of Reaction
Vinegar + chalk		
Vinegar + baking soda		
Vinegar + washing soda		

Exercises Answer the questions below:
1. How do you know carbon dioxide was inside the chalk, baking soda, and washing soda?
2. When the carbon dioxide bubbles popped, where did the carbon dioxide go?
3. What would happen to the chalk if you left it in the vinegar?
4. What is sublimation?
5. If you completed the bonus experiment, did carbon dioxide weigh more or less than air? How do you know?

Lesson #17: Plasma Grape

Teacher Section

This is a homework lab for your students to do on their own. You can demonstrate this lab using the guidelines below and then send off to complete their Student Worksheet on their own time.

Overview: Students will create the fourth state of matter, plasma, using food in a microwave.

Suggested Time: 30-45 minutes

Objectives: Students will learn that plasma is an ionized gas.

Materials (per lab group)

- microwave (not a new or expensive one)
- green grape
- red grape
- cherry tomato
- a knife with adult help

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

There are three well-known states of matter, which are solids, liquids, and gases. Plasma is the fourth state of matter. Note – this is NOT the kind of plasma doctors talk about that is associated with blood. Other places you can find plasma include neon signs, fluorescent lights, plasma globes, and small traces of it are found in a flame.

The textbook definition says plasma is an ionized gas. What does that mean? Plasma is formed when enough energy is added (often in the form of raising the temperature) to a gas so that the electrons break free and start zinging around on their own. Since electrons have a negative charge, having a bunch of free-riding electrons causes the gas to become electrically charged. This gives some cool properties to the gas. Anytime there are charged particles like electrons off on their own, they are referred to by scientists as *ions*.

Plasma is HOT HOT gas, and in this case, HOT HOT air, with a bit of water vapor. Grapes work well for this experiment because grapes contain high quantities of juice that conducts electricity. The grape halves are like little cups full of this conductive juice connected by a tiny bridge (the part that isn't cut all the way through). When you hit the ON button on the microwave, the energy being shot at the grape moves the electrons across the bridge very quickly, which heats up the bridge until it bursts into flame… and when this happens, the electrons that are traveling through the flame arc across and ionize the air around the grape and a burst of bright plasma shoots up. If you watch carefully, you will see two flames shoot up, not one.

Lesson

1. Begin by asking students what types of matter they already know about. They may need to be prompted, but they can probably come up with solid, liquid, and gas. Ask, "What do I need to add to go from a solid state to a liquid?" (heat) "How about if I want to take my liquid and turn it into a gas?" (heat again) "OK, is there anything after a gas? What if I heat the gas up even more?"(You'll probably get blank stares at this point, but some students may already know about plasma!) Explain that plasma is the fourth state of matter.
2. Write the word "plasma" on the board followed by its definition: an ionized gas. Explain that today they will actually make plasma in the microwave, but first they need to understand what exactly they will see. Explain that when energy is added to gas (usually by heating it up); electrons break free from the gas and begin to zoom around all over the place.
3. Say, "Remind me, what type of charge do electrons have?" (a negative charge) Tell students these negatively charged electrons zooming all around are called ions, and the gas has now been electrically charged and turned to plasma. They are now ready to create this ionized gas called plasma!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Carefully cut the grape lengthwise almost in half. Make sure to leave a bit of skin connecting the two halves.
4. Open the grape like a book, so that the two halves are next to one another still attached by the skin.
5. Put the grape into the microwave with the outside part of the grape facing down and the inside part facing up.
6. Close the door and set the microwave for ten seconds. You may want to dim the lights in the room.
7. Repeat with other items.

   Note: This experiment creates a momentary, high-amp short-circuit in the oven, a lot like shorting your stereo with low-resistance speakers. It's not good to operate a microwave for long periods with little to nothing in them. This is why we only do it for a few seconds. While this normally isn't a problem in most microwaves, don't do this experiment with an expensive microwave or one that's had consistent problems, as this might push it over the edge.

Exercises

1. Describe in detail what you observed in the plasma grape experiment. Was there a flame? What color was it? About how high did it go? How long did it last? (answers will vary but should include good details)
2. What are the four types of matter? (solid, liquid, gas, and plasma)
3. The textbook definition of plasma is "an ionized gas." What does this mean in plain English? (gas that has been heated enough so the electrons break free and zoom around)
4. Why do you think it was necessary to make sure there was a bit of skin connecting the two halves of the grape? What do you think happens to the electrons traveling across this "bridge?" (The electrons move across this bridge of skin very quickly until they burst into flame, which is what ionized the air around the grape and caused the plasma to form.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #17: Plasma Grape

Student Worksheet

Name____

Overview: You've heard about solids, liquids, and gases, but is there anything else out there? It's time to learn about plasma!

What to Learn: After today, you should know what plasma is and how it is formed.

Materials

- microwave (not a new or expensive one)
- green grape
- red grape
- cherry tomato
- a knife with adult help

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Carefully cut the grape lengthwise almost in half. Make sure to leave a bit of skin connecting the two halves.
4. Open the grape like a book, so that the two halves are next to one another still attached by the skin.
5. Put the grape into the microwave with the outside part of the grape facing down and the inside part facing up.
6. Close the door and set the microwave for ten seconds. You may want to dim the lights in the room.
7. Repeat with other items.

   Note: This experiment creates a momentary, high-amp short-circuit in the oven, a lot like shorting your stereo with low-resistance speakers. It's not good to operate a microwave for long periods with little to nothing in them. This is why we only do it for a few seconds. While this normally isn't a problem in most microwaves, don't do this experiment with an expensive microwave or one that's had consistent problems, as this might push it over the edge.

Plasma Grape Data Table

Item	Results
Green grape	
Red grape	
Cherry tomato	

Exercises Answer the questions below:

1. Describe in detail what you observed in the plasma grape experiment. Was there a flame? What color was it? About how high did it go? How long did it last?

2. What are the four types of matter?

3. The textbook definition of plasma is "an ionized gas." What does this mean in plain English?

4. Why do you think it was necessary to make sure there was a bit of skin connecting the two halves of the grape? What do you think happens to the electrons traveling across this "bridge?"

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Lesson #18: Sensing Temperature

Teacher Section

Overview: When an ice-cold glass of water gets water drops on the outside of it, that condensation occurs because of a change in temperature. Students will feel how a temperature difference can fool their fingers in today's hot and cold experiment.

Suggested Time: 30-45 minutes

Objectives: Students will understand why condensation occurs and experience the fact that skin can detect a temperature difference, but not an exact temperature.

Materials (per lab group)

- cup of hot water
- cup of cold water
- cup of room-temperature water

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Have you ever wondered how an ice-cold glass of water gets water drops on the *outside* of the cup? Where does that water come from? Does it ease its way through the glass? Did someone come by and squirt the glass with water? No, of course not. Some of the gaseous water molecules in the air came close enough to the cold glass to lose some molecular speed. Since they lost speed, they formed bonds between each other and liquefied. They condensed on the cold surface of the glass.

Imagine, though, if you will, that you live several hundred years ago and the process of condensation wasn't understood. You happen to be an inquisitive, highly perceptive, person (which of course you are) and you notice this film of water showing up on cold things. Water appearing out of apparently nowhere! You'd be pretty amazed, wouldn't you?!?

Isn't it amazing that every time you pick up a cold can of soda there are molecular interactions happening right in front of your eyes! This is why science is so wonderful. It provides the skills to see these amazing things and the skills to investigate and perhaps understand them.

The skin contains temperature sensors that work by detecting the direction heat flows in or out of the body, but not temperature directly. These sensors change temperature depending on their surroundings. When one finger is heated up then placed in water at room temperature, the heat flows out of the body. The brain gets a message saying the finger is cooler. A finger placed in ice water followed by room temperature water tells the brain it was detecting a heat flow into your body… and presto! You have one confused brain.

In order for heat to flow, there must be a temperature difference. But why then do the metal legs of a table feel colder than the wood tabletop when both are at the same room temperature? The metal will feel colder because heat flows away from your skin faster into the metal than the wood. We'll talk about heat capacity in a later experiment, but this is why scientists had to invent the thermometer: The human body isn't designed to detect temperature, only heat flow.

Lesson

1. Show students a can of soda. Tell them you recently had a strange experience on the beach. You got out a can of ice cold soda from the cooler but then decided to go into the ocean for a bit. When you got back, you realized the can was all wet! Did one of your kids drip on it? Did someone dump ice water on it? Did a stray dog come by and….yuck! Ask if anyone has any idea what happened! Allow students to share ideas then direct them toward what really happened…condensation!
2. Say, "What was colder, the can of soda straight from the cooler, or the air?" (the soda can) "OK, let's think about how fast those air molecules were zooming around. When the warmer air molecules came close to that cold can, how did that affect their speed? (They slowed down.)
3. Before we go on with this, let's think about a pot of water. If I put that water on the stove, heat it up until it boils, what has happened to the speed of those molecules? Are they going faster or slower? (faster) So with my soda can, we decided the air molecules slowed down. What did they become?" Allow students to ponder this in pairs, and then bring the class together to discuss.
4. Explain the air molecules did in fact turn to water. When they hit the cold metal they lost speed, formed bonds between each other, and liquefied. They condensed on the cold surface of the soda can.
5. Explain that a temperature difference can make someone very confused with their soda at the beach, but it can also make our bodies confused. Tell students they will fool their fingers just by using some hot and cold water!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.

3. Place one finger from one hand in the hot (not scalding) water. Place a finger from your other hand in the ice cold water. Leave them there for a moment.
4. At the same time, take both fingers and place them in the room-temperature water. What do you feel??

Exercises

1. How did the hot finger feel when it was placed into the room-temperature water? (cold)
2. How did the cold finger feel when it was placed into the room-temperature water? (hot)
3. Based on your observations, what can you infer about how a skin detects temperature? (The skin detects temperature change but not the actual temperature.)
4. After taking a hot shower, a student noticed something interesting. When she put on her glasses and went into the hallway, her glasses fogged up with tiny droplets of water. What was happening? (When she took her warm glasses into the colder hallway, the air around her glasses cooled off, causing the air to change to drops of liquid water.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #18: Sensing Temperature

Student Worksheet

Name____

Overview: Have you ever wondered how an ice-cold glass of water gets water drops on the *outside* of the cup? It's all about temperature change! You will see how a temperature difference can fool your fingers in today's hot and cold experiment.

What to Learn: You will understand why condensation occurs and feel how skin can detect a temperature difference, but not an exact temperature.

Materials

- cup of hot water
- cup of cold water
- cup of room-temperature water

Lab Time

1. Place one finger from one hand in the hot (not scalding) water. Place a finger from your other hand in the ice-cold water. Leave them there for a moment.
2. At the same time, take both fingers and place them in the room-temperature water. What do you feel??

Exercises Answer the questions below:

1. How did the hot finger feel when it was placed into the room-temperature water?

2. How did the cold finger feel when it was placed into the room-temperature water?

3. Based on your observations, what can you infer about how a skin detects temperature?

4. After taking a hot shower, a student noticed something interesting. When she put on her glasses and went into the hallway, her glasses fogged up with tiny droplets of water. What was happening?

Lesson #19: Indoor Rain Clouds

Teacher Section

Overview: Students get to vaporize liquid oceans of molecules and make it rain when the rising cloud decks hit the coldness of space. This is a great follow-up lab to *Sensing Temperature* since it really shows the students how water condensates on the outside of a cold glass.

Suggested Time: 30-45 minutes

Objectives: This lab demonstrates evaporation and condensation of molecules in the air.

Materials (per lab group)

- glass of ice water
- glass of hot water
- towel
- ruler

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

This experiment demonstrates state changes of matter. When hot vapor rises (like from the hot core of a gaseous planet) and hits a cold front (like the coldness of outer space in the upper atmosphere), the vapor condenses into liquid drops and rains, or can even freeze solid into ice chunks. Neptune and Uranus both have methane ice in their upper atmospheres. Both Jupiter and Saturn have upper cloud decks of water vapor and clouds of ammonia. The water vapor clouds are right at the freezing temperature of water.

Lesson

1. Please be careful with this lab! The hot water can burn the kids. If you prefer, you can give this as a homework assignment and give the responsibility of the kid's safety to the parents.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Take two clear glasses that fit snugly together when stacked. (Cylindrical glasses with straight sides work well.)

4. Fill one glass half-full with ice water and the other half-full with very hot water (definitely an adult job – and take care not to shatter the glass with the hot water!). Be sure to leave enough air space for the clouds to form in the hot glass.
5. Place the cold glass directly on top of the hot glass and wait several minutes. If the seal holds between the glasses, a rain cloud will form just below the bottom of the cold glass, and it actually rains inside the glass! (You can use a damp towel around the rim to help make a better seal if needed.)

Exercises

1. Which combination made it rain the best? Why did this work? (The greater the temperature difference, the better this experiment will work. The more water you have, the less the temperature will fluctuate for each glass, thus making it able to rain for longer periods of time.)
2. Draw your experimental diagram here, labeling the different components:
3. Add in labels for the different phases of matter. Can you identify all three states of matter in your experiment? (Ice = solid; water = liquid, gas between two glasses is water vapor, nitrogen, and oxygen.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #19: Indoor Rain Clouds

Student Worksheet

Name____

Overview: If you've ever wondered why water forms on the *outside* of a glass of ice water, this is your big chance to discover the real reason through chemistry and state changes.

What to Learn: This lab demonstrates evaporation and condensation of molecules in the air. Today you'll get to make it rain indoors!

Materials

- glass of ice water
- glass of hot water
- towel
- ruler

Lab Time

1. Take two clear glasses that fit snugly together when stacked. (Cylindrical glasses with straight sides work well.)
2. Fill one glass half-full with ice water and the other half-full with very hot water (definitely an adult job – and take care not to shatter the glass with the hot water!). Be sure to leave enough air space for the clouds to form in the hot glass.
3. Place the cold glass directly on top of the hot glass and wait several minutes. If the seal holds between the glasses, a rain cloud will form just below the bottom of the cold glass, and it actually rains inside the glass! (You can use a damp towel around the rim to help make a better seal if needed.)
4. Complete the table below. Measure the water height carefully with your ruler. If you have 2" of water in the hot water glass, then write 2". Please be careful when measuring hot water!

Indoor Rain Clouds Data Table

Hot Water Height	Ice Water Height	How well did it rain?

Exercises Answer the questions below:

1. Which combination made it rain the best? Why did this work?

2. Draw your experimental diagram here, labeling the different components:

3. Add in labels for the different phases of matter. Can you identify all three states of matter in your experiment?

Lesson #20: Soaking up Rays

Teacher Section

Overview: Students will experiment with dark- and light-colored paper and an ice cube to prove what they may have noticed before: Heat is transferred by radiation to dark colors more easily than light colors.

Suggested Time: 30-45 minutes

Objectives: Students will understand that the energy emitted by the sun is transmitted by radiation

Materials (per lab group)

- 2 ice cubes, about the same size
- white piece of paper
- black piece of paper
- a sunny day

Lab Preparation

1. Assemble items above and have them ready for each lab group.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

There are three ways to transfer heat: conduction, which means two objects touching; convection, where one of the objects is a fluid like water or air; and radiation, which doesn't need to be touching anything at all. Heat is transferred by radiation through electromagnetic waves. Energy is vibrating particles that can move by waves over a distance. If those vibrating particles hit something and cause those particles to vibrate, those particles begin to move faster, causing a temperature increase. The types of electromagnetic waves that transfer heat are infra-red waves.

If you hold your hand near an incandescent light bulb, you begin to feel heat on your hand. This is an example of heat traveling like a wave. This type of heat transfer is called radiation.

Now, don't panic. This is not a bad kind of radiation like you get from X-rays. It's infra-red radiation. Heat was transferred from the light bulb to your hand. The energy from the light bulb caused the molecules in your hand to resonate. Since the molecules in your hand are now moving faster, they have increased in temperature. Heat has been transferred! In fact, an incandescent light bulb gives off more energy in heat than it does in light. They are not very energy-efficient.

Now, if it's a hot sunny day outside, are your students better off wearing a black or white shirt if they want to stay cool? This experiment will help them figure it out. What they should eventually see is that the ice cube on the black sheet of paper melts faster than the ice cube on the white sheet. Dark colors absorb more infra-red radiation than light colors. Heat is transferred by radiation easier to something dark-colored than it is to something light-colored and so the black paper increases in temperature more than the white paper.

So, to answer the shirt question, a white shirt reflects more infra-red radiation so it will stay cooler. White walls, white cars, white seats, white shorts, white houses, etc. all act like mirrors for infra-red (IR) radiation. This is why you can aim your TV remote at a white wall and still turn on the TV. Simply pretend the wall is a mirror (so you can get the angle right), and bounce the beam off the wall before it gets to your TV. It looks like magic!

Lesson

1. Ask students if they have ever burned themselves by touching something hot. Allow for several answers, as this will get their minds geared up to think about heat. Say, "When you burned yourself, you felt something called conduction. This is where heat moves between two objects." Write the word conduction on the board.

2. Now, ask a volunteer to describe what it looks like when a pot of water is put on the stove to boil (bubbles form on the bottom then rise to the top, getting bigger and bigger). Say, "That is an example of convection. The heat rises from the bottom of the pan to the top, eventually boiling." Write convection on the board.

3. Pause before adding, "There is another way heat goes from one place to another. Can you guess what it is?" Allow students to discuss in pairs before discussing as a whole group. If they are struggling, draw a picture of a sun on the board. Say, "The sun transmits heat to the Earth using a totally different method called radiation." Write radiation on the board.

4. Briefly explain how radiation occurs, using the example of a light bulb. Say, "If you hold your hand near a light bulb, you begin to feel heat on your hand. This is an example of heat traveling like a wave. This type of heat transfer is called radiation." If your students are older or more advanced, explain in more detail: "It's actually a specific type of radiation called infra-red radiation. Heat was transferred from the light bulb to your hand, but how? The energy from the light bulb caused the molecules in your hand to vibrate. Since the molecules in your hand are now moving faster, they increase in temperature. Heat has been transferred from the light bulb to your hand!"

5. Pose this scenario: "It is a sunny day, and two students are outside. One is wearing a black shirt and the other a white shirt. Based on your experiences, which student will feel hotter?" Let them guess, but don't tell them the correct answer yet. Begin the experiment and let them discover for themselves.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Put the black paper and white paper on a sunny part of the sidewalk.
4. Put the ice cubes in the middle of the pieces of paper.
5. Wait. Record approximately how long it took for each ice cube to melt.

Exercises

1. How long did it take for the ice cube on black paper to melt? (answers will vary)
2. How long did it take for the ice cube on white paper to melt? (answers will vary)

3. What can you discover about light verses dark colors and the infra-red radiation of the sun based on this experiment? (Light colors reflect the infra-red radiation of the sun, and dark colors absorb it.)
4. What are three ways heat can be transferred? (conduction, convection, and radiation)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #20: Soaking up Rays

Student Worksheet

Name______________________________

Overview: It's a blistering hot day and you want to wear something cool. Will you choose the dark- or light-colored outfit? Is there science involved in fashion? You bet!

What to Learn: You should discover that the sun transfers its heat in a process called radiation and that dark colors absorb the infrared radiation while light colors reflect it.

Materials

- 2 ice cubes, about the same size
- white piece of paper
- black piece of paper
- a sunny day

Lab Time

1. Put the black paper and white paper on a sunny part of the sidewalk.
2. Put the ice cubes in the middle of the pieces of paper.
3. Wait. Record approximately how long it took for each ice cube to melt.

Exercises Answer the questions below:

1. How long did it take for the ice cube on black paper to melt? ____________________

2. How long did it take for the ice cube on white paper to melt? ____________________

3. What can you discover about light versus dark colors and the infra-red radiation of the sun based on this experiment?

4. What are three ways heat can be transferred?

Chemistry 1 Evaluation

Teacher Section

Overview: Kids will demonstrate how well they understand important key concepts from this section.

Suggested Time: 45-60 minutes

Objectives: Students will be tested on the key concepts of Section 1: Crystals, Atoms, Molecules, Polymers, Chemical Reactions, and States of Matter

- Structure of atoms and molecules
- Crystals are organized grouping of atoms or molecules that form specific patterns
- Supersaturated solid solutions
- Physical verses chemical change
- Indicators of a chemical change
- Molecules join together to form polymers
- States of matter: solids, liquids, gases, and plasma
- Non-Newtonian fluids
- Sublimation is the process by which a solid goes directly to a gas

Students will also demonstrate these principles:

4. Students will demonstrate understanding of atoms and molecules in a solid, liquid, and gas.
5. Students will demonstrate understanding of a chemical change by showing that when two or more substances are combined, a new substance may be formed that can have properties that are different from those of the original materials.
6. Students will demonstrate a technique to locate hidden carbon dioxide.

Materials (one set for entire class)

- 50 pennies
- borax (laundry whitener)
- water
- white glue
- disposable cups
- popsicle sticks
- tablespoon
- teaspoon
- chalk
- distilled white vinegar

Lab Preparation

1. Print out copies of the student worksheets, lab practical, and quiz.
2. Have a tub of the materials in front of you at your desk. Kids will come up when called and demonstrate their knowledge using these materials.

Lesson

The students are taking two tests today: the quiz and the lab practical. The quiz takes about 20 minutes, and you'll find the answer key to make it easy to grade.

Lab Practical

Students will demonstrate individually that they know how to demonstrate knowledge of the following: atoms and molecules in a solid, liquid, and gas; chemical change; and how to locate hidden carbon dioxide. While other kids are waiting for their turn, they will get started on their homework assignment. You get to decide whether they do their assignment individually or as a group.

Homework Assignment (Answer Sheet)

Part I. Using a periodic table, go on an element hunt. Write the name of each element in the first column, and the symbol of each element in the second column:

Fe	**iron**	zinc	**Zn**
Ni	**nickel**	potassium	**K**
Na	**sodium**	hydrogen	**H**
Ba	**barium**	helium	**He**
O	**oxygen**	fluorine	**F**
Xe	**xenon**	gold	**Au**
W	**tungsten**	mercury	**Hg**
Si	**silicon**	lead	**Pb**
C	**carbon**	neon	**Ne**
S	**sulfur**	nitrogen	**N**

Part II. Develop a game to test your knowledge about the names and symbols of these 20 elements.

Periodic Table of the Elements

Chemistry Reference Sheet

California Standards Test

Key

11 — Atomic number
Na — Element symbol
Sodium — Element name
22.99 — Average atomic mass*

Period	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 H Hydrogen 1.01																	2 He Helium 4.00
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)									

58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.

Chemistry 1 Evaluation

Student Worksheet

Overview: Today you're going to take two different tests: the quiz and the lab practical. You're going to take the written quiz first, and the lab practical at the end of this lab. The lab practical isn't a paper test – it's is where you get to show your teacher that you know how to do something.

Lab Test & Homework

1. Your teacher will call you up so you can share how much you understand about section 1: Crystals, Atoms, Molecules, Polymers, Chemical Reactions, and States of Matter, and how it works. Since science is so much more than just reading a book or circling the right answer, this is an important part of the test to find out what you really understand.
2. While you are waiting for your turn to show your teacher how much of this stuff you already know, you get to get started on your homework assignment. The assignment is due next week, and half the credit is for creativity and the other half is for content, so really let your imagination fly as you work through it. Here it is:

Unit 1 Homework Assignment

Part I. Using a periodic table, go on an element hunt! Write the name of each element in the first column, and the symbol of each element in the second column:

Fe	______________________	zinc	______________________
Ni	______________________	potassium	______________________
Na	______________________	hydrogen	______________________
Ba	______________________	helium	______________________
O	______________________	fluorine	______________________
Xe	______________________	gold	______________________
W	______________________	mercury	______________________
Si	______________________	lead	______________________
C	______________________	neon	______________________
S	______________________	nitrogen	______________________

Part II. Develop a game to test your knowledge about the names and symbols of these 20 elements.

Chemistry 1 Quiz

Teacher's Answer Key

1. Name at least three examples of chemical change. (Heat, color change, bubbles, foam, gel, ooze, cold, etc.)
2. What are crystals? (organized grouping of atoms or molecules that form specific patterns)
3. Why is it necessary to make a supersaturated solid solution to get sugar crystals? (With a normally saturated solution, the sugar crystals would simply dissolve in the water to make hot sugar water. When it cooled, it would make cool sugar water. With a supersaturated solution, the sugar "falls out" of solution as it cools, because it can no longer hold all of the sugar, and crystals are formed.)
4. What are polymers? (long chains of molecules)
5. Was making slime a physical or chemical reaction? How do you know? (chemical because it changed two substances into something completely different)
6. Why is moon sand called a non-Newtonian fluid? (its viscosity changes)
7. What is sublimation? When did you witness this event? (When a substance goes from a gas to a solid. It was seen when vinegar dissolved chalk to make carbon dioxide gas.)
8. Why does an egg turn "turn to rubber" when placed in vinegar? (the vinegar dissolves the calcium of the egg)
9. What are the four types of matter? (solid, liquid, gas, and plasma)
10. How does skin detect temperature? (The skin detects temperature *change* but not the actual temperature.)
11. Why do drops of water form on the outside of a cup of ice water? (The warmer air comes into contact with the cold glass, making the air molecules slow down and form water molecules.)
12. How were you able to make rain clouds? (When hot vapor rose from the hot cup and hit the cold air from the icy cup, the vapor condensed into liquid drops.)
13. Explain the difference between wearing light and dark colors in the sun. What happens to each? (Light colors reflect the infra-red radiation of the sun, and dark colors absorb it.)
14. How does a microwave heat things? (It uses electromagnetic waves to heat water molecules.)
15. What happens when you mix water and oil? What does this tell you about the density of oil? (They don't mix. The oil stays at the top, so it is less dense.)
16. How does a lava lamp work? (It uses materials that won't mix together—like oil and water—and have slightly different densities.)

Chemistry 1 Quiz

Name____

1. Name at least three examples of chemical change.
2. What are crystals?
3. Why is it necessary to make a supersaturated solid solution to get sugar crystals?
4. What are polymers?
5. Was making slime a physical or chemical reaction? How do you know?
6. Why is moon sand called a non-Newtonian fluid?
7. What is sublimation? When did you witness this event?
8. Why does an egg “turn to rubber” when placed in vinegar?
9. What are the four types of matter?
10. How does skin detect temperature?

11. Why do drops of water form on the outside of a cup of ice water?

12. How were you able to make rain clouds?

13. Explain the difference between wearing light and dark colors in the sun. What happens to each?

14. How does a microwave heat things?

15. What happens when you mix water and oil? What does this tell you about the density of oil?

16. How does a lava lamp work?

Chemistry 1 Lab Practical

Teacher's Answer Key

This is your chance to see how well your students have picked up on important key concepts, and if there are any holes. Your students also will be working on their homework assignment as you do this test individually with the students.

Materials:

- 50 pennies
- borax (laundry whitener)
- water
- white glue
- disposable cups
- popsicle sticks
- tablespoon
- teaspoon
- chalk
- distilled white vinegar

Lab Practical: Ask the student *Note: Answers given in italics!*

- Use these pennies to show how atoms and molecules are spaced in a solid, liquid, and gas. *Students should demonstrate knowledge that in a gas, the pennies are farthest apart; in a liquid they are closer together; in a solid, they are all touching one another.*

- Using borax, water, and glue, demonstrate how you can generate a chemical change. Explain how you know this is a chemical change. *Students should re-create the bouncy putty slime experiment by making a solution of water and borax in one cup, and a solution of water and glue in another cup. When the two solutions are mixed together, they form a completely different product, which signals a chemical reaction. Bonus points if they know this is a polymer!*

- Show there is hidden carbon dioxide in a piece of chalk. *Students should place the chalk in a cup filled with distilled white vinegar and point out the formation of carbon dioxide bubbles.*

Sample Project: Quick Rocketry

How to Use the Scientific Method for a Science Fair Project

This is a step-by-step guide on how to do a complete science fair project, from a spark of an idea through to the final presentation to the judges.

Every flying thing, whether it's an airplane, spacecraft, soccer ball, or flying kid, experiences four aerodynamic primary forces: lift, weight, thrust and drag. A rocket uses combustion, chemical reactions, or air pressure to generate both thrust (forward motion) and lift (upward movement). The fins are used for stability, unlike an airplane where the wings actually generate lift. The smooth, pencil-thin *aerodynamic* rocket shape minimizes drag. And the molecules that make up the rocket attribute to the weight.

Think of a time when you were riding in a fast-moving car. Roll down the window and stick your hand out, palm down. Notice how easily the wind slips over your hand. Now turn your palm facing the horizon. Which way do you feel more force against your hand?

When designing airplanes, engineers pay attention to details, such as the size and shape of their flying machines. They also look at the position of two important points: the *center of gravity* and the *center of pressure* (also called the *center of lift*). On a rocket, if the location of the *center of gravity* and *center of pressure* points are swapped, the rocket's flight is unstable and it somersaults chaotically (sick bags, anyone?).

Your first step: Doing Research. *Why* do you want to do this project? What originally got you interested in rockets? Is it the aerodynamic shape, the fin design, or do you just like blowing things up?

Take a walk to your local library, flip through magazines, and surf online for information you can find about rockets. Learn what other people have already figured out before you start re-inventing the wheel!

Flip open your science journal and write down things you've found out. Your journal is just for you, so don't be shy about jotting ideas or interesting tidbits down. Also keep track of which books you found interesting. You'll need these titles later in case you need to refer back for something, and also for your bibliography, which needs to have at least three sources that are not from the internet.

Your next step: Define what it is that you really want to do. In this project, we're going to walk you step by step through building a simple rocket that works by a chemical reaction. Go shopping and gather your equipment together now.

Materials: Before we start the real experiment, you'll need to gather items that may not be around your house right now. Take a minute to take inventory of what you already have and what you'll need.

- Fuji film canister (get at least three)
- Effervescent tablets (at least 48 tablets)
- Water (distilled or tap)
- Syringe to measure water or teaspoon/tablespoon measuring spoons
- Measuring tape or meter stick (yard stick)
- Thermometer to measure water temperature
- Stopwatch or clock (optional)
- Scale to measure weight of tablet (optional)
- Camera to document project
- Composition or spiral-bound notebook to take notes
- Display board (the three-panel kind with wings), about 48" wide by 36" tall
- Paper for the printer (and photo paper for printing out your photos from the camera)
- Computer and printer

Play with the experiment before you design the procedure. Place an effervescent tablet in a canister (you may need to break it into pieces) and fill partway with water. Working quickly, cap it and invert it on the sidewalk. Stand back… POP! You'll find there's an optimal water level for maximum height. If you work fast, you can get about four launches from one tablet. What happens if you try two tablets at once?

Why does that work? The tablets contain sodium bicarbonate (baking soda) and citric acid (a solid form of vinegar). What happens when you mix together vinegar and baking soda? It fizzes all over the place, doesn't it? Note that this reaction takes place because the vinegar (acetic acid) is in a liquid state. Notice how the effervescent tablets contain both chemicals, but they don't react until you get them wet.

(There's a more detailed description in the sample report, if you want to know more about what's *really* going, chemically-speaking.)

The chemical reaction of sodium bicarbonate and citric acid generates carbon dioxide gas bubbles (the same molecule you burp after chugging an entire soda), and those bubbles foam up and out of the canister. When you cap it, there's no room for the bubbles to go, and they build up pressure… and more pressure… and more pressure… until POP! There's so much pressure that the canister just can't hold it together anymore, and off flies the cap (or the canister, if you've inverted the canister).

Formulate your Question or Hypothesis: You'll need to nail down ONE question or statement you want to test if it is true. Be careful with this experiment - you can easily have several variables running around and messing up your data if you're not mindful. Here are a few possible questions:

- Do more tablets give a higher flight?
- Does more water give a higher flight?
- Does less water give a higher flight?

Once you've got your question, you'll need to identify the *control* and the *variable.* For the question: "Does more water give a higher flight?" your control would be one tablet, and your variable is the amount of water.

Taking Data: Sticking with the question "Does more water give a higher flight?" here's how to record data. Grab a sheet of paper, and across the top, write down your background information, such as your name, date, time of day, weather (and wind conditions), size of tablet (in weight, or grams - check the box), water temperature (in degrees), and anything else you'd need to know if you wanted to repeat this experiment *exactly* the same way on a different day.

Get your paper ready to take data… and write across your paper these column headers, including the things in ( ): (Note – there's a sample data sheet on page 10).

- Trial #
- Water (teaspoons)
- Time to Launch (seconds)
  Note: This is the time it takes for the rocket to pop after you've capped it.
- Maximum Altitude (feet)

Run your experiment starting with no water… while this seems pointless, you still need to test and see what happens. Plus, this is an excellent time to pull out your camera and get a good photo of you doing your experiment (you'll use this later on your display board). Run your experiment again and again, increasing the water amount by one teaspoon each time until you reach the volumetric limit of your film canister.

Hot Tip: Be sure to use a fresh tablet EACH TIME, or you'll also be varying the amount of tablet (chemical reactant) in this experiment as well. Don't forget to take photos as you go along - see if you can get a picture of the rocket actually blasting off the ground!

NOTE: Kodak (black) canisters will NOT work for this experiment!!

Analyze your data. Time to take a hard look at your numbers! Make yourself a grid (or use graph paper), and plot the *Altitude Height* (in feet) versus the *Water Amount* (in tsp). In this case, *Water Amount* goes on the horizontal axis, and *Altitude* goes on the vertical axis. You can make a second graph showing the *Altitude* (feet) and *Time to Launch* (seconds).

For Advanced Students: Use your projectile motion equations from physics to check your measurements against your theoretical values. You can even calculate percent error, too!

Conclusion: So - what did you find out? What water amount gives you the highest altitude? Is it what you originally guessed? Science is one of the only fields where people actually *throw a party* when stuff works out differently than they expected! Scientists are investigators, and they get *really* excited when they get to scratch their heads and learn something new.

One of the biggest mistakes you can ever make is to fudge your data so it matches what you wanted to have happen. Don't *ever* be tempted to do this… science is based on observational fact. Think of it this way: The laws of the universe are still working, and it's your chance to learn something new!

Recommendations: This is where you need to come up with a few ideas for further experimentation. If someone else was to take your results and data, and wanted to do more with it, what would they do? Here are a few spins on the original experiment:

> Hot glue foam fins and a foam nose to the rocket body. Put the fins on at an angle and watch it spin as it flies upward. You can also tip it sideways and add wheels for a rocket car. Stack them high for a multi-staging project, or strap three together with tape and launch them at the same time! You can also try different containers using corks instead of snap-on lids.
>
> What other chemicals do you have which also produces a gas during the chemical reaction? Chalk, vinegar, baking soda, baking powder, hydrogen peroxide, isopropyl alcohol, lemon juice, orange juice…

Make the display board. Fire up the computer, stick paper in the printer, and print out the stuff you need for your science board. Here are the highlights:

- Catchy Title: This should encompass your basic question (or hypothesis).
- Purpose and Introduction: Why study this topic?
- Results and Analysis: You can use your actual data sheet if it's neat enough, otherwise print one out.
- Methods & Materials: What did you use and how did you do it? (Print out photos of you and your experiment.)
- Conclusion: One sentence tells all. What did you find out?
- Recommendations: For further study.
- References: Who else has done work like this? (Wernher von Braun, Robert Goddard, etc.)

Outline your presentation. People are going to want to see you demonstrate your rockets, and you'll need to be prepared to answer any questions they have. We'll detail more of this in the later section of this guidebook, but the main idea is to talk about the different sections of your display board in a friendly, knowledgeable way that gets your point across quickly and easily. Test drive your presentation on friends and relatives beforehand and you'll be smoothly polished for the big day.

Sample Data Sheets

Rocket Data Log

Name

Number/Size of Tablet

Date

Water Temperature

Time

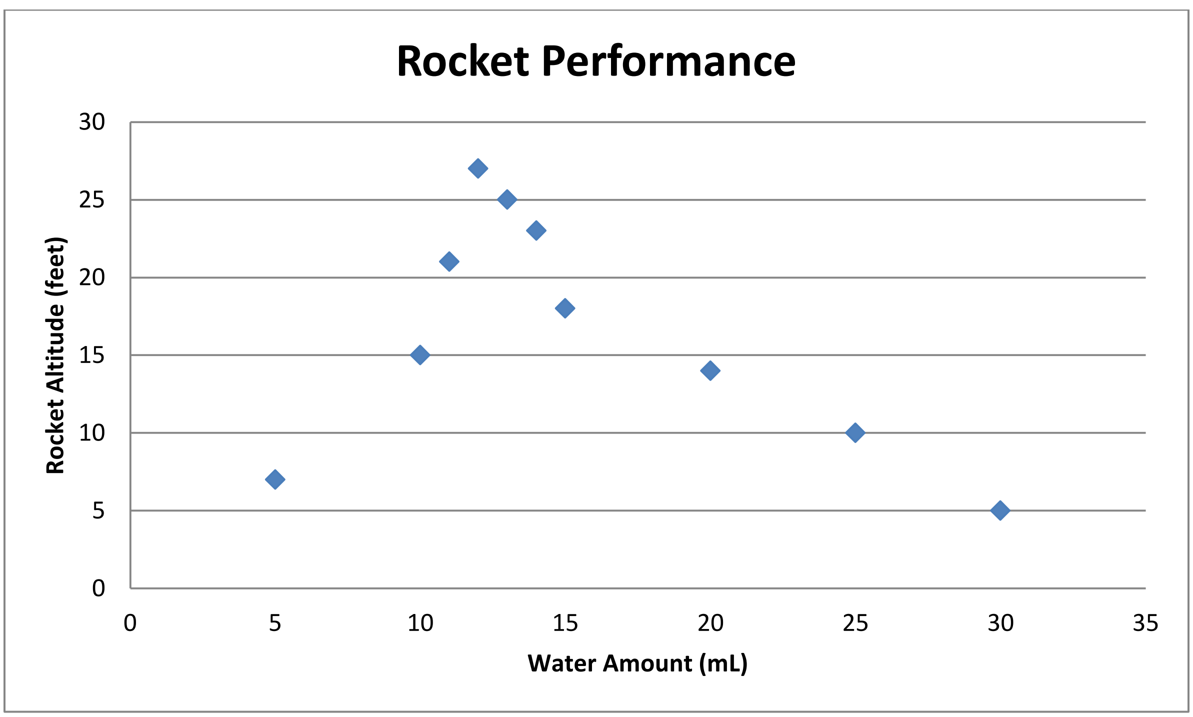
Weather Conditions

Trial Number	Amount of Water	Time to Launch	Maximum Altitude
	(mL)	(seconds)	(feet)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

SAMPLE Rocket Data Log

Name	*Aurora*	**Number/Size of Tablet**	*1 tablet*
Date	*November 12, 2009*	**Water Temperature**	*75 deg. F*
Time of Day	*12:05pm*	**Weather Conditions**	*Clear, 65 deg., calm*

Trial Number	Amount of Water	Time to Launch	Maximum Altitude
	(mL)	(seconds)	(feet)
1	5	5.4	7
2	10	3.2	15
3	15	4.6	18
4	20	2.3	14
5	25	2.1	10
6	30	1.9	5
7	11	4.4	21
8	12	4.5	27
9	13	4.3	25
10	14	4.2	23



Note – The numbers shown here are NOT from a real experiment… be sure to get your own!

Sample Report

In this next section, we've written a sample report for you to look over and use as a guide. Be sure to insert your own words, data, and ideas in addition to charts, photos, and models!

Title of Project

(Your title can be catchy and clever, but make sure it is as descriptively accurate as possible. Center and make your title the LARGEST font on the page.)

by Aurora Lipper

123 Main Street,
Sacramento, CA 10101

Carmel Valley Grade School
6th grade

Table of Contents

Abstract

This is a *summary* of your entire project. Always write this section LAST, as you need to include a brief description of your background research, hypothesis, materials, experiment setup and procedure, results, and conclusions. Keep it short, concise, and less than 250 words.

Here's a sample from Aurora's report:

How high can a chemical reaction really power a rocket? After researching streamline designs by Bernoulli to minimize drag, multi-staging ideas from Robert Goddard to increase total rocket thrust, and taking a closer look at the chemical reaction of combining baking soda and vinegar,
I realized I had all the basics for making a high-flying rocket. But how high could it really go?

I hypothesized the rocket would fly the highest when the most amount of chemical reactants were inside the rocket. Using generic effervescent tablets combined with water for the chemical reaction and a Fuji film canister for the rocket body, I ran ten trials varying the amount of water (increasing in increments of 5mL with each trial) combined with one standard effervescent tablet and measured the maximum altitude height reached using a measuring tape against a 30' high wall.

I found that my initial hypothesis was false. **The rocket actually flew the highest (27 feet vertically) when I combined one effervescent tablet with 12mL of water.** (It actually flew the poorest when I filled the entire canister with chemical reactants, as I originally had hypothesized.)

For further study, I recommend running an experiment to test the various available water types (tap water, distilled, filtered, etc.) and also another experiment to test for the ideal water temperature that will yield the highest rocket altitude. This experiment was a lot of fun, and had unexpected results; and I learned something new!

Introduction

This is where all your background research goes. When you initially wrote in your science journal, what did you find out? Write down a few paragraphs about interesting things you learned that eventually led up to your main hypothesis (or question).

Here is a sample from Aurora's report:

Rockets have been around for a long time. Black powder was first recorded being used in the first century, but it wasn't until the ninth century that the Chinese actually used gunpowder to launch projectiles. Three hundred years later, the first rockets were being launched in China and the Orient, some as military applications, others as fireworks for royal celebrations.

Early rockets were hard to control, both from the lack of knowledge about aerodynamics as well as not having the right tools for the job. Rockets would frequently veer sharply off-course and somersault unexpectedly, and it wasn't until the early 1900s when rocket designs were seriously improved by two great scientists: Robert Goddard and Wernher von Braun. Goddard figured out that rockets could be arranged in stages to reach higher altitudes, and von Braun's aeronautical designs made rocket flight stable and steerable.

Daniel Bernoulli in the 1700s figured out that the more streamlined an object is, the more easily it slips through the air. This reminds me of when I stick my hand out the car window – if I face my palm toward the oncoming wind, I feel more force on my arm than when I have my palm down. My hand is more *aerodynamic* when it faces down, and has a lot more drag force when it faces the wind.

When researching rocket engines, I realized I needed a way to launch the rocket without using a combustion reaction. Chemical reactions involving baking soda and vinegar give off a lot of gas bubbles, and I wondered if using one of these to pressurize a small canister (rocket) could work. And what kind of gas does it give off?

The reaction of baking soda and vinegar is deceptively simple: What appears to be one reaction is actually two, happening in quick succession. The first reaction takes the vinegar and baking soda (sodium bicarbonate) and forms carbonic acid. But carbonic acid is really unstable (meaning that it falls apart easily), and it breaks into water and carbon dioxide as soon as it forms. This means that the gas bubbles are carbon dioxide, since carbon dioxide needs to be at -109^{o}F to become a solid. (Carbon dioxide goes straight from a solid to a gas (called sublimation) at temperatures above -109^{o}F.) The gas bubbles escape from the liquid (called effervescence), leaving water behind with a bit of sodium acetate in the water.

Purpose

Why are you doing this science fair project at all? What got you interested in this topic? How can you use what you learn here in the future? Why is this important to you?

Come up with your own story and ideas about why you're interested in this topic. Write a few sentences to a few paragraphs in this section.

Hypothesis

This is where you write down your speculation about the project – what you think will happen when you run your experiment. Be sure to include *why* you came up with this educated guess. Be sure to write at least two full sentences.

Here's a sample from Aurora's report:

My hypothesis is that the more water used in the rocket, the higher it will fly. The combination of water and effervescent tablets generates carbon dioxide gas, which pressurizes the rocket (film canister). My best educated guess is that the more water I use, the more gas is produced, and the higher the rocket will fly.

Materials

What did you use to do your project? Make sure you list *everything* you used, even equipment you measured with (rulers, stopwatch, etc.) If you need specific amounts of materials, make sure you list those, too! Check with your school to see which unit system you should use. (Metric or SI = millimeters, meters, kilograms. English or US = inches, feet, pounds.)

Here's a sample from Aurora's report:

Fuji film canister (2.45 in^3 or 40.2 cm^3)
Effervescent tablets (3.4 grams each)
Water (75°F distilled, used in 5mL increments)
Syringe to measure water (5mL)
Measuring tape
Digital thermometer
Stopwatch
Scale to measure weight of tablet
Camera to document project
My Science Journal to take notes

Procedures

This is the place to write a highly detailed description of what you did to perform your experiment. Write this as if you were telling someone else how to do your exact experiment and reproduce the same results you achieved. If you think you're overdoing the detail, you're probably just at the right level. Diagrams, photos, etc. are a great addition (NOT a substitution) to writing your description.

Here's a sample from Aurora's report:

First, I became familiar with the experiment and setup. I plopped an effervescent tablet into a glass of water and watched it fizz. Then I tried the same thing in a film canister and snapped the lid on and watched what happened. After about four or five runs, I began to figure out how to get the film top on before the rocket exploded. Getting familiar with your equipment is a vital first step!

Once I was comfortable with the setup, I could now focus on my variable (water level) and how to measure it. I found a very tall grown up, a ladder, and a telephone pole and had my helper make chalk marks in increments of one foot from the sidewalk to 30' above the ground. I made sure to perform this experiment in the morning when the winds were calm, and ran through all my trials at the same time of day to minimize my variables.

I made myself a data logger in my science journal, and then brought my materials for this experiment outside. Using my digital thermometer, I first measured my pint of distilled water and recorded the water temperature in my science journal. Filling my syringe with water, I squirted 5mL of water carefully into a white Fuji film canister. I unwrapped one effervescent tablet, plopped it in and quickly snapped on the lid and inverted it top-side-down onto the sidewalk about a foot away from the marked telephone pole and waited for the launch. My assistant was armed with a stopwatch timer and measured from the time the reaction began (when I plopped in the tablets) to the time the rocket had just launched. (We didn't end up using this measurement.)

When the rocket reached maximum height, I recorded the measurement taken by eye in my data sheet. (We also took video so we could rewind and see the rocket against the pole, but we needed to first paint it bright orange in order for the tiny rocket to show up on film.)

After the first trial, I collected the canister and lid, cleaned and dried both, and used 10mL of water and a fresh effervescent tablet in the container. I continued this process, increasing the amount of water by 5mL with each trial, then went back to test specific amounts later.

Results

This is the data you logged in your Science Journal. Include a chart or graph – whichever suits your data the best – or both if that works for you. Use a scatter or bar graph, label the axes with units, and title the graph with something more descriptive than "Y vs. X or Y as a function of X". On the vertical (y-axis) goes your dependent variable (the one you recorded), and the horizontal (x-axis) holds the independent variable (the one you changed).

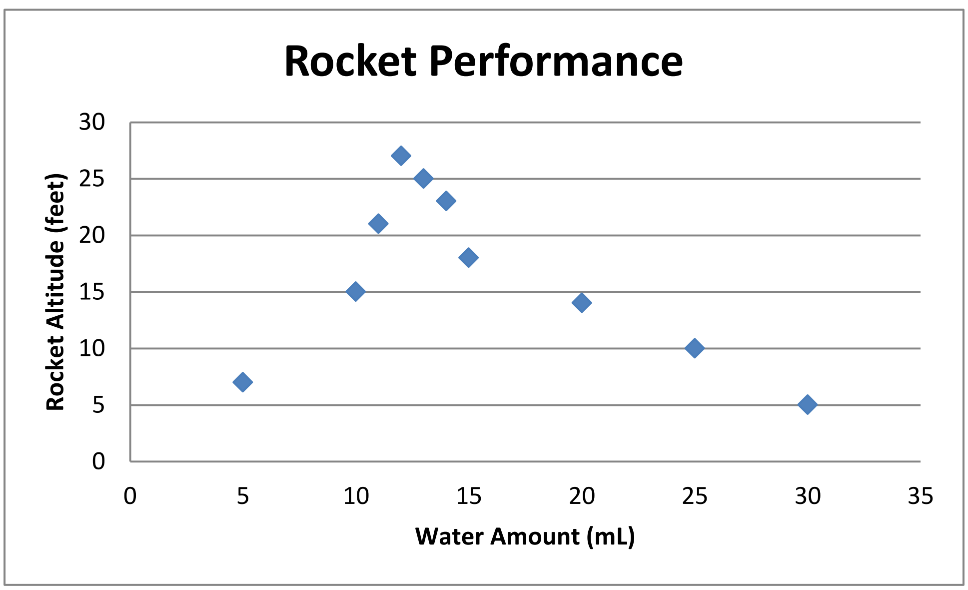
Here's a sample from Aurora's report on the next page.

The results from the experiment are shown in the table and chart below.

Rocket Data Log

Name	Aurora Lipper	**Number/Size of Tablet**	3.24 grams per tablet
Date	12/02/2009	**Water Temperature**	75 ^{o}F
Time of Day	9:54 am	**Weather Conditions**	Calm, sunny, 65^{o}F

Trial Number	Amount of Water	Time to Launch	Maximum Altitude
	(mL)	(seconds)	(feet)
1	5	5.4	7
2	10	3.2	15
3	15	4.6	18
4	20	2.3	14
5	25	2.1	10
6	30	1.9	5
7	11	4.4	21
8	12	4.5	27
9	13	4.3	25
10	14	4.2	23



Conclusion

Conclusions are the place to state what you found. Compare your results with your initial hypothesis or question – do your results support or not support your hypothesis? Avoid using the words "right", "wrong", and "prove" here. Instead, focus on what problems you ran into as well as why (or why not) your data supported (or didn't support) your initial hypothesis. Are there any places you may have made mistakes or not done a careful job? How could you improve this for next time? Don't be shy – let everyone know what you learned!

Here's a sample from Aurora's report:

I found that my data from this experiment did not support my hypothesis. The rocket actually flew the highest (27 feet vertically) when I combined one effervescent tablet with 12mL of water. (It actually flew the poorest when I filled the entire canister with chemical reactants, as I originally had hypothesized.)

I did not have absolute control over the outside weather conditions, which may have affected my rocket's performance a bit. Next time, I'd recommend doing this indoors in a large (and tall) building, such as a gymnasium. I also didn't have the best measuring device, as I had to estimate by eye the actual height of something tiny flying nearly 30' above my head. Next time, I can use a height gauge (a plumb bob attached to a protractor with a straw to peek through) and a bit of geometry to find the altitude more accurately.

For further study, I recommend running an experiment to test the various available water types (tap water, distilled, filtered, etc.) and also another experiment to test for the ideal water temperature that will yield the highest rocket altitude. This experiment was a lot of fun, and had unexpected results; and I learned something new!

Bibliography

Every source of information you collected and used for your project gets listed here. Most of the time, people like to see at least five sources of information listed, with a maximum of two being from the Internet. If you're short on sources, don't forget to look through magazines, books, encyclopedias, journals, newsletters… and you can also list personal interviews.

Here's an example from Aurora's report:
(The first four are book references, and the last one is a journal reference.)

Fox, McDonald, Pritchard. Introduction to Fluid Mechanics, Wiley, 2005.

Hickam, Homer. Rocket Boys, Dell Publishing, 1998.

Gurstelle, William. Backyard Ballistics, Chicago Review Press, 2001.

Turner, Martin. Rocket and Spacecraft Propulsion. Springer Praxis Books, 2001.

Eisfeld, Rainer. "The Life of Wernher von Braun." Journal of Military History Vol 70 No. 4. October 2006: 1177-1178.

Acknowledgements

This is your big change to thank anyone and everyone who have helped you with your science fair project. Don't forget about parents, siblings, teachers, helpers, assistants, friends…

Formatting notes for your report: Keep it straight and simple: 12 point font in Times new Roman, margins set at 1" on each side, single or 1.5 spaced, label all pages with a number and total number of pages (see bottom of page for sample), and put standard information in the header or footer on every page in case the report gets mixed up in the shuffle (but if you bind your report, you won't need to worry about this). Create the table of contents at the end of the report, so you can insert the correct page numbers when you're finished.

Add a photo of your experiment in action to the title page for a dynamic front page!

Exhibit Display Board

Your display board holds the key to communicating your science project quickly and efficiently with others. You'll need to find a tri-fold cardboard or foam-core board with three panels or "wings" on both sides. The board, when outstretched, measures three feet high and four feet long.

Your display board contains *all* the different parts of your report (research, abstract, hypothesis, experiment, results, conclusion, etc.), so it's important to write the report *first*. Once you've completed your report, you'll take the best parts of each section and print it out in a format that's easy to read and understand. You'll need to present your information in a way that people can stroll by and not only get hooked into learning more, but can easily figure out what you're trying to explain. Organize the information the way museums do, or even magazines or newspapers.

How to Write for your Display Board: Clarity and neatness are your top tips to keep in mind. The only reason for having a board is to communicate your work with the rest of the world. Here are the simple steps you need to know:

Using your computer, create text for your board from your different report sections. You'll need to write text for the title, a purpose statement, an abstract, your hypothesis, the procedure, data and results with charts, graphs, analysis, and your conclusions. And the best part is - it's all in your report! All you need to do is copy the words and paste into a fresh document so you can play with the formatting.

The title of your project stands out at the very top, and can even have its own "shingle" propped up above the display board. The title should be in Times New Roman or Arial, at least 60 point font... something strong, bold, and easy to read from across the room. The title has to accurately describe your experiment *and* grab people's attention. Here are some ideas to get you started:

- Burp-Blasting Rockets: Determining the Ideal Mixture in a Chemical Reaction
- How to Belch a Rocket: Studying the Principles of Pressurization and Propulsion
- Flameless Rockets: The Effect of Temperature on a Chemical Reaction
- How to Turn your Indigestion into Rocket Fuel: Investigating the Thrust Ratio of a Rocket

On the left panel at the top, place your abstract in 16-18 pt font. Underneath, post your purpose, followed by your hypothesis in 24 point font. Your list of materials or background research can go at the bottom section of the left panel. If you're cramped for space, put the purpose in the center of the board under the title.

In the central portion of the board, post your title in large lettering (24-60 pt. font). (You can alternatively make the title on a separate board and attach to the top of the display board… which is *great* if you really want to stand out!) Under the title, write a one-sentence description of what your project is really about in smaller font size (24-48 pt. font) Under the title, you'll need to include highlights from your background research (if you haven't put it on the left panel already) as well as your experimental setup and procedures. Use photos to help describe your process.

The right panel holds your results with prominent graphs and/or charts, and clear and concise conclusions. You can add tips for further study (recommendations) and acknowledgements beneath the conclusions in addition to your name, school, and even a photo of yourself doing your project.

Use white copy paper (*not* glossy, or you'll have a glare problem) and 18 point Times New Roman, Arial, or Verdana font. Although this seems obvious, spell-check and grammar-check each sentence, as sometimes the computer does make mistakes! Cardstock (instead of white copy paper) won't wrinkle in areas of high humidity.

Cut out each description neatly and frame with different colored paper (place a slightly larger piece of paper behind the white paper and glue in place. Trim border after the glue has dried. Use small amounts of white glue or hot glue in the corners of each sheet, or tape together with double-sided sticky tape. Before you glue the framed text descriptions to your board, arrange them in different patterns to find the best one that works for your work. Make sure to test out the position of the titles, photos, and text together before gluing into place!

In addition to words, be sure to post as many photos as are pleasing to the eye and also helps get your point across to an audience. The best photos are of *you* taking real data, doing real science. Keep the pictures clean, neat, and with a matte finish. Photos look great when bordered with different colored paper (stick a slightly larger piece of paper behind the photo for a framing effect). If you want to add a caption, print it on a sheet of white paper, cut it out, and place it near the top or bottom edge of the photo, so your audience clearly can tell which photo the caption belongs to. Don't add text directly to your photo (like in Photoshop), as photos are rich in color, and text requires a solid color background for proper reading.

Check over your board as you work and see if your display makes a clear statement of your hypothesis or question, the background (research) behind your experiment, the experimental method itself, and a clear and compelling statement of your results (conclusion). Select the text you write with care, making sure to add in charts, graphics, and photos where you need to in order to get your point across as efficiently as possible. Test drive your board on unsuspecting friends and relatives to see if they can tell you what your project is about by just reading over your display board.

How to Stand Out in a Crowd: Ever try to decide on a new brand of cereal? Which box do you choose? All the boxes are competing for your attention… and out of about a hundred, you pick one. This is how your board is going to look to the rest of the audience – as just one of the crowd. So, how do you stand out and get noticed?

First, make sure you have a BIG title – something that can be clearly seen from across the room. Use color to add flair without being too gaudy. Pick two colors to be your "color scheme," adding a third for highlights. For example, a black/red/gold theme would look like: a black cardboard display board with text boxes framed with red, and a title bar with a black background with red lettering highlighted with gold (using two sets of "sticky" letters offset from each other). Or a blue/yellow scheme might look like: royal blue foam core display board with textboxes framed with strong yellow. Add color photographs and color charts for depth. Don't forget that the white in your textboxes is going to add to your color scheme, too, so you'll need to balance the color out with a few darker shades as you go along.

It's important to note that while stars, glitter, and sparkles may attract the eye, but they may also detract from displaying that you are about "real science." Keep a professional look to your display as you play with colors and shades. If you add something to your board, make sure it's there to help the viewer get a better feel for your work.

For a rocketry exhibit, you can add tongues of flames up the edges of your display board and around the top of your board in red, orange, or gold. Add an 18" – 36" model rocket (if you have one nicely painted) poking out the top of your board as an attention-getter. Have a beaker filled with water and drop in a few tablets when people start passing by. Wear a lab coat and safety goggles, but be sure that the look you've got is professional, not costume.

If you're stuck for ideas, here are a few that you might be able to use for your display board. Be sure to check with your local science fair regulations, to be sure these ideas are allowed on your board:

- Your name and photo of yourself taking data on the display board
- Captions that include the source for every picture or image
- Acknowledgements of people who helped you in the lower right panel
- Your scientific journal or engineer's notebook
- The experimental equipment used to take data and do real science
- Photo album of your progress (captions with each photo)

Oral Presentation

You're now the expert of the Rocketry Experiment… you've researched the topic, thought up a question, formulated a hypothesis, done the experiment, worked through challenges, taken data, finalized your results into conclusions, written the report, and built a display board worthy of a museum exhibit. Now all you need is to prep for the questions people are going to ask. There are two main types of presentations: one for the casual observer, and one for the judges.

The Informal Talk: In the first case, you'll need quick and easy answers for the people who stroll by and ask, "What's this about?" The answers to these questions are short and straightforward – they don't want a highly detailed explanation, just something to appease their curiosity. Remember that people learn new ideas quickly when you can relate it to something they already know or have experience with. And if you can do it elegantly through a story, it will come off as polished and professional. Here's an example:

> You see people wandering by, stopping in front of the board. Step up to them and ask: "What about my display caught your eye?"
>
> After they mention or point to something, you can start talking *briefly* about it, preferably with some snippet that will peak their interest. For instance: "Yes, that's the time it flew onto the roof. I had to retake that set of data, though. Let me know if you have any questions."
>
> If they have more questions, and ask about how your rocket works, you can say:
>
> "I'll bet you already know the most important parts about rocket science. Here, let me know you how you already know the Universal Laws of Physical Motion…" and pull out an un-inflated balloon as you continue:
>
> "If I blow this up, and hold it here in my fingers, which way will the balloon go when I release it?" They point one direction.
>
> "Which way will the air inside the balloon go?" They point in the other direction.
>
> "That's right – equal and opposite. The third law is, 'For every action, there is an equal and opposite reaction'. A rocket works the same way. The flames come out this side (point to the engine), and the rocket goes this way. See? You're practically a rocket scientist yourself!"

The Formal Presentation: The second talk is the one you'll need to spend time on. This is the place where you need to talk about everything in your report without putting the judges to sleep. Remember, they're hearing from tons of kids all day long. The more interesting you are, the more memorable you'll be.

Tips & Tricks for Presentations: Be sure to include professionalism, clarity, neatness, and "real-ness" in your presentation of the project. You want to show the judges how you did "real" science – you had a question you wanted answered, you found out all you could about the topic, you planned a project around a basic question, you observed what happened and figured out a conclusion.

Referring back to your written report, write down the highlights from each section onto an index card. (You should have one card for each section.) What's the most important idea you want the judges to realize in each section? Here's an example:

Research Card: How high can a chemical reaction really power a rocket? After researching streamline designs by Bernoulli to minimize drag, multi-staging ideas from Robert Goddard to increase total rocket thrust, and taking a closer look at the chemical reaction of combining baking soda and vinegar, I realized I had all the basics for making a high-flying rocket.

Question/Hypothesis Card: But how high could it really go? I hypothesized the rocket would fly the highest when the most amount of chemical reactants were inside the rocket.

Procedure/Experiment Card: Using generic effervescent tablets combined with water for the chemical reaction and a Fuji film canister for the rocket body, I ran ten trials varying the amount of water (increasing in increments of 5mL with each trial) combined with one standard effervescent tablet and measured the maximum altitude height reached using a measuring tape against a 30' high telephone pole.

Results/Conclusion Card: The data recorded did not support my hypothesis. The rocket actually flew the highest (27 feet vertically) when I combined one effervescent tablet with 12mL of water. (It actually flew the poorest when I filled the entire canister with chemical reactants, as I originally had hypothesized.)

Recommendations Card: For further study, I recommend running an experiment to test the various available water types (tap water, distilled, filtered, etc.) and also another experiment to test for the ideal water temperature that will yield the highest rocket altitude. This experiment was a lot of fun, and had unexpected results: and I learned something new!

Acknowledgements Card: I want to express my thanks to mom for driving me to the drug store three different times in one week, for my teacher who encourages me to go further than I really think I can go, and for dad for his help building model rockets that inspired me in the first place.

Putting it all together… Did you notice how the content of the cards were already in your report, in the abstract section? The written report is such a vital piece to your science fair project, and by writing it first, it makes the rest of the work a lot easier. You can do the tougher pieces (like the oral presentation) later because you took care of the report upstream.

As you practice your oral presentation, try to get your notes down to only one index card. Shuffling through papers onstage detracts from your clean, professional look. While you don't need to memorize exactly what you're going to say, you certainly can speak with confidence because you've done every step of this project yourself.

You're done! Congratulations!! Be sure to take lots of photos, and send us one! We'd love to see what you've done and how you've done it. If you have any suggestions, comments, or feedback, let us know! We're a small company staffed entirely human beings, and we're happy to help you strive higher!

Vocabulary for the Unit

Acids are sour (like a lemon), react with metals, and can burn your skin. They register between 1 and 7 on the pH scale.

An **atom** is the smallest part of stable matter. Atoms are made up of protons and neutrons that are in the center of an atom (the nucleus) and electrons that are moving around outside the nucleus. Atoms differ from one another by how many protons, neutrons, and electrons they have in them.

Bases are bitter (like baking soda), slippery, and can also burn your skin. They measure between 7 and 14 on the pH scale.

A **chemical change** rearranges the molecules and atoms to create new molecule combinations (like a campfire).

Chemists study **chemical kinetics** when they want to control the speed of a reaction as well as what gets generated from the process (the products of the reaction). Several factors affect the speed of a chemical reaction, including catalysts, surface area, temperature, and concentration.

Cleavage in a solid refers to the way in which the crystals break apart, usually in a straight line.

A **combustion reaction** gives off energy, usually in the form of heat and light.

Condensation is the process by which a gas or vapor changes into a liquid.

Chemicals form various **crystal structures** when they freeze. Water is one of the few molecules which expand when changing from a liquid to a solid. Atoms in a solid have a tendency to form **crystals**, since the molecules are pulled close together and tight, causing them to form specific patterns.

Density is a measurement of mass and volume. The denser something is, the tighter its atoms are packed together. Mathematically, density is mass/volume.

Elasticity is the ability of a solid to be stretched, twisted or squashed and come back to its original shape.

Electrons don't orbit nuclei. They pop in and pop out of existence. Electrons do tend to stay at a certain distance from a nucleus. This area that the electron tends to stay in is called a shell. The electrons move so fast around the shell that the shell forms a balloon-like ball around the nucleus.

Elements A substance made up of only one particular kind of atom is called a chemical element, and you can find a whole slew of these on the periodic table. The number assigned to the chemical element refers to the number of protons in the nucleus. There are over 112 elements, 90 of which are found naturally. Twelve different elements are the major ingredients of over 90% of all matter. Five different elements are the major ingredients of all living things.

Endothermic reactions are reactions that absorb heat when they react (like a cold compress).

Exothermic reactions release energy in the form of heat, light, and sound (think fireworks).

Evaporation occurs when a liquid changes into a gas.

Gases have no bonds between the molecules.

The jiggling motion in atoms is called **heat**.

Different **indicators** are used for specific ranges of acids and bases. Phenolphthalein changes from clear to pink when added to a base.

Atoms that have an electrical charge are called **ions**, as they have a different number of electrons than protons.

Liquids have loose, stringy bonds between molecules that hold molecules together but allow them some flexibility.

Mass is a measure of how much matter (how many atoms) make up an object.

Matter is anything that has mass (anything that is affected by gravity). Most matter on our planet is made up of atoms and ions. Not all matter is made up of atoms, but all matter is made up of some kind of particle. Carbon, hydrogen, oxygen, nitrogen, and calcium are the five main elements that make up all living matter.

Changing from a solid to a liquid is called **melting**. Melting point is the temperature at which a material changes from solid to liquid. Objects absorb heat as they melt.

A **molecule** is the smallest unit of a compound that still has the compound's properties attached to it. Molecules are made up of two or more atoms held together by covalent bonds.

A **non-Newtonian** fluid, such as moon sand, is a substance that changes viscosity.

A periodic chart has a bunch of boxes, each representing one element. In each box is a ton of information about each element. In the upper left hand corner of each box is what's called the atomic number. The atomic number is the same as the number of protons in the atom.

pH stands for "power of hydrogen" and is a measure of how acidic a substance is.

A **physical change** happens when the molecules stay the same, but the volume and/or shape change (like wadding up tissue).

Plasma is basically a very high-energy gas. It is not very common on Earth but is the most common state of matter in the universe. Gas becomes plasma when the molecules move about so rapidly that they knock electrons off the atoms when they collide.

Polymers are long chains of slippery molecules. Coagulation happens when you cross-link the chains into a fishnet-looking design.

Radiation is heat transfer through waves.

Different factors affect the **rate of reaction**, or speed of the chemical reaction, including temperature, pressure, surface area, catalysts, and more. The main idea is that the more collisions between particles, the faster the reaction will take place.

Solids are the lowest energy form of matter on Earth. Solids are generally tightly packed molecules that are held together in such a way that they cannot change their position. The atoms in a solid can wiggle and jiggle (vibrate) but they cannot move from one place to another. The typical characteristics that solids tend to have are that they keep their shape unless they are broken and they do not flow.

Materials change from one **state** to another depending on the temperature and these bonds. All materials have given points at which they change from state to state. As objects change state they do not change temperature. The heat that goes into something as its changing phases is used to change the "bonds" between molecules. Freezing points, melting points, boiling points and condensation points are the “speed limits” of the phases. Once the molecules reach that speed, they must change state.

There are five known **states of matter**: Bose-Einstein condensate, solids, liquids, gases and plasma.

Sublimation is the process by which a solid goes directly to a gas.

Tension and **compression** happen when solids are bent. **Tension** is when things get pulled apart. **Compression** is when things get squashed together.