MY SUPER SCIENCE HEROES

Marie Curie

and the POWER of PERSISTENCE

EXPERIMENT GUIDE

MARIE CURIE ALUMNI

Science Connected

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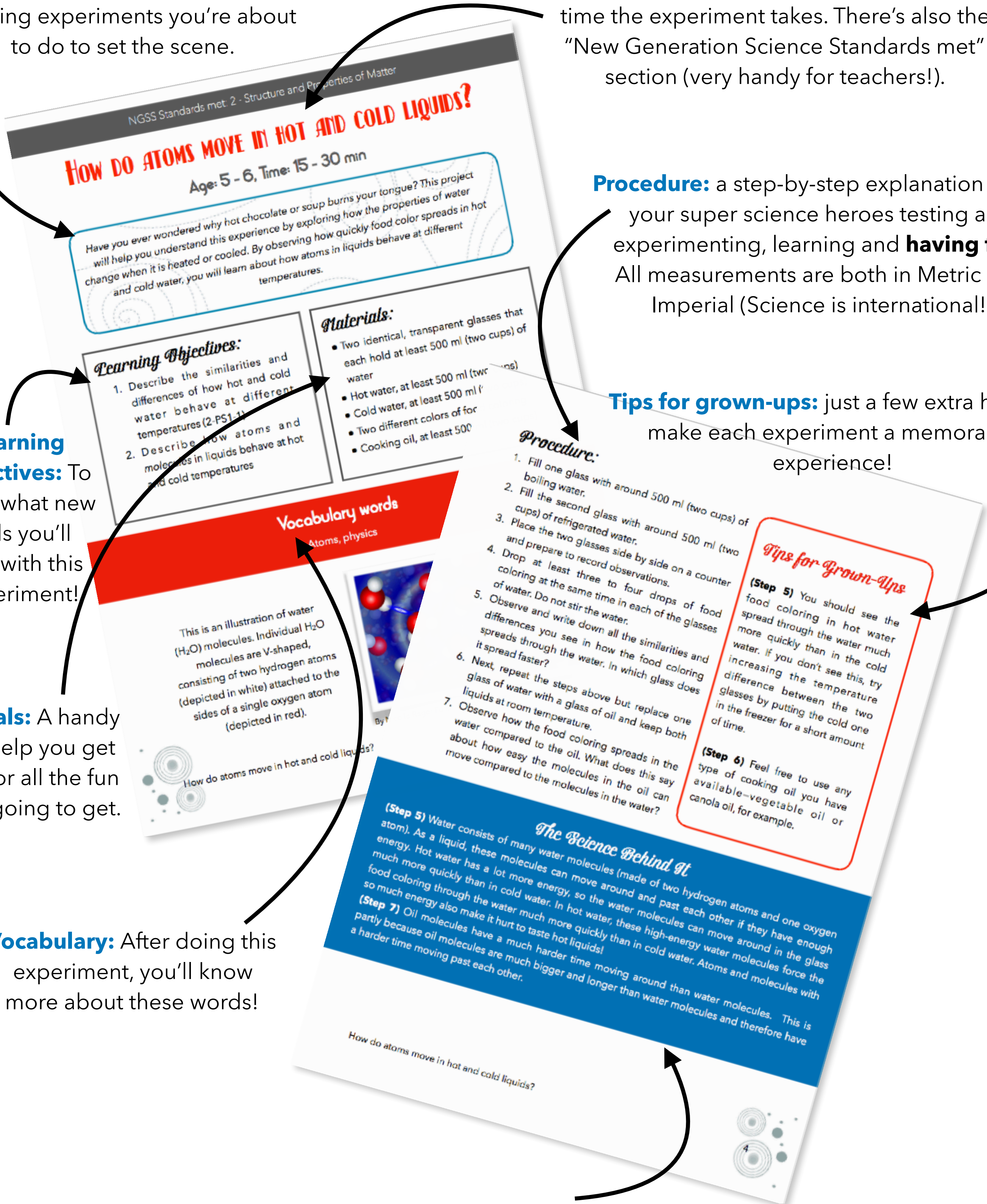
How to read this guide

Introduction: A few words on what exciting experiments you're about to do to set the scene.

Heading: The title, age range and approximate time the experiment takes. There's also the "New Generation Science Standards met" section (very handy for teachers!).


NGSS Standards met: 2 - Structure and Properties of Matter

How do atoms move in hot and cold liquids?

Age: 5 - 6, Time: 15 - 30 min

Have you ever wondered why hot chocolate or soup burns your tongue? This project will help you understand this experience by exploring how the properties of water change when it is heated or cooled. By observing how quickly food color spreads in hot and cold water, you will learn about how atoms in liquids behave at different temperatures.

Learning Objectives:

1. Describe the similarities and differences of how hot and cold water behave at different temperatures (2-PS1-1)
2. Describe how atoms and molecules in liquids behave at hot and cold temperatures

Materials:

- Two identical, transparent glasses that each hold at least 500 ml (two cups) of water
- Hot water, at least 500 ml (two cups)
- Cold water, at least 500 ml (two cups)
- Two different colors of food coloring
- Cooking oil, at least 500 ml

Vocabulary words

Atoms, physics

This is an illustration of water (H_2O) molecules. Individual H_2O molecules are V-shaped, consisting of two hydrogen atoms (depicted in white) attached to the sides of a single oxygen atom (depicted in red).

How do atoms move in hot and cold liquids?

Procedure:

1. Fill one glass with around 500 ml (two cups) of boiling water.
2. Fill the second glass with around 500 ml (two cups) of refrigerated water.
3. Place the two glasses side by side on a counter and prepare to record observations.
4. Drop at least three to four drops of food coloring at the same time in each of the glasses of water. Do not stir the water.
5. Observe and write down all the similarities and differences you see in how the food coloring spreads through the water. In which glass does it spread faster?
6. Next, repeat the steps above but replace one glass of water with a glass of oil and keep both liquids at room temperature.
7. Observe how the food coloring spreads in the water compared to the oil. What does this say about how easy the molecules in the oil can move compared to the molecules in the water?

Tips for Grown-Ups

(Step 5) You should see the food coloring in hot water spread through the water much more quickly than in the cold water. If you don't see this, try increasing the temperature difference between the two glasses by putting the cold one in the freezer for a short amount of time.

(Step 6) Feel free to use any type of cooking oil you have available–vegetable oil or canola oil, for example.

The Science Behind It

(Step 5) Water consists of many water molecules (made of two hydrogen atoms and one oxygen atom). As a liquid, these molecules can move around and past each other if they have enough energy. Hot water has a lot more energy, so the water molecules can move around in the glass much more quickly than in cold water. In hot water, these high-energy water molecules force the food coloring through the water much more quickly than in cold water. Atoms and molecules with so much energy also make it hurt to taste hot liquids!

(Step 7) Oil molecules have a much harder time moving around than water molecules. This is partly because oil molecules are much bigger and longer than water molecules and therefore have a harder time moving past each other.

How do atoms move in hot and cold liquids?

Procedure: a step-by-step explanation to get your super science heroes testing and experimenting, learning and **having fun**! All measurements are both in Metric and Imperial (Science is international!)

Tips for grown-ups: just a few extra hints to make each experiment a memorable experience!

Learning objectives: To know what new skills you'll gain with this experiment!

Materials: A handy list to help you get ready for all the fun you're going to get.

Vocabulary: After doing this experiment, you'll know more about these words!

The Science behind it: the serious explanation on how things work!

Table of contents

What is the scientific method?

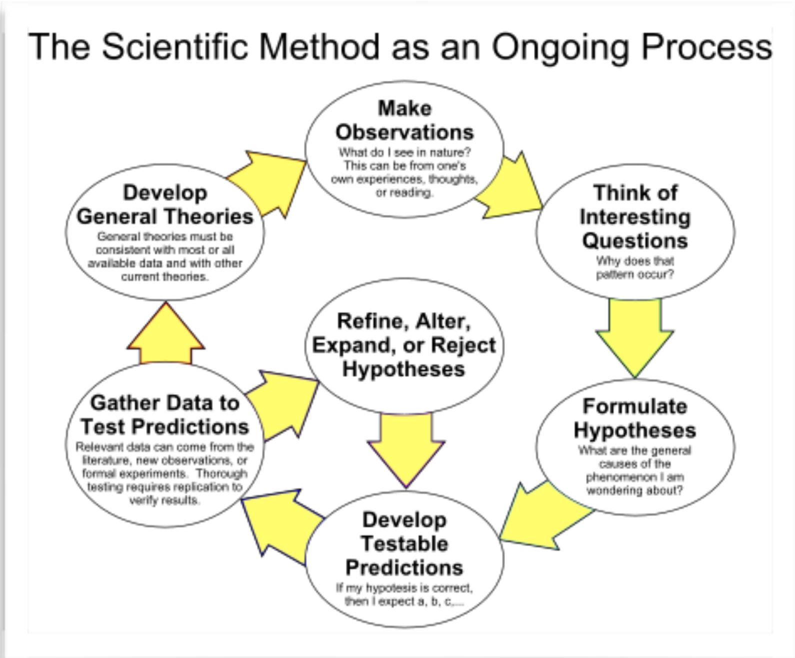
an introduction to Science!

Dr. Marie Curie used the scientific method to make her discoveries, and you can, too. The scientific method is a process that scientists use to investigate and understand our world. You can use this method every day. In fact, you've probably used it before!

Here's how it works

Look around and observe something. Next, ask yourself some questions about your observation. Gather information about what you observed. Then use that information to form a *hypothesis*—one possible explanation. Now you can make some predictions based on your hypothesis.

But that's just the beginning! You must test your hypothesis. Make a prediction based on your hypothesis and gather data to test it out. Was your prediction right or wrong? If it was wrong, then you have gained new data. This is excellent! Use your new data to change your hypothesis, then test it again.



By ArchonMagnus (original work) [CC BY-SA 4.0], via Wikimedia Commons.

Remember, do not try to *prove* your hypothesis. **To do good science, try as hard as you can to *disprove* your hypothesis.** Get someone to help you try to disprove it. Keep testing and changing your hypothesis until you are able to correctly predict the outcome. Now, at last, you can use what you've learned to develop a working theory. And you may have just added a bit of new scientific knowledge to the world.

The Scientific Method is an *ongoing process*–it keeps going and going. As we learn more about our world, our hypothesis, theories, and scientific laws can change based on new evidence.

Other great resources

Scientific Hypothesis, Theory, and Law with Joe Hanson
In this video, Dr. Joe Hanson explains what scientific hypotheses, theories, and laws are and how they work: http://www.gotscience.org/2015/10/theory-vs-hypothesis-vs-law-explained/

How Science Works with Neil deGrasse Tyson
In this video interview, Dr. Neil deGrasse Tyson explains how the scientific method works using hot chocolate and whipped cream as an example: https://www.youtube.com/watch?v=6FvSXI2iBcA

Now let's do some Science!

Now that you've learned about Dr. Marie Curie and the scientific method, it's time to roll up your sleeves and do some science! Try out the experiments in this guide. Use the scientific method to observe, question, hypothesise, test, gather evidence, and learn.

And most importantly, enjoy!

How do atoms move in hot and cold liquids?

Age: 5 - 6, Time: 15 - 30 min

Have you ever wondered why hot chocolate or soup burns your tongue? This project will help you understand this experience by exploring how the properties of water change when it is heated or cooled. By observing how quickly food colour spreads in hot and cold water, you will learn about how atoms in liquids behave at different temperatures.

Learning Objectives:

1. Describe the similarities and differences of how hot and cold water behave at different temperatures (2-PS1-1)
2. Describe how *atoms* and *molecules* in liquids behave at hot and cold temperatures

Materials:

- Two identical, transparent glasses that each hold at least 500 ml (two cups) of water
- Hot water, at least 500 ml (two cups)
- Cold water, at least 500 ml (two cups)
- Two different colours of food colouring
- Cooking oil, at least 500 ml (two cups)

Vocabulary words

Atoms, Physics

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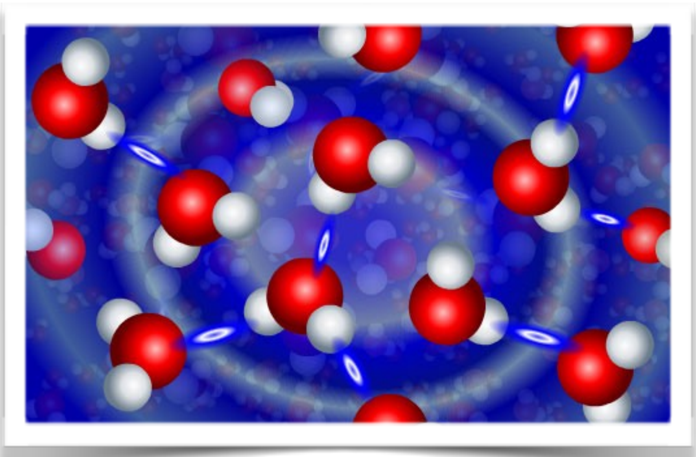

By Nicolle Rager Fuller, National Science Foundation

Procedure:

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2. Fill the second glass with around 500 ml (two cups) of refrigerated water.
3. Place the two glasses side by side on a counter and prepare to record observations.
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Tips for Grown-Ups

(Step 5) You should see the food colouring in hot water spread through the water much more quickly than in the cold water. If you don't see this, try increasing the temperature difference between the two glasses by putting the cold one in the freezer for a short amount of time.

(Step 6) Feel free to use any type of cooking oil you have available–vegetable oil or canola oil, for example.

The Science Behind It

(Step 5) Water consists of many water molecules (made of two hydrogen atoms and one oxygen atom). As a liquid, these molecules can move around and past each other if they have enough energy. Hot water has a lot more energy, so the water molecules can move around in the glass much more quickly than in cold water. In hot water, these high-energy water molecules force the food colouring through the water much more quickly than in cold water. Atoms and molecules with so much energy also make it hurt to taste hot liquids!

(Step 7) Oil molecules have a much harder time moving around than water molecules. This is partly because oil molecules are much bigger and longer than water molecules and therefore have a harder time moving past each other.

Why are clear skies blue and sunsets orange?

Age: 6, Time: 30 min

Have you ever wondered why the sun looks so different at sunset than it does in the middle of the day? In this experiment, students will use common materials to simulate Earth's atmosphere and observe how rays of light scatter (bounce in different directions).

Learning Objectives:

1. Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light (1-PS4-3).
2. Describe how white light is made up of different colours and why we see some of those colours – but not others – in a sunset.

By Steven Spence, GotScience Magazine

Vocabulary words

Ray, Beam

Tips for Grown-Ups

(Step 2) Do not use skim or non-fat milk. Fat is needed to see the light scattering. Milk powder is a good substitute for liquid milk.

(Step 2) When adding milk to the water, add it a little bit at a time. A small amount will go a long way!

(Step 3) Glass or plastic bottles are less likely to spill than a glass.

(Step 4) Use the strongest flashlight you can find.

Procedure:

1. Fill the bowl with water.
2. Slowly add a small amount of milk (a few drops at a time) to the water and stir until the water becomes slightly cloudy.
3. Pour one to two centimetres (cm) (about one-half to three-quarters inch) of liquid into the bottle or glass.
4. Turn the lights off and shine the flashlight up through the bottom of the bottle or glass.
5. Look at the rays of light coming straight through the bottle and the rays of light coming out of the side. What happens to the colour as it goes through the liquid? What colours do you see?
6. Add 1–2 cm (about one-half to three-quarters inch) more liquid and shine the light through again. What do you notice?
7. Keep adding liquid 1–2 cm at a time and shining the light through the liquid to observe changes in the colour of the liquid until the bottle or glass is full.
8. If you don't observe any changes after adding more liquid, add a little more milk. If you can't see the light through the liquid, you will need to make a new batch of water and milk, using less milk the next time.

The Science Behind It

Milk is made of tiny droplets of fat suspended in the water. The white light coming from the flashlight is made up of all the colours of the rainbow. When the light hits the fat droplets, some of the light scatters off of the droplets and goes in different directions away from our eyes.

Blue light is scattered more easily than red light. As the light moves through the column of water, the blue light will scatter more easily and the other colours (red, orange, yellow, green) of light will pass through.

Air molecules and dust in the atmosphere act in the same way as the milk in the water. The blue light from the sun scatters easily, and red, orange, and yellow light pass through the atmosphere. The sun actually looks white from space, but as soon as the light travels through Earth's atmosphere, some of the blue scatters and the other colours that make up white light are left. This why the sun looks yellow from Earth. This is also why sunsets look orange. The light from the sun is coming from a different angle and has to travel through more molecules in the atmosphere. The more molecules the light hits, the more blue light scattering that occurs. This is why we see more yellow, orange, and red light reaching our eyes.

Are there colours inside white light?

Age: 6, Time: 20 - 30 min

Have you ever wondered why a rainbow sometimes appears in the sky after a thunderstorm? In this experiment, you will learn why rainbows show up and discover how you can create your own version of a rainbow in your home! After you are done, you will be able to explain how white light contains every colour of the rainbow.

Learning Objectives:

1. Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light (1-PS4-3).

Solar lens flare on a winter day

By Kathy Milks, GotScience Magazine

Vocabulary words

Ray, Rainbow

Procedure:

1. Fill the cooking pan with at least 2 cm of water.
2. Place the mirror at an angle in the pan so that it is partially submerged in the water.
3. Using the flashlight, shine light on the section of the mirror that is underwater in the pan.
4. While shining light on the mirror, hold the sheet of white paper a few centimetres directly above the mirror.
5. Look for the colours of the rainbow to appear on the white sheet of paper!

Tips for Grown-Ups

(Steps 4 and 5) You may need to experiment with the angle of the mirror and the distance of the flashlight to make sure the light reflects from the mirror onto the sheet of paper.

(Step 5) You can also try this experiment outside using sunlight instead of a flashlight!

The Science Behind It

(Step 3) White light is actually made of many different colours of light. When white light passes through water (or any other material), each colour of light bends, or refracts, at a different angle. Because of this, each light of a different colour hits the mirror at different locations.

(Step 5) Since differently coloured light hits the mirror at different locations, each will be reflected from the mirror onto different locations on the white piece of paper. This creates the image of a small rainbow!

(Step 6) The same principles shown in this experiment apply to rainbows in the sky. In that case, light passes through water droplets, instead of a pan of water, and bends at different angles to reveal the colours of the rainbow.

Why do some objects of the same size weigh more than others?

Age: 6 - 7, Time: 30 - 45 min

In this project, you will create a beautiful, multicoloured glass of sugar water to investigate how materials with different densities behave when poured into a glass of water. Kids will learn to think about how properties like mass and volume affect the behaviour of liquids and classify different substances by these properties. At the end of the project, kids should be able to describe why objects that are the same size can weigh different amounts.

Learning Objectives:

1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties (2-PS1-1).
2. Describe how the density of an object will determine how it floats in water.

Materials:

- Transparent glass that can hold at least 480 millilitres (ml) (two cups) of water
- Four smaller glasses that can hold at least 120 ml (one-half cup) of water
- Four different bottles of food colouring
- Teaspoon
- Water
- About 80 ml (around 16 teaspoons) of sugar

Vocabulary words

Atoms, Physics

By APN MJM (Own work) [CC BY-SA 3.0], via Wikimedia Commons

Adding sugar to water doesn't increase its volume, but it does make the solution more dense, thus increasing its weight.

Procedure:

1. Fill each of the four smaller glasses with around 120 ml (one-half cup) of hot water.
2. In one of the small glasses, mix 5 ml (one teaspoon) of sugar. In the second glass, mix 15 ml (three teaspoons) of sugar. In the third glass, mix 25 ml (five teaspoons) of sugar. In the fourth glass, mix 35 ml (seven teaspoons) of sugar.
3. Stir each glass of water until the sugar is completely dissolved.
4. Once the sugar has dissolved, add three to four drops of different food colouring to each glass of water. Feel free to add more or less drops to change the darkness of the chosen colour to your artistic taste!
5. Write down which water colour corresponds to which number of sugar teaspoons to help remember for the following steps.
6. Hold the large and empty transparent glass at a 45-degree tilt.
7. Now, beginning with the glass with the most sugar, slowly pour the coloured water down the side of the large glass. Using a spoon to transfer the water to the large glass is another option.
8. Repeat Step 7 for each of the next three glasses, pouring in order from most sugar to least sugar.
9. You are done! You should now see layers of the water, each with a different colour, ordered vertically in the glass. The water with the most sugar should be at the bottom and the water with the least sugar should be at the top.

Tips for Grown-Ups

(Step 3) It might help to heat up the water to help the sugar dissolve into the water more quickly.

(Step 7/8) The key to this step is to pour slowly into the large glass. If the coloured water is poured too quickly, this can cause the water to splash and mix with other colours already in the glass. This could lead to colours mixing and an inability to see the colours separated into layers at the end.

The Science Behind It

(Step 2) Adding different amounts of sugar to each glass changes the *density* of the liquid. Density is equal to mass divided by volume. Adding sugar increases the mass of each liquid. Dividing different masses by the same volume for each glass of water leads to sugar waters with different densities.

(Step 9) Even though each individual glass had the same volume of water, different amounts of sugar gave the sugar waters different densities, and therefore they weighed different amounts. The same applies to atoms in different materials! The same volume of iron is a lot heavier than cotton because iron atoms have more mass than the carbon atoms in cotton, making it denser.

What molecules are inside coloured ink?

Age: 7, Time: 45 - 60 min

In this experiment, we will find out what colours ink is made of by separating the molecules using paper chromatography. When we look at something, we are seeing light reflecting into our eyes. Different molecules (a group of atoms bonded together) reflect different colours. Colours that we see are often a combination of the primary colours (red, blue, and yellow). Our eyes might see only one colour, but each of them is actually many different-coloured molecules

Materials:

Vocabulary words

Chemistry, chromatography, molecule

- Two white paper coffee filters
- Scissors
- Ruler
- Water-soluble drawing markers (not permanent): brown, yellow, and any other colours you would like to test
- At least two pencils (one for each colour you will test)
- At least two tall water glasses or jars (one for each colour you will test), 10 centimetres or taller (about four inches)
- Water
- Two binder clips or clothespins
- At least two more tall water glasses or jars (one for each colour you will be testing)
- Pencil or pen and paper for taking notes/drawing pictures

Learning Objectives:

1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties (2-PS1-1).
2. Describe how coloured ink is made up of smaller molecules by observing how quickly the molecules move.

Procedure:

1. Cut the coffee filters into strips that are each about 2.5 cm (about one inch) wide and at least 10 cm long (about four inches). Cut at least two strips, one to test brown and one to test yellow. Cut an extra strip for each additional colour you would like to test.
2. With a pencil (don't use a pen—the ink will run!), draw a line across the width of each paper strip, about one centimetre from the bottom end.
3. Take the brown marker and draw a short line (about one centimetre) on the middle section of the pencil line on one of your paper strips. Your marker line should not touch the sides of your strip.
4. Use a pencil to write the colour of the marker you just used on the top end of the strip.
5. Repeat Steps 2–4 with a yellow marker and then with any other colours you would like to test.
6. Hold a paper strip next to the outside of one of the tall glasses. Make sure to line up the top of the strip with the rim of the glass. Slowly add water to the glass until the water just reaches the bottom end of the paper strip. Repeat with the other glass(es), keeping the strips still on the outside and away from the water.
7. Clip the top of a strip (the side farthest from the marker line) to the pencil with a binder clip or clothespin.
8. Hang the strip in one of the glasses that is partially filled with water by letting the pencil rest on the glass rim. The bottom of the strip should just touch the water level. If it does not touch, add water until it is just touching the paper (don't fill the water past the bottom of the strip!).
9. Leave the first strip in its glass, and then repeat Steps 7–8 with the second strip and the second glass. Repeat with any other colours you are testing.
10. Watch as the water rises up the strips. When the water level reaches about one centimetre from the top, take the pencils with the strips attached out of the glasses. If you leave the strips in the water too long, the water can reach the top of the strips and change your results.
11. Write down and/or draw what you observe. Questions to answer:
    a. Did the colours run?
    b. Did they separate in different colours?
    c. Which colours can you see?
    d. Which colours are on the top?
    e. Which are on the bottom?

By Gerwin Sturm via Flickr, Creative Commons license

Tips for Grown-Ups

If you don't have coffee filters, try using paper towels!

Only non-permanent markers will work. Look for markers labeled "washable" or "water soluble."

(Step 6) Ask, "What do you think the water is for?"

(Step 7) Ask, "Do you think this colour will come from of a mixture of colours or from just one colour?" You or the student can then write down their prediction.

(Step 10) Ask, "What happens to the coloured lines on the strips?"

The Science Behind It

The coffee filter has many tiny, empty spaces between the paper fibres. These spaces are all connected by the paper fibres. When the filter paper absorbs water, the water moves into the small spaces, then to the fibre, and then into the next empty space. As a molecule of water moves through the filter paper, it draws other water molecules with it. This is how water moves through the coffee filter. Coloured ink is also made up of molecules. Different colours have different amounts of molecules in them. These molecules come in all different sizes. When the coffee filter absorbs the water, the ink dissolves into colour molecules as the water passes through the ink. Some of the colour molecules are smaller and lighter than others, so they move faster up the coffee filter. The larger, heavier molecules move more slowly and will be closer to the bottom of the coffee filter.

What's the volume of that container?

Age: 7-8, Time: 30 min

In this experiment, students will use mathematics and measurement to prove that volume is the amount of space a substance or object takes up.

Learning Objectives:

1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties (2-PS1-1).
2. Students will learn that different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (PS1.A).

Procedure:

1. Place containers in the large pan to catch any drips or spills.
2. Without the student present, an adult should use the measuring cup to fill each container with 240 millilitres (ml) of water (about one cup).
3. Add food colouring (a different colour to each container if possible) to make it easier to see the water.
4. Invite the student back to observe the containers.
5. The student should make a list of the containers, starting with the one she or he thinks contains the most amount of liquid to the least.
6. The student should then pour the liquid from one container back into the measuring cup and measure how much liquid was in each container. Do this one container at a time. Have the student record the measurements next to the containers she or he listed. Compare the predictions with the results. Were the results surprising? Why or why not?

Materials:

- At least four containers of different sizes (water glasses, mason jars, vases, etc.)
- Water
- Food colouring
- Large pan
- Measuring cup

The Science Behind It

The volume of a container is just how much space there is inside the container. The volume of a liquid like water is how much space that liquid takes up. A set amount of water will take up the same amount of space no matter what size or type of container it is in. A container will always hold the same volume of a substance. Even though our eyes make our brains think that there is a different amount of water in each container because the water is a different height in each one, the amount of water remains the same. By measuring the water in each container, mathematics proves that the volume of water is the same, but the volume of the containers is different.

United States Department of Energy

A researcher at Sandia National Laboratory investigates radioactive materials in a beaker of dissolved uranium. Her gloves are taped to her coat sleeves for safety.

Tips for Grown-Ups

You can do this experiment a number of different ways. You can start by having the student look at the empty containers and guess which will hold the most water. Then have the student fill each container 240 ml (about one cup) at a time and write down how many ml it took to fill the container. The container might overflow. This is a great way to show the student what happens when the volume of water is more than the volume of the container!

You can also use a solid like rice to do this experiment. This will show the student that the volume of a solid can be measured the same way as the volume of a liquid!

Vocabulary words

Mathematics, Measurement

What is radioactive decay?

Age: 7-9, Time: 30 min

Marie Curie observed the radioactive decay of elements to identify them. In this experiment, students will simulate radioactive decay by eliminating "decayed" candies and counting remaining candies.

Learning Objectives:

1. Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-PS1-1)
2. Use simple mathematics to observe patterns in numbers by recording data creating a graph

Materials:

- One 200 g (7 oz) bag of plain M&M's
- A cup
- A table or other clean, flat surface
- Data table

Vocabulary words

Radioactivity, Polonium, Radium

By Grace Courbis via Flickr, Creative Commons license, commercial use allowed

Procedure:

1. Count out 128 M&M's candies and place them in a cup.
2. Carefully "spill" the candies onto a table. Do not drop them since they might bounce.
3. If the candy lands with the "M" pointing up, it is still "good" and you should place it back into the cup.
4. The candies that land "M"-side down are "decayed." Put them aside for now.
5. Count how many candies are still "good," and record the number in your data table.
6. Repeat the procedure until all candies have "decayed."
7. Answer the following questions together:
   a. Each spill represents a "half-life" of a radioactive isotope. How many candies were decayed during the first half-life?
   b. How many candies were decayed during the second half-life?
   c. For each half-life, does the number of candies increase, decrease, or remain the same?
   d. Make a bar graph that has spills on the x-axis and "good" candies on the y-axis. What do you notice?

The Science Behind It

A half-life is the time it takes for the radioactivity of an isotope to decrease by half of its original value. Over time, the radioactivity of an isotope decreases. This is called radioactive decay. Marie Curie needed to know the half-life of each element that she worked with. She discovered the elements radium and polonium using radioactive decay. Radium has a half-life of 1600 years, meaning it takes 1600 years for half of a given amount of radium to decay into a different isotope. This long half-life made it an easy element for Marie Curie to work with. Polonium, on the other hand, only has a half-life of 138 days. This made it difficult for Marie Curie to work with polonium because it kept "disappearing" (it was really just changing into something different)!

Tips for Grown-Ups

(Step 1) If you don't have M&M's, you can also use Skittles, coins, or poker chips with a sticker on one side.

(Step 5) A simple data table can just have columns for each "spill" and a row below, where your student records the number of "good" candies remaining.

How does a lava lamp work?

Age: 8-9, Time: 30-40 min

Chemistry is the study of the interactions between all the atoms and molecules that make up the world around us! This project will demonstrate the basic principles of chemical reactions by showing you how to build your own lava lamp.

Learning Objectives:

1. Describe how the mixing of two substances creates a new substance in a lava lamp (5-PS1-4).

Materials:

- Large glass or bottle container (you can also use an empty, two-litre soda bottle)
- Vegetable oil
- Water
- Food colouring
- Alka-Seltzer tablets

Vocabulary words

Chemistry, Chemical Reaction

By Kumar Jhuremalani via Flickr, Creative Commons license, commercial use allowed

Procedure:

1. Fill the container with vegetable oil, leaving about 10 centimetres (cm) (four inches) between the oil level and the top of the container.
2. Fill the rest of the container with water. You should observe the water sink to the bottom of the container.
3. Add a few drops of food colouring to the container. You should also see it sink to the bottom and spread through the water.
4. Take two Alka-Seltzer tablets and break each into several small pieces. Throw half of these into the container.
5. Observe the *chemical reactions* that take place inside the container. What do you see?
6. If you see less bubbles forming, add the other half of the Alka-Seltzer pieces to the container.

The Science Behind It

(Step 2) Water sinks below the oil because it is denser than oil! See *Why Do Some Objects of the Same Size Weigh More Than Others?* To learn more about density!

(Step 3) The food colouring sinks below the oil because it is made primarily of water (and is therefore denser than oil)!

(Step 5) The Alka-Seltzer tablets react with water to form carbon dioxide (CO_2) gas molecules. These molecules stick to water, forming a molecule that is now less dense than the oil. This causes the gas bubbles to rise to the top of the container.

(Step 6) The Alka-Seltzer provides the "fuel" for the reaction to create carbon dioxide gas in the container. Without adding more Alka-Seltzer, eventually the container will run out of fuel and the lava lamp will stop working.

Tips for Grown-Ups

(Step 3) Feel free to mix different colours of food colouring to create a colour for your lava lamp that suits you!

Can you defy gravity?

Age: 8-9, Time: 20-30 min

Gravity is one of the most well-known physical forces we feel every day. Is it ever possible to overcome it? In this experiment, you will explore how other forces can overcome gravity and make objects behave in ways you would never expect! By the end of the project, you will be able to explain how gravity competes with other forces that can affect the motion of objects around you.

Learning Objectives:

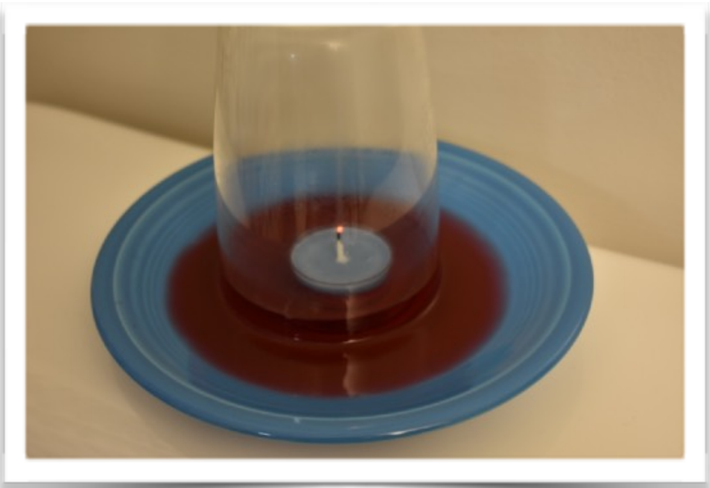
1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object (1-PS4-3).

Vocabulary words

Physics

Materials:

- Shallow plate or dish
- Water
- Food colouring
- Small candle (about three to eight centimetres (cm), or one to three inches, high)
- Lighter or match
- A glass that, when upside-down, is wide enough to fit over the candle



By Jonathan Trinastic

Candle partially submerged in water and covered using a glass. Look for the water to rise inside the glass.

Procedure:

1. Pour the water so it fills the shallow plate almost to the top.
2. Add two or three drops of food colouring to the water.
3. Position the candle in the middle of the plate and light it with the lighter or match.
4. Now, flip the glass upside down and place it over the candle on the plate.
5. Observe the water and the candle's flame. What do you see?
6. Once you placed the glass over the candle, you should see the flame go out after a few seconds. What happens to the water once the flame goes out?
7. After the flame went out, you should see the water inside the glass rise upward until the candle is floating!
8. For additional variations on this experiment, try changing the size of the candle wick or the glass. Mark how far up the glass the water climbs and how long it takes for the flame to go out in each case. This way of changing one part of the experiment at a time is how scientists systematically study the world through the scientific method!

The Science Behind It

(Step 6) The flame must consume oxygen in the air through a chemical reaction known as a combustion reaction to continue burning. When you placed the glass onto the plate, the candle could only access the small amount of oxygen inside the glass. Once all this oxygen was used up, the combustion reaction could no longer take place and the flame went out.

(Step 7) With the candle lit and the glass covering it, the air inside the glass heats up. As air warms it expands, and some escapes through the bottom of the glass (you might see bubbles form along the glass edge). Now, once the candle goes out from lack of oxygen, the air cools inside the glass, but there is less since some left the container. This creates lower pressure inside the glass than outside, so the water is "pushed" up by the pressure of the air outside the glass. In this way, differences in pressure can overcome the force of gravity!

Tips for Grown-Ups

(Step 3) The candle can sink into the water as far as you like as long as the wick doesn't get wet. This provides some flexibility in the shallowness of the plate you use.

Which force is greater?

Age: 8-9, Time: 20-30 min

In this experiment, students will make predictions and observe how much force is needed to move an object.

Learning Objectives:

1. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
2. Describe how force and mass are related.

Vocabulary words

Physics, Force

Materials:

- Socks
- Approximately 340 grams (g) (one cup) of rice
- Piece of string (30 centimetres (cm), or about 12 inches)
- Piece of string (90 cm, or about 36 inches)
- Large paper clip
- Twenty metal washers or rings

What you'll need to set up the experiment

By Emily Rhode

Procedure:

1. Fill a sock with 85 g (one-quarter cup) of rice and tie it shut with the shorter piece of string.
2. Attach the longer piece of string to the cuff of the sock.
3. Bend the two loops of the paper clip (so it looks like an S).
4. Pull out the loose end of the larger loop.
5. Attach the smaller loop to the loose end of the longer piece of string.
6. Place the bag of rice on a smooth surface (approximately 75 cm or 30 inches from the edge), with the end of the string with the paper clip hanging off the edge.
7. Predict how many washers will need to be placed on the paper clip before the bag of rice begins to move.
8. Predict how many washers will need to be placed on the paper clip before the bag of rice is pulled over the edge of the table.
9. Add washers to the loose end of the paper clip until the bag of rice begins to move and is pulled over the edge of the table. Compare your prediction with your results.
10. Repeat this procedure with 170 g (one-half cup) of rice, and then again using 340 g (one cup) of rice. Record your results.

The Science Behind It

As the mass of something increases, the force that it applies to an object also increases. The sock filled with rice has a certain amount of force that must be overcome before it will move. As washers are added to the paper clip, eventually there is enough force to overcome the force of the sock full of rice. This causes the sock to move! The greater the amount of force (number of washers) on one side of the string, the faster the sock will move across the table. In physics, this is known as Newton's second law of motion: Force=mass times acceleration.

Tips for Grown-Ups

(Step 1) If you don't have rice at home, you could use beans, coins, or other small objects.
(Step 7) If you don't have washers at home, you can hang a paper or plastic cup from the paper clip (poke the paper clip right through the top edge of the cup) and add coins, beans, or other small identical objects to the cup.

What's inside an atom?

Age: 9, Time: 30-45 min

This project gives kids the opportunity to explore a world so small that their eyes cannot see it! Atoms are tiny objects that make up everything around us, from people to chairs to clouds. But even atoms are made up of smaller objects known as protons, neutrons, and electrons. You will explore these building blocks of matter by building a large-scale model of an oxygen atom. The procedures will teach kids about the particles inside the atom and how they relate to one another.

Learning Objectives:

1. Develop a model of the particles that are too small to see that make up all matter around us (5-PS1-1).
2. Identify the three primary types of particles inside an atom (protons, neutrons, and electrons) and where they are located in an atom.

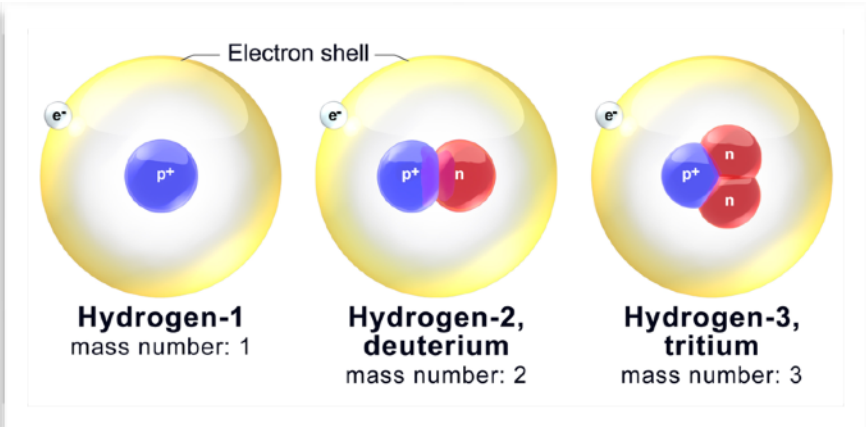
Vocabulary words

Atoms, Chemistry

Materials:

- Sixteen large styrofoam balls (about 2.5 centimetres, or one inch, in diameter)
- Eight smaller styrofoam balls (about half the size of the large balls)
- Ten to twelve pieces of different-coloured felt wire
- Glue or adhesive that works with styrofoam

The different hydrogen isotopes contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties



By BruceBlaus - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=33041239

Procedure:

1. Divide the 16 large styrofoam balls into two piles of eight. Paint one pile any colour you like. These will be one type of particle, called *protons*.
2. Paint the other pile of large balls a different colour. These will be another particle, called *neutrons*.
3. Paint all the smaller styrofoam balls a third colour. These will be the smallest particles inside an atom, known as *electrons*.
4. Glue together the eight proton balls and eight neutrons balls in a cluster. They can be glued in a random order so that all 16 balls form a larger spherical blob. This combination of protons and neutrons exists at the centre of the atom and is known as the *nucleus*.
5. String two electron balls along a felt wire of any colour (it might help to first "drill" a hole through the styrofoam using a pencil so the wire can easily pass through it). Shape the felt wire in a form of a loop and place it around the nucleus. Shift the electron balls so they are evenly spaced around the loop.
6. Create a second loop of electrons farther from the nucleus. String the rest of the six electron balls along felt wire of a colour different from the first loop. Shift the electron balls so they are evenly spaced around the loop.
7. Connect the nucleus and each electron loop together so the model can hang from a hook or the ceiling. You can use a different piece of felt wire to pierce one of the balls of the nucleus, then use it to connect to each electron loop so that they are approximately 4 centimetre (about 2 inches) from one another.
8. Finally, attach another piece of felt wire to the outer electron loop and form it into a hook. Hang this final piece of wire from your hand and admire your finished model of an oxygen atom!

Tips for Grown-Ups

(Step 5) Depending on your length of felt wire and how you created your proton/neutron cluster, you may need to connect multiple felt wires end to end (of the same colour) to make a large enough loop.
(Step 6) If you like, you can glue the electron balls in fixed places along the felt-wire loop. However, letting them move around is actually closer to reality! Scientists have discovered that the electrons orbiting the nucleus are not fixed particles, but are more like clouds of particles. The electron only has a probability of being in any one place at a given point in time.

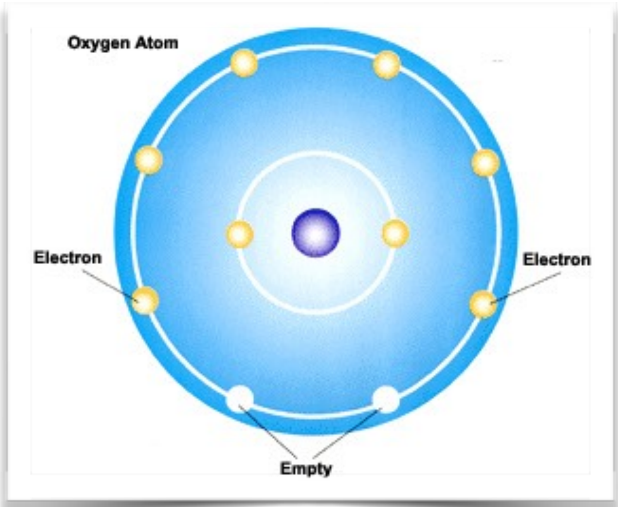
The Science Behind It

(Step 4) The nucleus is located at the centre of the atom and contains protons and neutrons. Neutrons have no net electric charge, and protons are positively charged, so the nucleus as a whole has a net positive charge.

(Step 5) This first loop of two electrons is known as the first electron *energy level* or *shell*. Although this is a simple model, the distance of these two electrons from the nucleus is actually predicted using quantum physics! Scientists have determined that only two electrons can fit at such a close distance to the nucleus. The rest of the electrons must orbit farther from the nucleus.

(Step 6) Electrons have the same amount of negative charge as protons have positive charge. Since the oxygen atom you built has the same number of protons as electrons, the atom as a whole has no net charge. If the oxygen were to gain or lose an electron, then it would become charged, which affects how it reacts with other atoms.

A model of an oxygen atom. The centre sphere represents the nucleus, made of protons and neutrons. Remember, this is just a model! Atoms don't actually have this "orbit" structure.



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How are molecules formed?

Age: 9, Time: 45-60 min

This project builds upon the "What's Inside an Atom?" experiment to demonstrate how two atoms can form a bond to become a molecule, one of the most important principles in chemistry. You will explore chemical bonding by building two models of oxygen atoms and then showing how they can share electrons to become an oxygen molecule (O_2). The ideas learned in this project can be generalised to understand how many other molecules form!

Learning Objectives:

1. Develop a model of molecules that are too small to see that make up matter around us (5-PS1-1).
2. Describe the covalent bonding process by which atoms share electrons to form molecules that are more stable than individual atoms by themselves.

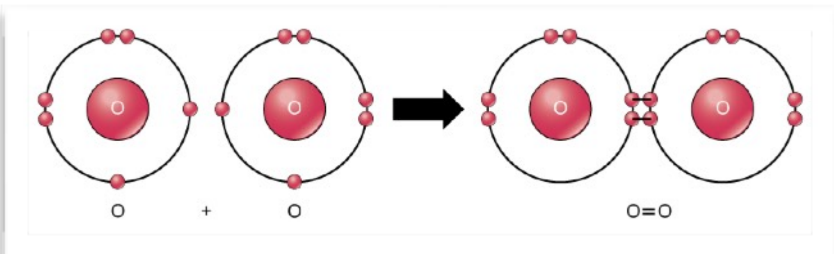
Vocabulary words

Atoms, Chemistry

Materials:

- Thirty-two large styrofoam balls (about 2.5 centimetres (cm), or one inch, in diameter)
- Sixteen smaller styrofoam balls (about half the size of the large balls)
- Twenty to twenty-four pieces of different-coloured felt wire
- Glue or adhesive that works with styrofoam

In the O_2 molecule, two oxygen molecules share four of the electrons in their shells.



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Procedure:

1. Repeat twice the procedures in *What's Inside an Atom?* to create two individual oxygen atom models (the materials described above are required for this step).
2. Place the two models next to each other so that their outermost felt wire loops are touching.
3. The outer loop of electrons on each model is likely made of multiple connected pieces of felt wire. Undo this connection for the felt wire piece that is closest to the other model so that the outer loop of each atom is no longer closed.
4. Remove two electron balls from the outer loops of each atom (remove four total) using the open end of felt wire created in Step 3.
5. Now, hold the disconnected ends of each felt wire close together and string the four electron balls through both felt wires at the same time. This step represents the two oxygen atoms sharing these four electrons.
6. After the electron balls have been strung through the wires simultaneously, reconnect each outer loop for each atom separately.
7. The end result should now be that the two models are connected by four electron balls in the outer loop that are directly between both atoms. The other four electron balls on this loop for each atom should be equally spaced around the loop.
8. Use additional pieces of felt wire to hang this oxygen molecule model from a hook as described in *What's Inside an Atom?* You have just created an O_2 molecule that demonstrates covalent bonding between atoms!

The Science Behind It

(Step 7) This sharing of electrons between atoms is known as *covalent bonding*. This bonding occurs because atoms are more stable when they have the maximum number of electrons allowed in their *outer electron shell*. This number is eight for oxygen, so sharing four electrons total leads to the most stable configuration being an O_2 molecule.

Tips for Grown-Ups

(Step 5): It might be helpful to "drill" a slightly larger hole through these four electron balls using a pencil so that you can easily pull both felt wires through them at the same time.

(Step 8): This same model can be extended to many other types of atoms. For example, you can create a carbon dioxide (CO_2) molecule by creating a carbon atom model (six protons and six electrons), and show how it shares electrons with two oxygen atoms to create a CO_2 molecule!

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