SCIENTISTS IN SCHOOL
SCIENTIFIQUES À L'ÉCOLE

Teacher Resource Package

Let us help you piece together the science!

Background Information an overview of the topic and theoretical concepts.

Hands-on Activities
Activity 1 - pen/paper activity
Activity 2 - short, easy-to-do activity (30-60min)
Activity 3 - short, easy-to-do activity (30-60min)
Activity 4 - longer activity (greater than 1 hr)
Activity 5 - complex activity

Teacher Resources
Literary Resources
Website Resources
Interactive White Board Resources
Multi-media

Student Resources
Literary Resources
Interactive Websites

Please help us improve our teacher resource packages!

If you have any feedback about this package or suggestions for new resources to include, please don't hesitate to contact us at: inquiries@scientistsinschool.ca.

What in the World is Matter?

A house can be made of bricks, cement and wood, with glass windows, plastic on the electrical outlets, and so much more. Each of the materials used to make the house can also be used for building other things. Similarly, our bodies are built from elements, like calcium which makes our bones strong and iron, which makes our blood red. Iron is part of a molecule found in our blood that transports oxygen around our body. Iron is also the main element in steel, which is used to build your family car. Atoms make up everything living and non-living on Earth. All elements have different characteristics and they are the building blocks of matter, which includes everything that takes up space and has mass.

Background Information

Atoms are so tiny that a tower of 3,000,000 gold atoms would be only one millimetre high. They are so small that they cannot be seen with a regular microscope. Images of atoms can be captured indirectly with a scanning tunneling microscope, where a computer generates an image of the atom by scanning the material and making calculations.

Atoms can join with other atoms to form molecules. If there is more than one kind of atom in a molecule, that substance is called a compound. Compounds generally have completely different characteristics than the individual elements which make it up. We can think of the Earth as a huge recycling plant where atoms and molecules are constantly rearranged to make different types of matter with completely different characteristics. For example, chlorine is added to swimming pools as a disinfectant. The chemical container label indicates that chlorine may be toxic to our health if exposed to undiluted amounts either through inhalation or skin contact. Yet sodium chloride, commonly known as table salt, contains the same element and is safely used to flavour food.

Many substances do not dissolve in water. No matter how much you stir sand into a glass of water, it will not dissolve. It might be suspended for a little while, but it will quickly fall to the bottom of the glass. However when some substances mix with water, they can stay suspended. The resulting mixture is called a suspension. Milk is mostly comprised of water but because fat and other molecules are suspended in it, milk appears white and opaque. In a suspension, each of the individual components retains its chemical composition.

Physical Properties of Matter

Chocolate is a compound that is brown and solid at room temperature but melts to a liquid in your hand. It is still chocolate and still tastes delicious in solid or liquid form. These characteristics are physical properties of matter - how it looks, feels, smells or tastes. All substances have physical properties and we can use these properties to help identify them. Physical properties can include mass, density, vapour pressure, boiling point and freezing point. Certain elements have characteristics in common. Metals look shiny and are usually solid at room temperature. Because the atoms in most metals are packed closely together, metals are generally dense and heavy for their size. Mercury is a unique metal that is a silver liquid at room temperature and used in some thermometers as the use of mercury results in more accurate measurements and it reacts quickly to temperature changes.

In a physical change from solid to liquid to gas, the molecules which make up that matter do not change, just the speed with which they are moving changes. In solids, the molecules are packed close together in a specific pattern and held in place by intermolecular forces. Solid molecules are in a fixed position and cannot move around each other but they can vibrate. As a result, solids do not change shape easily. When a solid is heated, the molecular vibrations increase until some of the intermolecular bonds get broken. This results in a phase change called melting. In liquids, the particles are not arranged in a specific pattern and they can move freely around each other. Liquids do not have a definite shape but do have a definite volume. They will take the shape of the container they are in. Gases do not have a definite shape or a definite volume. Gas molecules will take the shape of their container. In gases, the molecules are very far apart and move very quickly in all directions. When you smell a yummy dinner cooking in the kitchen from all the way in your bedroom, this is a result of the movement of molecules in the air.

Water is the only substance on Earth that occurs naturally in all three states of matter. It is unique in other ways too. Water will become more dense and sink as it gets colder. Based on the most common properties of different states of matter, it would be expected that water should freeze from the bottom up. However, at 4°C, water does something unusual. At this temperature, water actually expands, becomes less dense, and floats to the surface above the warmer water below. This is an important process for a healthy lake as the ice essentially caps the lake and water below that layer stays above freezing. This allows oxygen and nutrient turnover during the freezing and thawing stages in the spring and sustains lake life at 4°C under the ice layer during the cold winter.

Chemical Reactions

The chemical properties of a substance are defined by the way it interacts with other substances. Wood contains a large percentage of carbon. When wood burns, the carbon combines with oxygen, resulting in a hot campfire you can roast marshmallows over. The next day, you are left with ashes and the wood has been changed. Yes, the piece of firewood is gone, but the atoms in the wood still exist and have been rearranged as a result of the chemical reaction.

You can imagine the bonds between the atoms to be like people holding hands. If two people are trying to hold tightly to each other, a force will be required to separate them. Likewise, it takes force to separate atoms that are bonded together. Conversely, when new bonds are formed, energy is released because the product is more stable than its predecessor. How many and how strong the bonds are in the original substances versus the final products of the chemical reaction determines whether the reaction will be exothermic (giving off energy) or endothermic (requiring energy).

Fun Fact: Plasma

Plasma is a collection of charged gaseous particles that are sometimes considered a fourth state of matter. The northern lights are an example of plasma.

Activity 1: It's Just a Phase!

Time: 1 hour

Other Applications: Geography

Key Terms: phase changes, evaporation, sublimation, melting, freezing and condensation

Group Size: 2-4

Materials:

- ☐ dice (1 die per group)
- ☐ "It's Just a Phase! – Background Information. How the Water Changes and Moves Around the Planet" page per student
- ☐ "It's Just a Phase! Recording the Journey of My Water Droplet" worksheet per student
- ☐ 1 plain piece of paper
- ☐ pen or pencil (optional pencil crayons or markers)

Fun Fact: Ice
Liquid water expands when it freezes. By the time water freezes, it takes up approximately 9% more space!

Learning Goal: Students will learn about the phase changes of water.

Water is the only matter on Earth that is naturally present as a solid, liquid and gas. Water cycles between all three phases but the total amount of water on Earth remains essentially constant. Students will follow a unique journey of a drop of water going through the water cycle. The roll of a die will determine which phase change the drop of water will go through and the student will imagine where their water drop will be at each step.

Procedure:

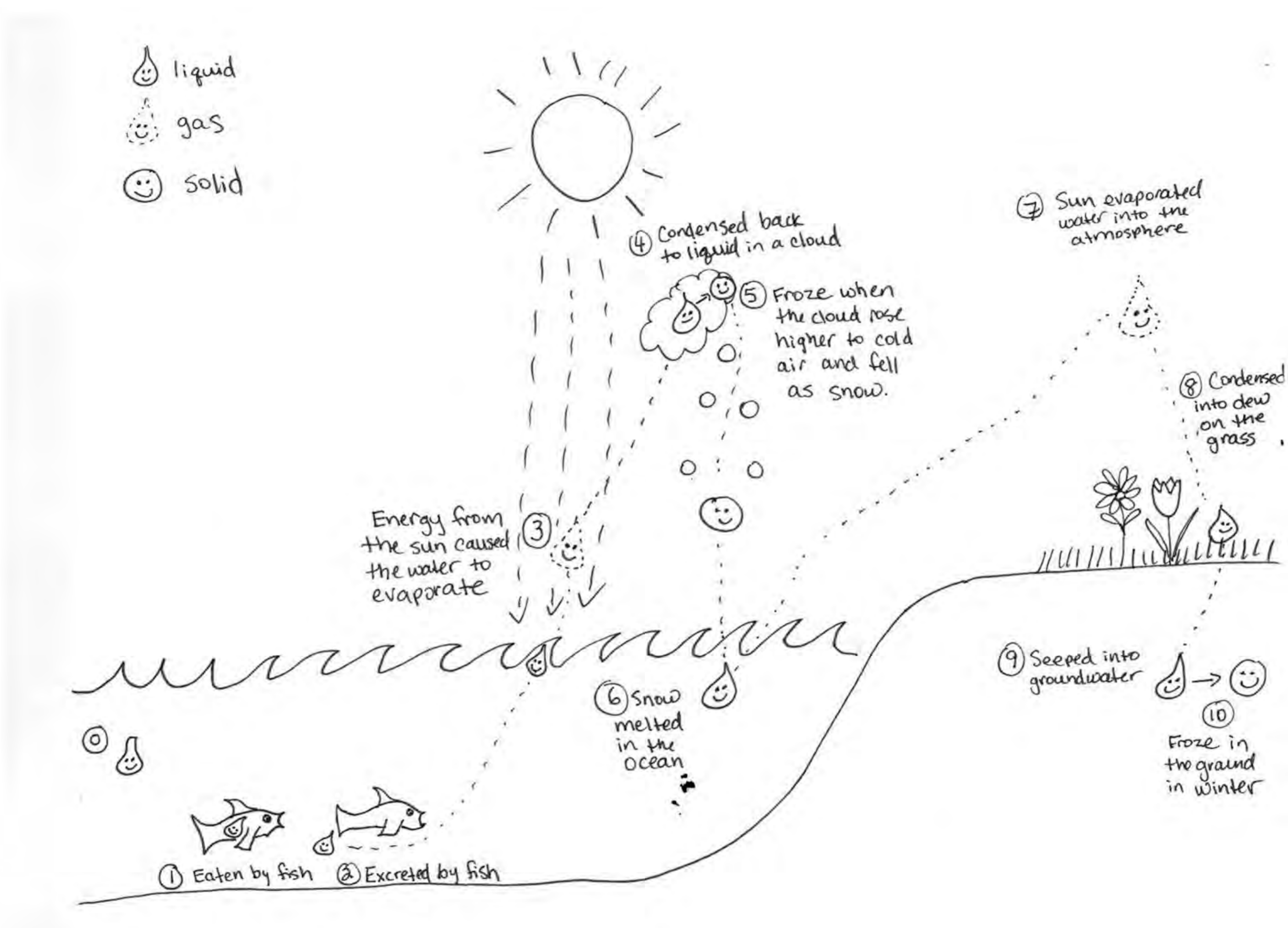
1. Discuss the three different phases of water. Water can be found as solid (ice), liquid (water) and gas (water vapour).
2. Ask students for some ideas about where water can be found in its different forms on Earth. A class discussion would include:
    - Oceans – 97.2% of surface water.
    - Rivers, lakes and groundwater – 0.7% of surface water.
    - Living organisms – 0.00004% of surface water. Blood is mostly water. Cells and tissues in plants and animals are largely composed of water. Water leaves an animal through urine and feces, or when they die and decompose. Animals can take in water or breathe it out, as water vapour.
    - Atmosphere and clouds – 0.001% of surface water. Clouds can contain water in all three forms. Water vapour in the air will vary depending on humidity.
    - Ice caps and glaciers – 2.1% of surface water.
3. Hand-out "It's Just a Phase – Background Information. How the Water Changes and Moves Around Our Planet" to each student.
4. Review with students the different phase changes a drop of water might encounter on Earth.
    - Evaporation: Water can evaporate from an ocean, lake or the ground. Water evaporates off us and other animals, from our skin through sweating, or from our respiratory system when we talk or breathe heavily after exercise. Sweating brings a liquid to the surface of your skin. This results in a phase change from liquid to gas that requires heat. The heat for this reaction is taken out of the air right next to our skin surface, which is why we feel cooler. Plants also have a way of sweating through openings in their leaves – it's called transpiration. In addition to shading from the sun, trees cool the air by removing heat from the air when water evaporates.

- Condensation: In clouds, condensation of water vapour to liquid makes rain. On the ground, condensation of water vapour to liquid ends up as dew.
- Freezing: In clouds, liquid droplets can freeze to snowflakes, or as the rain falls, it can freeze to sleet. Lakes, ponds and rivers can freeze during the winter months.
- Melting: Ice crystals in clouds melt to form raindrops. Glaciers, ice and snow are melted by the sun.
- Sublimation: Ice crystals in clouds and ice on the ground can go directly from a solid to a gas. Or in reverse, water vapour changes to ice without going through a liquid phase. Unlike other phase change descriptor words, sublimation can go either direction. On very cold sunny days, snow can sublimate. Another example is when frost is visible on grass after a cold night or frost appears on the wings of an airplane high in the atmosphere, where the air is cold.

5. Divide the class into groups of two to four. Provide each group with a die.
6. Hand-out "It's Just a Phase! Recording the Journey of My Water Droplet" worksheet to each student. Explain that they will be working in small groups and taking turns rolling a die. The first roll of the die will determine the starting point of each water droplet's journey:
    - 1 = Freshwater (liquid)
    - 2 = Groundwater (liquid)
    - 3 = Ocean (liquid)
    - 4 = Atmosphere (gas)
    - 5 = Living Organism (students choice if plant or animal) (liquid)
    - 6 = Glacier (solid)
7. Allow time for each student in the group to roll the die and record their starting point on their worksheet.
8. Students will then take turns rolling the die for a total of 10 more times. The number on the die will determine the phase change their water droplet will go through on its journey. At each step the water drop may stay in the same phase or it may change to a different phase.
    - 1 or 2 = Solid
    - 3 or 4 = Liquid
    - 5 or 6 = Gas
9. Each time the student rolls their die, they will record information on their worksheet including whether they went through a phase change and if so, what type of phase change occurred. It is up to the student to create a story about where their water droplet goes at each step. Students will then determine if energy was used or released. Everyone's water droplet will be unique. Encourage students to be creative about how the phase changes move their water droplet around the planet. Students should discuss what is happening to their water droplet with their group and they can exchange ideas about where their water droplet could go next.
10. Each student will draw a picture of their water droplets' journey based on the information on their worksheet. The drawing should include each step along the journey with depictions or labels explaining how the water got from one step to the next.

Observations:
A sample completed worksheet and diagram are provided below.

Step	Roll	Phase	Phase Change	Energy used (U) or released (R)	What happened to you? Where did you go?
Start	3	Liquid			Starting Point: Ocean
1	4	Liquid	None	None	- swallowed by fish, now inside fish blood
2	3	Liquid	None	None	- fish went to the bathroom, back in the ocean
3	5	Gas	Evaporation	U	- sun heated up the ocean surface and water evaporated into the air
4	3	Liquid	Condensation	R	- condensed into liquid droplets in a cloud
5	2	Solid	Freezing	R	- air was cold and water droplets froze to snowflakes - snow fell on the ocean
6	4	Liquid	Melting	U	- melted into the ocean
7	6	Gas	Evaporation	U	- sun evaporated water into the air and it was carried in the wind over land
8	4	Liquid	Condensation	R	- dew drops on the grass
9	3	Liquid	None	None	- seeped into the groundwater
10	1	Solid	Freezing	R	- cold winter weather froze the ground

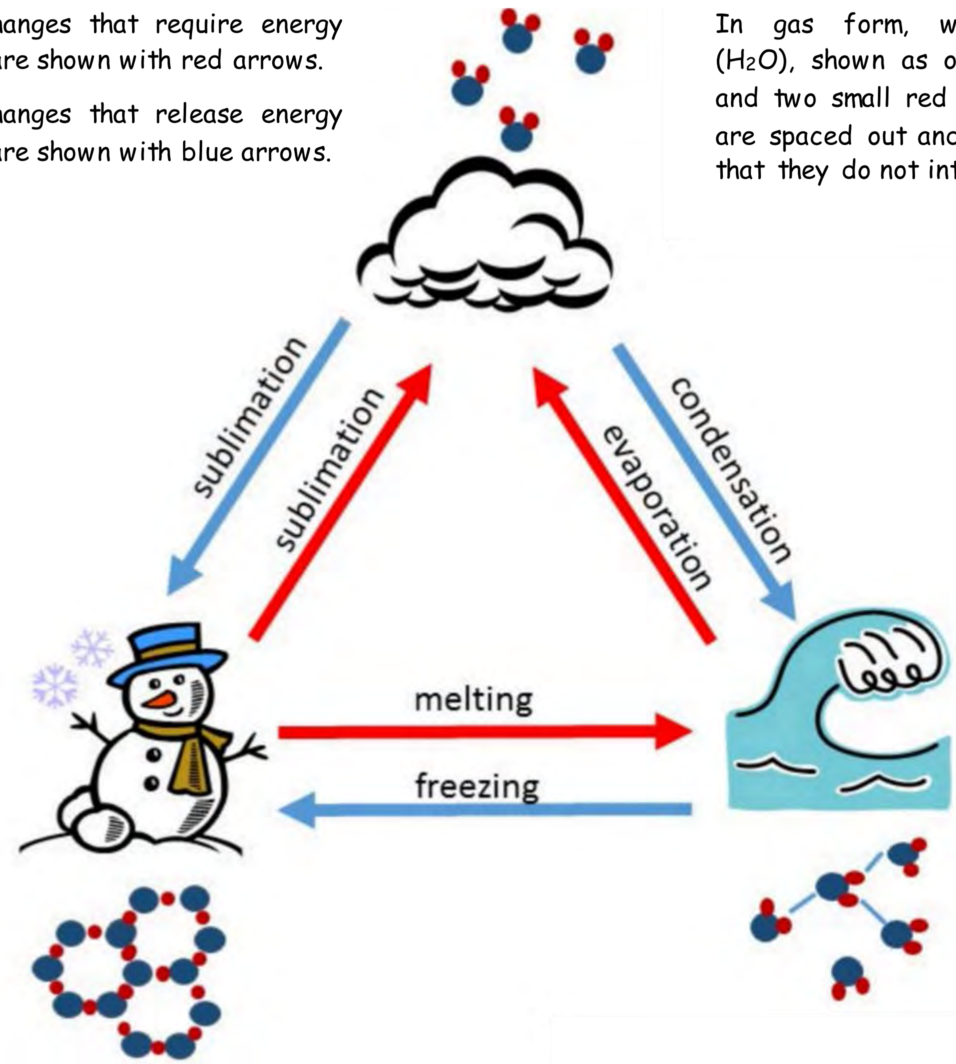


It's Just a Phase! – Background Information
How Water Changes and Moves Around Our Planet

Phase changes that require energy or heat are shown with red arrows.

Phase changes that release energy or heat are shown with blue arrows.

In gas form, water molecules (H_2O), shown as one blue oxygen and two small red hydrogen atoms are spaced out and moving so fast that they do not interact.



In solid form, water molecules form a hexagonal lattice. This lattice structure takes up more space than liquid water, which is why when water freezes in a pipe, it can burst it.

In liquid form, water molecules interact with each other. The oxygen of a water molecule is attracted to the hydrogen of another water molecule forming hydrogen bonds.

Name: ______________________

It's Just a Phase!

Recording the Journey of My Water Droplet

Step	Roll	Phase	Phase Change	Energy used (U) or released (R)	What happened to you? Where did you go?
Start					**Starting Point:**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Activity 2: Let's Shake Things Up!

Time: 30 minutes

Other Applications:
Culinary Arts

Key Terms: colloid, homogenize

Group Size: 3 students

Materials (per group):

☐ 3 jars with lids (mason jars or jam jars)

☐ heavy cream (35% milk fat) – volume of ⅓ jar

☐ whole milk (3.25% milk fat) – volume of ⅓ jar

☐ skim milk – volume of ⅓ jar

☐ "Let's Shake Things Up!" datasheet per student

☐ stopwatch (optional)

Learning Goal: Students will discover which type of milk produces the best butter.

A colloid is a suspension of tiny particles in another medium. Very small particles of one substance are evenly distributed throughout the other substance. Colloids appear very similar to solutions but the particles are suspended, not dissolved. These particles will not settle to the bottom over time. An emulsion is a type of colloid of two or more liquids that are normally immiscible (unblendable). Milk is an emulsified colloid and is made mostly of water with tiny fat globules suspended in it. When we shake the milk vigorously, the fat globules crash into each other and clump together. Agitation of cream or milk can disrupt the colloid and change its physical characteristics. The cream will fully separate into other familiar supermarket products, butter and buttermilk.

Procedure:

1. Allow milk and cream to sit at room temperature for three hours.
2. Provide each group with a set of three jars filled to about ⅓ full with cream (Jar 1), whole milk (Jar 2) and skim milk (Jar 3).
3. Hand out a "Let's Shake Things Up!" datasheet to each student.
4. Begin with the cream (Jar 1). Have students take turns shaking the jar vigorously for 5 minutes.
5. Record the exact time when any change in the consistency is observed on the "Let's Shake Things Up!" datasheet. After each 5 minute interval, record a description of the liquid and continue taking turns shaking for another 5 minutes. Students may open the lid from time to time to see what it looks like but they should also notice any differences when they are shaking it.
6. Students can continue to shake for approximately 20 minutes. They may stop shaking when the butter is completely separated as shown in the picture. They can continue shaking for the full duration of the experiment if the butter has not formed.
7. Repeat steps four to six for Jar 2 and Jar 3.
8. When students are finished, they may spread their experiment on bread and eat it, if desired. If students plan to take their butter home, be sure to store it in the refrigerator.

Fun Fact: Whipped Cream

Whipped cream is a type of gas-liquid colloid in which air is dispersed throughout the milk fat and water.

Observations:
Below is a chart of sample observations the students may record on their datasheets.

Time	Cream	Whole milk	Skim milk
2 min	thickened	no change	no change
5 min	separated into a solid clump of butter and liquid	no change	no change
10 min		tiny white particles	no change
15 min		tiny white particles	no change
20 min		tiny white particles	no change

Students should observe that the heavy cream changed to butter and buttermilk in about 5 minutes while the whole milk and skim milk did not change.

Discussion:
Heavy cream has a fat content of 38%, while whole milk is 3.25% and skim milk is virtually zero fat. The higher fat content means that there are more fat globules that can collide and interact. The fat globules begin to stick together and separate out. The more fat available, the faster this occurs. The whole milk with a lot of shaking would give you a very small amount of butter. While the skim milk has almost no fat, so you would be shaking forever!

Some other examples of mixtures include oil and vinegar salad dressing and mayonnaise. When you try to mix oil and vinegar to make salad dressing, it needs to be shaken up before adding it to salad. The dressing is a suspension and the oil and vinegar will separate over time. Emulsifiers keep colloids and emulsions stable. For example, mayonnaise, which is also oil and vinegar, does not need to be shaken before being used. Mayonnaise contains egg yolk which is a type of emulsifier that keeps the oil and vinegar in the mayonnaise from separating.

When untreated, milk will separate and become non-uniform. Large fat globules will rise to the top. Homogenization is a process applied to modern milk that makes the fat content a uniform consistency throughout the milk. Homogenization involves pumping milk through small channels so that the larger fat globules are broken into smaller ones and distributed more evenly throughout the milk.

Fun Fact: What is Ice Cream?

Ice cream is a complex colloid formed from a liquid (milk fat), a solid (ice crystal) and a gas (air). Once the milk fat starts to freeze, it is whipped to create foam. This helps the smaller fat particles join together to form larger ones. In turn, this keeps the air bubbles stable. Commercial ice creams use stabilizers that help keep the air bubbles from disappearing as well as keeping the ice crystals small.

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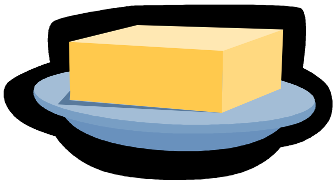
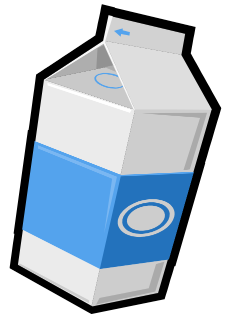
Name: ___________________________



Let's Shake Things Up!



Time	Cream	Whole milk	Skim milk

Activity 3: Homemade Toys using Milk Polymers

Time: 30-45 min to make toys; 2 days to air dry; 30 min for decorating (optional)

Other Applications: Art, Environmental Science

Key Terms: polymer, protein, casein

Group Size: Pairs

Materials for Teacher Preparation:

☐ 250 ml measuring cup

☐ stove or microwave safe dishes to heat milk

Materials (per pair):

☐ 250 ml homogenized milk (3.25% fat)

☐ small cup with 1-2 tablespoons of vinegar

☐ 1 tablespoon for measuring

☐ 1 coffee mug

☐ 1 spoon

☐ 2 large plastic dinner plates

☐ 8 sheets of paper towels

☐ 1 piece of plastic wrap to cover/protect desktop

Learning Goal: Students will learn how to make a sculpture from milk.

Milk is comprised of two types of proteins: whey and casein. Casein contains phosphorus. When milk is heated and acid is added, the casein protein will coagulate due to the low pH level and phosphorus present. This causes the protein molecules to combine together to create a long chain. This process is called polymerization. Plastics are a moldable polymer and most often made from petroleum, however many small items, such as buttons, jewellery and buckles, have been made using milk casein.

Procedure:

Teacher Preparation Before Class Activity

1. Heat up the milk on the stove or microwave to the point where it is hot but not boiling (70°C). If using the stove, keep heat at medium and stir to avoid burning the milk. In the microwave, 50% power works well. When it starts to produce a skin on top remove it from the heat.
2. Measure out 1 cup of hot milk (per pair of students) into a mug.
3. Create workstations for pairs of students including the hot milk mug, two plastic plates with four layers of paper towel on each and a piece of plastic wrap lying flat on the desk to protect it.

Class Activity

1. Add 1 tablespoon of vinegar to the mug of hot milk. Stir for about 30 seconds. What happened?
2. Pour the curdled milk onto the stack of four paper towels on one of the plates.
3. Scrape the curds off the paper towel and place them onto the second stack of paper towels on the other plate. Allow the curds to cool for a minute or two.
4. Roll the curds in the paper towels, like a burrito, and apply a little pressure to remove some excess moisture but let it stay fairly moist.
5. Spoon up the curds and squish them together in your hands and place them on the plastic wrap that is covering the desktop.

Step 1

Step 2

Step 3

6. Knead the curds until they become smooth and have the consistency of play dough. This can be done by repeatedly pushing your fingertips on the curds to flatten them and then folding them up and then flattening with fingertips again, similar to kneading bread.
7. Divide the curds in half and have each student create their own toy. Have students mold their curds into their desired shape. If it becomes very crumbly, you may add a tiny bit of water and knead again. Molds can be used if desired. A drop of food colouring or glitter can also be added and kneaded into the creation. Stamps can be used to imprint pictures on it. If using stamps, place the stamp into the inkpad and then into the curds while they are still warm. Examples of items that can be made out of milk casein are toys, pendants, or key chains. In the photo below, the heart was stamped on while it was soft. For the shark, one drop of food colouring was added while kneading.
8. Leave the creation to air dry for 2 days. Keeping it in a mold will require longer to dry.
9. Homemade items may be further decorated with markers or paint if desired.

Discussion:

Milk is a complex liquid made up of over 100 different chemical compounds. The predominant compounds are water, fat, lactose, casein, whey, and minerals. These compounds react in a fascinating way when milk is heated. Some of the water in the milk will evaporate from the surface. The proteins and fat in the milk become more concentrated and start to stick together. This forms the skin that is seen on top of the milk.

Normally the casein molecules in milk are negatively charged and therefore would repel each other. The addition of acid, in the form of vinegar, neutralizes the negatively charged casein molecules. These unstable casein molecules then unfold and rearrange themselves into long chains. This process is called polymerization and happens more quickly if the milk is heated. These casein molecules will precipitate out of the milk and are known as curds. The curds can be dried and molded. Curds can also occur naturally, when acid builds up due to bacteria growing in milk.

Casein polymers were developed and used from the early 1900s until 1945 to manufacture items such as buttons. These polymers were strong and did not dissolve in water but making them from milk was very expensive. Industry has now moved to using petroleum-based polymers, commonly known as plastics, to replace the casein polymer. Other common polymers include silk, DNA and play dough.

When the average consumer thinks of plastics, they likely think of water bottles or plastic bags. Plastics are long chain molecules that are made from repeating units of smaller molecules. They are soft and can be molded and then hardened to retain their shape. A plastic can be either naturally occurring, such as cellulose or rubber, or man-made such as Styrofoam. Scientists and engineers are continuously researching and developing new types of plastics. For example, corn starch plastics have been recently developed that are now widely used in biodegradable bags. Interestingly, milk casein combined with clay is also being researched as a potentially greener plastic.

Fun Fact: Plastic – Is It the Next Epidemic?

Plastic is everywhere…plastic keyboard, plastic sandwich bag, plastic water bottle, plastic straws. In the last 10 years, we have produced more plastic than was produced during the last century! Where does it all go? Virtually every piece of plastic produced, still exists in some shape or form. Tiny plastic beads, used in facial scrubs and toothpaste, have been found in the Great Lakes! Gigantic plastic garbage patches are floating in our oceans. Plastic has been found in the bodies of sea birds, marine mammals, sea turtles and fish. Over one million sea birds and 100,000 marine mammals die annually due to plastic in the ocean. Plastic pollution is a large problem for our Earth and our health.

What can you do to help? Try using: cloth bags, metal or glass water bottles, lunch bags and a thermos. If you have to use plastic, limit your use to #1 (PETE) or #2 (HDPE) which are commonly recycled plastics. Try to avoid the use of plastic bags and polystyrene foam as they have very low recycling rates.

Activity 4: How much oxygen is in the air? Try this Rusty Experiment!

Time: 2 days

Other Applications: Math (volume, ratio, percent, proportion)

Key Terms: oxidation reaction, catalyst, corrosion

Group Size: 3 students

Materials per group:

- ☐ 3 glass jars of similar proportions (jam, salsa, large baby food)
- ☐ sticky tack
- ☐ rubber gloves
- ☐ steel wool, extra fine, 0000 from hardware store (not the type with soap)
- ☐ masking tape
- ☐ waterproof marker
- ☐ 3 elastic bands
- ☐ vinegar
- ☐ water
- ☐ measuring cup
- ☐ 1 basin or container large enough to hold the jars with some space to spare and deep enough to hold 5 cm of water
- ☐ 6 pencils
- ☐ 1 bendy straw
- ☐ ruler
- ☐ "Rusty Experiment" datasheet per student

Learning Goal: Students will learn what proportion of oxygen is in air.

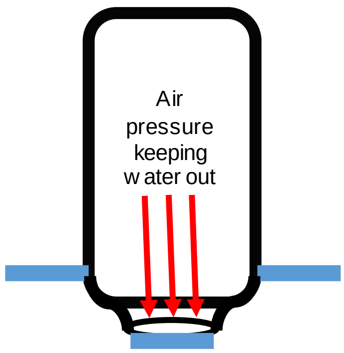
When oxygen, from the air, and water combines with iron, it forms a new compound called rust. In this activity, the rusting, or oxidation reaction, can be monitored as oxygen in the air is used up. The volume of air used up in the reaction equals the proportion of oxygen in the air. Steel wool is the source of iron for this activity. Steel is composed of iron plus carbon and other elements that make it stronger.

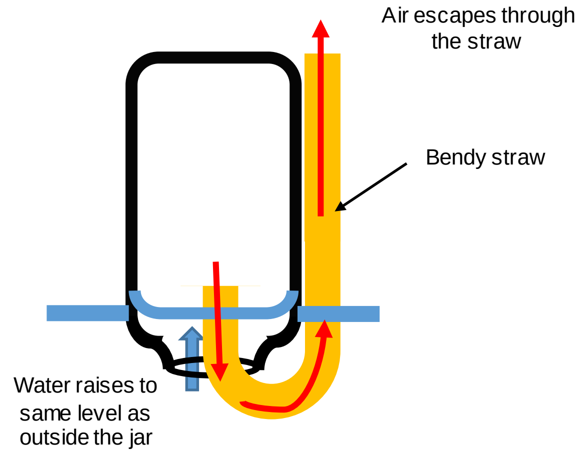
Precaution: Wear rubber gloves when handling steel wool to avoid splinters.

Procedure:

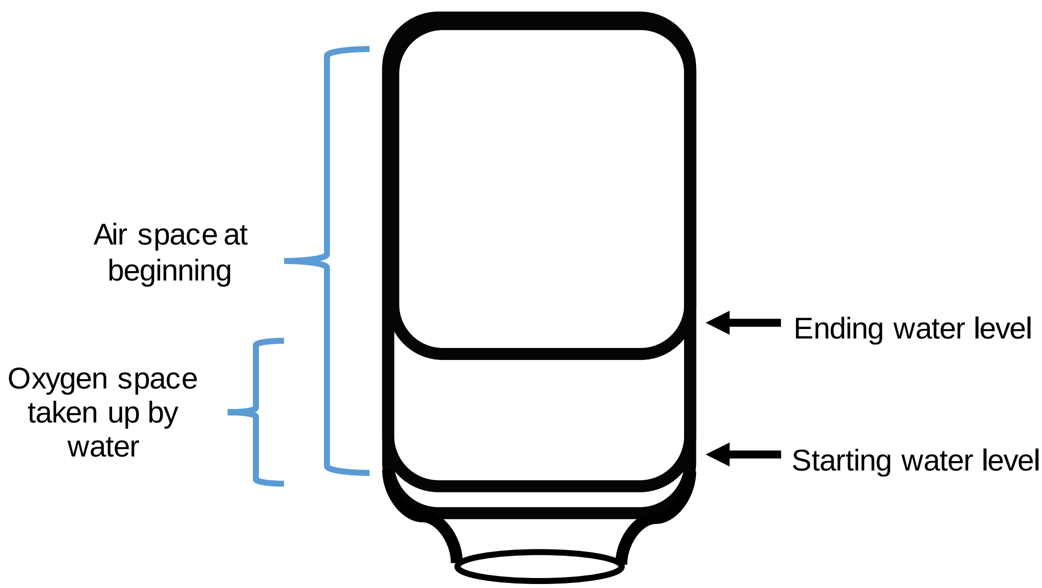
1. Knead some sticky tack and place it in the bottom of the jars using the pencil to apply pressure so it sticks.
2. While wearing gloves, tease out a small bit of steel wool. Stretch it out and then ball it up (~3 cm ball). Drop the steel wool into the jar and using the pencil tamp it down so it sticks to the sticky tack. Repeat for each jar. Using masking tape and marker, label each jar on the bottom: Jar 1, Jar 2 and Jar 3.
3. Place an elastic band around each jar. Jar 1 (dry) will have no further treatment.
4. Add enough water to Jar 2 (wet) to cover the steel wool.
5. For Jar 3 (acidic), prepare a 50:50 water:vinegar mixture. Fill a measuring cup with 50 ml vinegar. Add 50 ml water. In Jar 3, add enough of this 50:50 water:vinegar mixture to cover the steel wool.
6. Let the liquid sit for two minutes in Jar 2 and 3 and then empty the liquid from the jars.
7. On the bottom of the basin, place two pencils per jar so they are parallel, separated at slightly smaller width than the jar openings, and tape them down. The inverted jars will rest on these pencils during the experiment (see photo).
8. Fill the basin with water, about 5 cm height, so that when the inverted jars are placed on the pencils, the water level is a few cm above the opening of the jars.
9. Place all three jars inverted onto pencils in the basin.

10. Initially when you place the jar into the basin, water will not enter the jar because the air pressure is too high. Lower the air pressure inside the jar by placing a thumb over the long end of a bendy straw and hooking the short end under the jar so it comes above the water. Remove your thumb to allow the water level to rise inside the jar to the same level as outside the jar (see diagram). Remove the straw and repeat the process with the other two jars.
11. Mark the "zero" water level by moving the elastic band to the water level on each jar.





12. Hand out a "Rusty Experiment" datasheet to each student. Measure, in cm, the water height changes at 15 minute intervals for the first hour, then 1 hour intervals throughout the day and then a final measurement the next morning. Record the measurements on the datasheet.
13. Throughout the experiment observe the steel wool for signs of change and record any noticeable observations on the datasheet. Feel the top of the jar and note any changes.
14. After measuring the final water level, remove the jars from the water and place them upright.



Observations:
The water level in Jar 1 (dry wool) should remain at start level. It should not feel warm or foggy. There should be visible rusting on the steel wool for both Jar 2 (water) and Jar 3 (50:50 vinegar:water). The steel wool in the vinegar:water jar should rust faster and the water should rise faster than in Jar 2 but both water levels should rise to the same final height. Both Jar 2 and 3 should have approximately the same amount of rust showing on the steel wool. The areas around the steel wool on Jars 2 and 3 should become foggy and the jars should feel warm. Rusting is an exothermic reaction which means that heat will be produced. See sample observation chart below with the distance the water travelled up the inside of the jar.

Sample observations for "Rusty Experiment" datasheet:

Elapsed Time	Jar 1 (dry)	Jar 2 (wet/water)	Jar 3 (acidic/50:50 water vinegar)	Observations
Initial	0 cm	0 cm	0 cm	
15 min	0 cm	0 cm	0.5 cm	
30 min	0 cm	0 cm	1 cm	visible rust forming on steel wool for Jar 2 (water) and Jar 3 (water:vinegar)
45 min	0 cm	0.5 cm	1 cm	Jar 3 is getting steamy and feels warm Jar 2 is slightly steamy and feels slightly warm
1 hour	0 cm	0.5 cm	1.5 cm	
2 hours	0 cm	1 cm	2 cm	steel wool in Jar 2 and 3 look more rusty
3 hours	0 cm	1 cm	2.4 cm	
24 hours	0 cm	2.4 cm	2.4 cm	Jar 1 steel wool has no rust Jar 2 and 3 steel wool is very rusty

Discussion:
In Jar 1, no rust forms on the steel wool. In order for the rusting process to occur, both water and oxygen need to be present. Since the steel wool is dry, no discernible rust forms during the experiment. Jar 2 will show some rust since both water and oxygen are available to react with the iron. The rusting in Jar 3 will be more pronounced for two reasons. Vinegar is acidic and can remove the protective coating on the steel wool. It also acts as a catalyst, making the rusting process quicker. As the rusting process proceeds, the water level in the jar rises. The oxygen reacts with the iron to form iron oxide (rust). With less oxygen in the jar, the air pressure inside the jar falls. The higher air pressure outside the jar pushes water into the jar.

Most metals will undergo oxidation (i.e. corrosion) in the presence of water and oxygen. Another familiar metal that corrodes or becomes oxidized when exposed to air and water is copper. Oxidation of old pennies makes them turn a minty green colour, known as patina. Sometimes people wonder why the Statue of Liberty is green. It was once shiny reddish-brown copper but oxidation has turned it green.

Extensions:
1. Try experimenting with different substances. For example, what happens if you add salty water to the steel wool? We use salt in the winter on our icy roads but like acid, salt acts as a catalyst in the rusting process. Discuss how salting roads in the winter could affect your car and ways that cars can be prevented from rusting.
2. Try adding Jar 4 which contains steel wool pretreated with cooking oil. This will prevent contact between the steel and the oxygen and water. This is similar to "undercoating" your car.

Name: ______________________

Rusty Experiment!

	Measurement (cm)			
Elapsed Time	**Jar 1 (dry)**	**Jar 2 (wet)**	**Jar 3 (acidic)**	**Observations**
Initial				
15 min				
30 min				
45 min				
1 hour				
2 hours				
3 hours				
24 hours				

Activity 5: Calcium: Now You See It, Now You Don't!

Time: 2 days

Other Applications: Geology, Health

Key Terms: dissolve, precipitate

Group Size: Pairs

Materials (per pair):
Part 1

- ☐ 1 cup vinegar
- ☐ measuring cup
- ☐ 2 glasses (or mason jars)
- ☐ 1 piece of classroom chalk (Crayola or other brand of white hard chalkboard); may be labelled as dustless.
- ☐ 1 piece of sidewalk chalk (or ½ piece if large pieces).
- ☐ masking tape and marker
- ☐ "Calcium: Now You See It, Now You Don't!" datasheet per student

Part 2

- ☐ 1 ½ tsp baking soda
- ☐ ½ tsp measuring spoon
- ☐ ¼ cup vinegar
- ☐ measuring cup
- ☐ funnel (can be shared between groups)
- ☐ paper towel
- ☐ 2 glasses (or mason jars)
- ☐ stirring spoon

Learning Goal: Students will learn about and observe different chemical reactions.

A chemical reaction occurs when two or more chemicals interact to produce one or more new chemicals. In comparison, a physical change means that no new substances are made. A change in temperature can be evidence that a chemical reaction is occurring. Other changes that may indicate a chemical reaction include a colour change, production of a gas or formation of a precipitate. If the reaction is taking place in a liquid, the formation of a gas may be observed as bubbles and a precipitate may be seen as an insoluble product that results in cloudiness or a solid that settles to the bottom.

Eggs, shells, bones and most chalkboard chalk contain calcium carbonate. Students will observe a chemical reaction as calcium carbonate reacts with acetic acid in vinegar to produce a new compound, calcium acetate. The release of carbon dioxide produces fizzing and the formation of gas bubbles. The calcium acetate will dissolve in the vinegar. Adding sodium bicarbonate, in the form of baking soda, will create another chemical reaction where the calcium carbonate reforms. The calcium carbonate precipitates from solution and should be visible.

Procedure:
Part 1: Vinegar and Chalk Chemical Reactions
Day 1

1. Provide each student with a copy of the "Calcium: Now You See It, Now You Don't!" datasheet.
2. Have the students add ½ cup of vinegar to each of the two glasses. Using masking tape and marker, label the glasses as 'Chalkboard' and 'Sidewalk'. Place a piece of chalkboard chalk in one glass and a piece of sidewalk chalk in the second glass.
3. Record any initial observations in the two glasses on Part 1 of the datasheet. Record any new observations after 15 minutes. Was there a chemical reaction?

Day 2 (24 hours)

4. Record any noticeable observations in the two glasses after 24 hours. What happened? If there was a precipitate, is it a different colour? If it is, why? Do not discard as this vinegar will be used in step 7 and 8 of Part 2.

Part 2 (Day 2): Baking Soda and Vinegar Chemical Reactions

5. Provide students with materials for Part 2 as well as the glasses and contents from Part 1.
6. Add ½ tsp of baking soda to ¼ cup of vinegar in a glass. Stir with a spoon. What happened? Record observations on Part 2 of the datasheet under "Pure Vinegar".

7. Label two clean empty glasses as ‘Chalkboard’ and ‘Sidewalk’.
8. Place a funnel over the new chalkboard glass. Line the funnel with a paper towel by folding a paper towel in half and then fold in half again. Place the point of the paper towel into the funnel and open it so that it forms a cone.
9. Pour the liquid from the chalkboard glass from Part 1 through the paper towel and funnel into the new glass. This will remove any larger particles.
10. Pour the liquid collected from the chalkboard glass into a measuring cup until it measures ¼ cup and discard the remainder. Pour the ¼ cup of liquid back into the new chalkboard glass.
11. Repeat steps 8 and 9 with the sidewalk chalk.
12. One person in the group will work with the chalkboard chalk and another person with the sidewalk chalk. Simultaneously, add ½ tsp of baking soda to each glass containing ¼ cup of the liquid. Let sit for 15 minutes and observe. Record observations on Part 2 of the datasheet.

Observations:
Students should observe a variety of different changes suggesting that a chemical reaction has occurred. A sample completed datasheet is provided as well as some photos that illustrate expected results.

Part 1: Observation Chart – Chalk and Vinegar Chemical Reactions

Elapsed Time	Chalkboard Chalk	Sidewalk Chalk
Day 1 – 0 min	lots of bubbles	a few bubbles along the edge
Day 1 - 15 min	bubbles and the chalk is dissolving	it bubbled a little more during the 15 minutes and then almost ceased bubbling; chalk is not dissolving
Day 2	chalk is completely broken up; although the chalk was white, the material in the bottom of the glass is beige	chalk is intact; has not changed or broken down; no material at the bottom of the glass

Part 1:
After 24 hours, the chalkboard chalk reacted with the vinegar, dissolved and left behind beige particles (calcium acetate) that settled to the bottom of the glass.

Part 2: Observation Chart – Vinegar and Baking Soda Chemical Reactions

Observations	Pure Vinegar	Chalkboard Chalk Vinegar	Sidewalk Chalk Vinegar
Initial	a lot of fizzing and bubbling	a lot of fizzing and bubbling	a lot of fizzing and bubbling
15 minutes	no precipitate, baking soda dissolved in vinegar	a significant amount of solid precipitate formed, can spoon it out	no precipitate, baking soda dissolved in vinegar

Part 2:
The chalkboard vinegar reacted with the baking soda. It foamed and the precipitate (calcium carbonate) settled to the bottom of the glass.

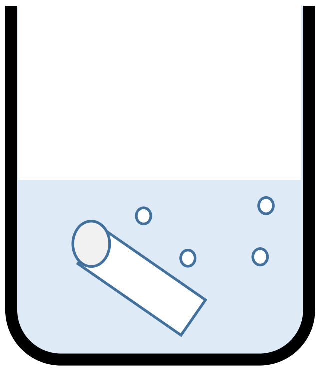
Discussion:
Chalk comes from a form of limestone that is created by tiny marine plankton when they decompose. These skeletal fragments of marine organisms contain different forms of calcium carbonate. In a sense, the chalk used today was made 60 – 100 million years ago.

The calcium carbonate in the chalkboard chalk reacted with the vinegar to produce water, carbon dioxide, observed as gas bubbles, and calcium acetate. In comparison, the sidewalk chalk showed only minor signs of reaction and did not dissolve. Sidewalk chalk is made from calcium sulfate. Vinegar is a weak acid and does not react with this compound.

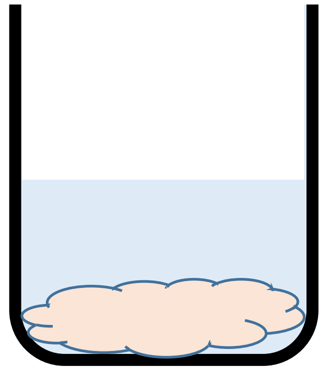
In Part 2, there was a chemical reaction between the baking soda, known as sodium bicarbonate, and vinegar. One of the products of the chemical reaction, carbon dioxide, was visible as fizzing and bubbling. After the reaction was complete, there was no visible precipitate as the baking soda dissolved into the vinegar.

There was a different observation when baking soda was added to the filtered vinegar from the chalkboard chalk glass. This vinegar contained dissolved calcium ions. As a result, when it was combined with baking soda, the calcium ions reacted with the baking soda to form another kind of precipitate. This precipitate, calcium carbonate, is very white.

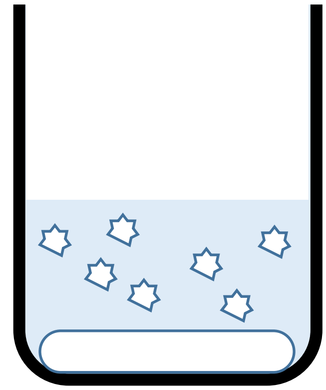
The following diagrams explain what is happening at different stages:



Acetic acid reacted with the calcium carbonate in the chalk to form calcium acetate (precipitate) and carbon dioxide (bubbles).



The reaction initially produced a precipitate which is suspended in solution and settles to the bottom of the glass. Some calcium acetate dissolves in the vinegar.



Baking soda is made up of sodium bicarbonate. Sodium bicarbonate reacted with the calcium was dissolved in the vinegar to reform calcium carbonate.

Extensions:

Different substances can be tested for the presence of calcium carbonate:

- Collect different types of rocks and see which ones contain calcium carbonate by seeing if they bubble when placed in vinegar. Marble contains calcium carbonate, which is why statues and tombstones are affected by acid rain.
- Bones and shells also contain calcium carbonate. Try bones from a roast chicken dinner or snail shells found on the ground, or how about a lost tooth? Calcium gives strength to shells and bones. Place a bone in vinegar for three days and change the vinegar each day. After three days, it will become bendable. Place an egg in water for 3 days and see what happens to the shell.

Name: ____________________________

Calcium: Now You See It, Now You Don't!

Part 1: Chalk and Vinegar Chemical Reactions

Elapsed Time	Chalkboard Chalk	Sidewalk Chalk
Day 1: 0 min		
Day 1: 15 min		
Day 2		

Part 2: Vinegar and Baking Soda Chemical Reactions

	Pure Vinegar	Chalkboard Chalk Vinegar	Sidewalk Chalk Vinegar
Prediction			
Observations			

Teacher Resources

Literary Resources

The Nature of Matter. Anna Claybourne. 2007. Gareth Stevens Publishing. ISBN 978-0-8368-8088-5. The basics about matter, how different substances behave and how they are useful.

Painless Chemistry. Loris Chen. 2011. Barron's Educational Series. ISBN 978-0-7641-4602-2. About chemistry and its connections to everyday life.

Website Resources

http://www.exploratorium.edu/origins/cern/ideas/bang.html *(08/09/17)*
CERN, European Organization for Nuclear Research, explains how matter came from the Big Bang.

http://education-portal.com/academy/lesson/states-of-matter-and-chemical-versus-physical-changes-to-matter.html#lesson *(08/09/17)* About physical and chemical changes.

http://kitchenscience.sci-toys.com/protein *(08/09/17)*
Food chemistry: How protein molecules change when you heat, whip them or add other ingredients.

http://www.plastiquarian.com/index.php?id=60 *(08/09/17)*
The plastic historical society presents the history of milk casein plastic. There is also excellent general information on this website about polymers and plastics.

http://www.wisegeek.com/what-is-homogenized-milk.htm#didyouknowout *(08/09/17)*
About the homogenization of milk.

http://www.sciencekids.co.nz/sciencefacts/metals/iron.html *(08/09/17)* Interesting facts about iron.

http://www.madehow.com/Volume-1/Chalk.html *(08/09/17)* How chalk is made from rocks.

http://www.engageengineering.org/e3s-faculty-submitted-e3s *(08/09/17)*
Click to download lesson plan exploring why the statue of liberty is green and rust chemistry.

http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=23CEC266-1 *(08/09/17)*
The water cycle and the water-climate relationship, from Environment Canada.

http://education-portal.com/academy/lesson/phase-change-evaporation-condensation-freezing-melting.html#lesson *(08/09/17)* About phase changes and energy.

Interactive White Board Resources

"Matter Review"
http://exchange.smarttech.com/details.html?id=b2cbfa03-0078-4745-b31c-302765acb7b6 *(08/09/17)*
Review questions on matter.

Multimedia

https://www.youtube.com/watch?v=xdedxfhcpWo 1:34 min *(08/09/17)*
Canadian Museum of Nature shows what happens at the level of molecules when water dissolves salt.

http://easyscienceforkids.com/all-about-internal-combustion-engines/ 1:39 min *(08/09/17)*
The engine of a car is a chemical reaction put to work. Find out how an internal combustion engine works and click on the movie to see it in action.

https://www.youtube.com/watch?v=VgVQKCcfwnU 2:53 min *(08/09/17)*
The periodic table song by ASAP science.

Student Resources

Literary Resources

Atoms and Molecules: Bringing chemistry to life. Molly Aloian. 2009. Crabtree Publishing Company. ISBN 978-0-07787-4240-1. This introduction to atoms and molecules and how they behave provides clear explanations.

Exploring Atoms and Molecules. Nigel Saunders. 2008. Wayland/The Rosen Publishing Group, Inc. ISBN 13: 978-1-4042-3750-6. From Exploring Physical Science series, this book introduces elements and compounds, and how they behave, with excellent examples anyone can relate to.

Elements. David Krasnow and Tom Seddon. 2003. Gareth Stevens Publishing. ISBN 0-8368-3357-0. From the Discovery Channel School Science series, this book describes how it became known that matter is composed of elements and uses stories and interesting anecdotes to highlight different elements.

Water. Trevor Day. 2007. Dorling Kindersley Limited. ISBN 978-0-7566-2562-7. A book explaining the properties of water at the molecular level, the water cycle, and demonstrates the significance of water in climate, life, and shaping our land.

Interactive Resources

http://www.eo.ucar.edu/kids/wwe/ *(08/09/17)*
Follow the water drops through the water cycle by clicking on different parts of the water cycle.

http://www.sheppardsoftware.com/periodictable_L.html *(08/09/17)*
Click on an element in the periodic table to learn about its properties.

References
In addition to resources listed above, the following websites were also used to develop this package *(21/08/14)*:
http://chemwiki.ucdavis.edu/Theoretical_Chemistry/Chemical_Bonding/General_Principles/Bond_Energies; http://www.sciencebuddies.org/science-fair-projects/Classroom_Activity_Teacher_MilkPlastic.shtml?from=Blog; http://www.scientificamerican.com/article/bring-science-home-milk-plastic/; http://www.wisegeek.org/why-does-milk-form-a-skin-when-it-is-heated.htm; http://www.eng.umd.edu/~nsw/ench485/lab1.htm; http://www.etymonline.com/index.php?search=plastic&searchmode=none; http://www.acs.org/content/acs/en/pressroom/podcasts/globalchallenges/future/our-sustainable-future-biodegradable-plastic-from-milk-and-clay.html; http://www.scientificamerican.com/article/bring-science-home-butter-emulsion/; http://scienceline.ucsb.edu/getkey.php?key=3964; http://www.csiro.au/helix/sciencemail/activities/Rust.html; http://www.atmo.arizona.edu/students/courselinks/fall12/atmo170a1s1/coming_up/week_1/oxygen_conc_expt.html; http://scienceforkids.kidipede.com/chemistry/atoms/doing/calcium.htm; http://en.wikipedia.org/wiki/Limestone; http://humantouchofchemistry.com/the-chemistry-of-chalk.htm; http://www.theweatherprediction.com/habyhints2/524/; http://www.nc-climate.ncsu.edu/edu/k12/.watercycle; http://www.nc-climate.ncsu.edu/edu/k12/.lsheat; http://en.wikipedia.org/wiki/Scanning_tunneling_microscope; http://easyscienceforkids.com/all-about-internal-combustion-engines/ http://www.livescience.com/32691-what-are-greenhouse-gases-and-how-do-they-warm-the-earth.html; http://www.scienceprojectideas.co.uk/ice-cream-colloidal-chemistry.html. http://www.onthelake.net/fishing/turnover.htm

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Scientists in School is a leading science education charity that reaches more Kindergarten to Grade 8 youth than any other science non-profit in Canada – 703,000 in the 2017-18 school year.

Through our hands-on, inquiry-based science, technology, engineering, math (STEM) and environmental classroom and community workshops, we strive to ignite scientific curiosity in children so that they question intelligently; learn through discovery; connect scientific knowledge to their world; get excited about science, technology, engineering and math; and have their interest in careers in those fields piqued.

By making science a verb - something you do - our workshops allow children's natural curiosity to reign, inspire kids to see themselves as scientists and engineers, and make connections between science and the world around them. This sets the stage for a scientifically-literate future generation who will fuel Canada's economic prosperity and think critically about the scientific challenges facing our society.

Scientists in School relies upon corporate, community, government and individual donors, as well as school board partners for support to develop new programs, continuously improve our existing programs, reach new geographic areas, provide complimentary workshops to less-privileged schools, and subsidize the cost of every one of our 25,040 annual classroom workshops.

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Amgen Canada, John and Deborah Harris Family Foundation, Nuclear Waste Management Organization, Ontario Power Generation, RBC

Imagination Level:

ArcelorMittal Dofasco, General Motors Canada, McMillan LLP, Pure Green Earth Fund, Superior Glove Works Ltd., TELUS

Discovery Level:

Ajax Community Fund at Durham Community Foundation, AtlasCare, Bruce Power, Cameco, Hamilton Community Foundation, MilliporeSigma, Ottawa Community Foundation, pharmaKARe consulting, Purdue Pharma, Syngenta, Systematix Inc., The Johansen-Larson Foundation, The McLean Foundation, The Township of Tiny, Waste Management

Exploration Level:

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