MAINE MOBILE BIOLAB
TEACHER GUIDE

What's In a Change?

Topic(s): Chemistry, chemical/physical changes

Grade level(s): 6th – 8th grades

Time: 60 – 80 minutes

Maine Science and Engineering Standards: MS-PS1-2

ACTIVITY OVERVIEW

This activity dives into physical and chemical changes by having students learn and investigate the clues of each. Physical and chemical changes can be difficult concepts to teach students due to differences happening at the molecular level. This lab activity will allow students to see the differences between physical and chemical changes that challenge their observations and understandings. Students will look at amylose and water to see that creating a solution is not creating anything new chemically. They will also look at calcium carbonate and acetic acid to see how the carbon dioxide gas produced when combined has different properties than the reactants.

ALIGNMENT TO STANDARDS

MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

LEARNING OUTCOMES

Students will know:

- The common examples of physical change: color, shape, change of state of matter, density.
- The common examples of chemical change: change in temperature, change in color, noticeable odor after reaction, formation of a solid, formation of a gas.
- Mixing acetic acid and calcium carbonate is a chemical change.

Students will understand:

- Appearance or form of matter changes in a physical change, but not the kind of matter in a substance, e.g. ice to water.
- Kind of matter changes in a chemical change and at least one new product or substance with NEW properties is formed, e.g. calcium carbonate and acetic acid create carbon dioxide.
- Matter of different types will have different physical and/or chemical properties.
- The skills practiced in this lab are the same skills needed in many STEM careers.

Students will be able to:

- Collect and analyze data about the physical and chemical properties of substances.
- Use data as evidence to construct an argument that a change is chemical.
- Identify the formation of a new substance by interpreting data on the properties of substances before and after a change.
- Distinguish between physical and chemical changes in matter.

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CAREER CONNECTIONS

Chemical Technician

Chemical technicians use special instruments, equipment, and techniques in research labs to assist chemists and chemical engineers.

Work Environment: Chemical technicians can usually be found in laboratories or manufacturing facilities.

Duties: Monitor chemical processes, test quality of products, setup and maintain lab equipment, troubleshoot problems, prepare chemical solutions, run experiments, analyze and interpret data, prepare reports, and give presentations.

Median Salary: $56,750 (US Bureau of Labor Statistics, 2023)

Source: https://www.bls.gov/ooh/life-physical-and-social-science/chemical-technicians.htm

Food Chemist

A food chemist researches foods and their ingredients for improvements. This research could range from examining the balance of ingredients in different foods, to improving taste, to testing the quality to ensure safety for human consumption before production and sales.

Work Environment: Many food chemists work in laboratories and offices. Many food chemists work for the United States Food and Drug Administration, a federal agency.

Duties: Testing food or drink samples to ensure they follow federal guidelines, observing quality of food processing, and analyzing ingredients to offer accurate nutritional information.

Median US Salary: $76,400 (US Bureau of Labor Statistics, 2023)

Source: https://www.bls.gov/ooh/life-physical-and-social-science/agricultural-and-food-scientists.htm

Geochemist

A geochemist specializes in research that improves the quality of essential things for natural life, such as oil, minerals, and water. Geochemists often explore the history of the earth and its changing conditions.

Work Environment: Many geochemists work mainly outdoors. They are typically employed by oil companies, universities, and research institutes.

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Duties: Collecting environmental samples for quality testing, analyzing data for quality improvement, and writing reports and presenting them to other scientists or elected officials in a community.

Median US Salary: $92,580 (US Bureau of Labor Statistics, 2023)

Source: https://www.bls.gov/ooh/life-physical-and-social-science/geoscientists.htm

Materials Scientist

A materials scientist examines natural and man-made substances to document their composition, properties, and how the quality can be the most efficient.

Work Environment: Many materials scientists work in manufacturing facilities and laboratories. Many of these professionals are employed by technology manufacturing facilities.

Duties: Examining chemical properties of different materials, testing the quality of materials, and creating materials to improve a specific model.

Median Salary: $87,180 (US Bureau of Labor Statistics, 2023)

Source: https://www.bls.gov/ooh/life-physical-and-social-science/chemists-and-materials-scientists.htm

Chemical Engineer

Chemical engineers apply chemistry, biology, physics, and math to solve problems involving the use of chemicals. This includes areas like fuel (biodiesel), drugs (vaccines), and foods (GMOs).

Work Environment: You can find chemical engineers working in the office or in laboratories. You may also find them at work sites like an industrial plant or refinery to monitor and ensure operations run smoothly.

Duties: Conducting research, designing and planning the layout of instruments and equipment, conducting tests and monitoring performance, developing processes for step-by-step use, and much more. They can be responsible for overseeing entire projects or very specific processes within a project.

Median Salary: $112,100 (US Bureau of Labor Statistics, 2023)

Source: https://www.bls.gov/ooh/architecture-and-engineering/chemical-engineers.htm

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BACKGROUND INFORMATION

In this activity, students will investigate different combinations and determine if they are physical or chemical changes. Students will measure physical and chemical properties of reactants and products and analyze their data to form their conclusions.

Students should be introduced to chemical and physical changes prior to this experiment. Students should know that chemical changes produce new substances and that those new substances will have different properties from the reactants. Physical changes occur when substances are combined but do not chemically change; the products have the same properties as the reactants but might differ physically.

Physical changes would include a change in state of matter (solid, liquid, gas), a change in size or shape, or sometimes even a color change as seen in some solutions. Each change might affect how we view the substance, but at the molecular level, the substance is the same. Chemical changes occur when a new substance with new properties is created. This can be evidenced by the formation of a gas or precipitant (insoluble product), color change, change in temperature, or formation of an odor.

In our experiment, we utilize limewater (saturated $Ca(OH)_2$ aka calcium hydroxide) and iodine as a way to determine chemical properties of a substance. When limewater comes into contact with carbon dioxide an insoluble product, calcium carbonate ($CaCO_3$), is created and turns the clear solution cloudy white. When iodine comes in contact with a starch, it creates a purplish/black product (details in article below). We will be testing our reactants and products to see if they react with limewater or iodine in addition to looking at a change in physical properties.

Physical and chemical change

- https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Fundamentals/Chemical_Change_vs._Physical_Change

Video of the interaction of carbon dioxide and limewater

- https://www.youtube.com/watch?v=Vl9A8Iyc_LY

Science of baking soda and vinegar

- https://www.youtube.com/watch?v=HmzFG_xOeaQ

Why Does Iodine Turn Starch Blue?

- https://www.chemistryviews.org/details/education/10128441/Why_Does_Iodine_Turn_Starch_Blue/

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PRE-LABORATORY ENGAGEMENT

Invisible Ink

Before the mobile lab visit, students can complete the Invisible Ink activity for an introduction to chemical changes. In this activity, students will make an invisible ink of baking soda and water. This invisible solution can be revealed with grape juice and creates a color change, an indication of a chemical change.

Separation by Distillation

After the mobile lab visit, students can complete the Separation by Distillation activity by Science Buddies. It is recommended to use a powdered drink mix in this activity to highlight that a solution is a physical change because the reactants are unchanged (the water can be removed and is the same chemically at the end as it is in the beginning).

REAGENT PREPARATIONS

Amylose

- Fill 50mL conicals with about 30mL of cornstarch.
- Keep for use with multiple classes and refill as necessary.

Iodine

- Fill 15mL conicals with povidone iodine.
- Keep for use with multiple classes and refill as necessary.

Solid Calcium Carbonate

- Place 1 small boiling chip on a weigh boat for each station.

Powdered Calcium Carbonate

- Fill 50mL conicals with about 30mL of calcium carbonate.
- Keep for use with multiple classes and refill as necessary.

Water

- Fill 50ml conicals with distilled water.
- Keep for use with multiple classes and refill as necessary.

Acetic Acid

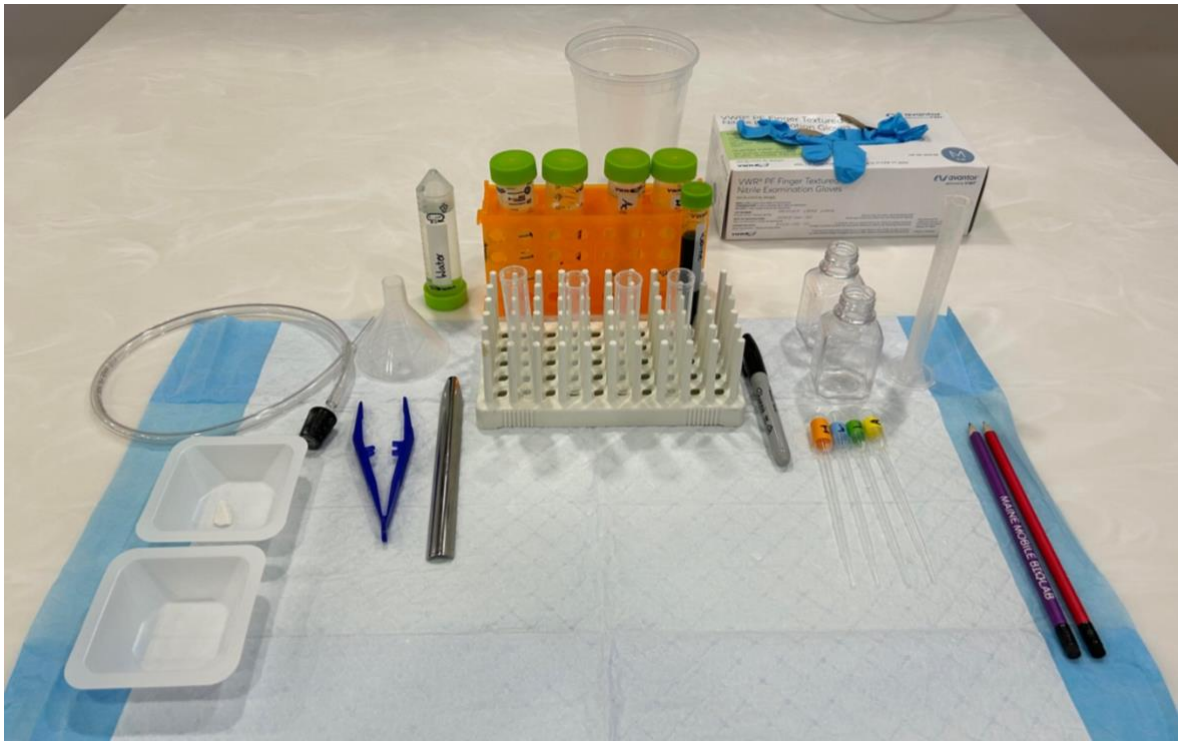
- Fill 50mL conicals with vinegar.
- Keep for use with multiple classes and refill as necessary.

Limewater

- Fill 50mL conicals with saturated limewater.
    - The bottle often comes with undissolved powder at the bottom. For this reason, do not shake or invert before aliquoting.
    - If possible, filter the limewater through multiple coffee filters before aliquoting.
- Keep for use with multiple classes and refill as necessary.

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LABORATORY SETUP



MATERIALS

Each station accommodates 2 students who will work on the activity as a pair.

- Absorbency pad
- Peg rack
- 50 mL conical of water
- 50mL conical of amylose
- 15mL conical of iodine
- 50mL conical of powdered calcium carbonate
- 50mL conical of acetic acid
- 50mL conical of limewater
- Empty white weigh boat
- Weigh boat with one small piece of solid calcium carbonate
- Scoopula
- 2 small bottles
- Rubber stopper with vinyl tubing
- 4 transfer pipettes (Iodine-orange, water-blue, limewater-green, and acetic acid-yellow)
- 10mL graduated cylinder
- 4 test tubes
- Permanent Marker

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LESSON PLAN

Slide 1: What's in a Change?

- Introduce today's activity about types of changes and ensure students are aware that it is a laboratory activity.

Slide 2: Learning Objectives

- Explain to students that at the end of today's activity, they will have done the following:
  - Observed and recorded chemical and physical properties of substances.
  - Identified evidence of chemical and physical changes.
  - Analyzed data to form conclusions about the type of change demonstrated.

Slide 3: Properties

- Explain that properties are characteristics that allow us to differentiate materials.
- Physical properties can be observed and measured without changing the substance in the process.
  - Size, shape, mass, hardness, density, boiling point, melting point, solubility.
- Chemical properties only become evident during or after a chemical reaction.
  - Flammability, reactivity, heat of combustion, corrosivity, pH.

Slide 4: What Do You observe?

- Have students view the two GIFs on the slide and ask them if either shows a change. Ask them how they know a change occurs.
  - For the can-crushing, students might observe that it changed in size and shape. For the elephant toothpaste, students might observe that something very large was created from something small or that liquids seem to change into something more solid.
- Explain that both are changes, but of different types. The can being crushed is an example of a physical change and the reaction on the right is an example of a chemical change.

Slide 5: Physical Change

- Explain to students that a physical change may change the way a substance looks, but the molecules that make it up remain unchanged.
- Ask students if they know of any ways to physically change a substance like paper.
  - Answers include crumpling it, cutting/ripping it into pieces, or drawing on the paper with pencils or markers.
  - *Teacher's Note: Emphasize with each correct example that after the action, the paper remains the same at the molecular level. It is still paper.*
- Ask students if they know of any ways to physically change a substance like water.
  - Answers include pouring it into separate glasses, adding dyes, or heating it.
  - *Teacher's Note: Emphasize in the case of heating or cooling, the water remains the same even as its phase changes. It is still H_2O.*

Slide 6: Phase Changes (Optional)

- Explain to students that a phase change does not change the substance, but it does impact the way the substance behaves.
- Explain that there are three main phases: solid, liquid, and gas. They each have different properties.
- Explain to students that we can change from one phase to another when heat or pressure is added or removed. The change is reversible.

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Slide 7: Chemical Change

- Explain to students that a chemical change allows molecules to rearrange to create new substances. We can identify chemical changes have occurred if the products have different properties from the reactants.

Slide 8: What is a Chemical Reaction?

- Ask students to think of cake batter compared to a fully cooked cake. Ask students what changes we observe in this task.
    - A new smell after baking and a darker golden color.
    - *Teacher's Note: Emphasize that these are two pieces of evidence (new odor/ color change) that can help us identify chemical changes.*
    - After baking, the reaction is not reversible. You cannot get the ingredients back out.

Slide 9: Evidence of Chemical Changes

- Explain to students that chemical reactions can be clued in by color changes, new odors, a change in temperature, a formation of light, production of a gas, or production of a precipitate (an insoluble product).
    - *Teacher's Note: Emphasize that though these clues can indicate a chemical reaction, we must analyze the reactants' and products' properties to provide strong evidence that a chemical change occurred.*

Slide 10: General Chemical Reaction Equation

- A+B→C
    - A and B are reactants: chemical compounds present before a reaction occurs.
    - The arrow shows the direction in which the reaction is proceeding.
    - C is the product: the new chemical compound that is formed.

Slide 11: Reactions with Limewater – Carbon Dioxide

- Explain to students that in today's lab they will be observing the chemical reaction with limewater as a property of the substance they work with. Elaborate to say that limewater reacts with carbon dioxide to turn a clear solution milky white. A demonstration can be conducted by exhaling through a straw into a test tube of limewater to help students understand this chemical property. The limewater will turn foggy when CO_2 is introduced.

Slide 12: Today's Investigation

- Explain that we will also be using the interaction with iodine to identify the presence of starches. When they are together, the complex creates a dark black/blue/purple color.
- Introduce students to the material they will be investigating in the activity.

Slide 13: Part 1 Observing Physical and Chemical Properties of Reactants

- Review the procedure for Part 1 "Observing Physical and Chemical Properties of Reactants." Emphasize the importance of taking observations before and after to identify if a new substance is created.
- Review and record collected data in the table on the slide.

Slide 14: Part 1 Observing Physical and Chemical Properties of Products

- Review the procedure for Part 1 "Observing Physical and Chemical Properties of Products."
- Review and record collected data in the table on the slide.
- If time allows, review the "Quick Check" questions with students.

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- Can you still see the amylose when it is added to just the water? When combined, what did it make?
  - *Yes, it's floating in the water. It made a solution or mixture.*
- When iodine is added to the amylose and water solution, does the product have similar chemical properties to either of the reactants?
  - *Yes, the product formed a black color as did the amylose reactant with just iodine.*

Slide 15: Part 2 Observing Physical and Chemical Properties of Reactants

- Review the procedure for Part 2 "Observing Physical and Chemical Properties of Reactants." Emphasize the importance of taking observations before and after to identify if a new substance is created.
  - Students will observe and test a calcium carbonate rock for this part of the procedure, NOT powdered calcium carbonate. (The powder could lead students to think there is a color change when it would really just be the powder suspended in the liquid.)
- Review and record collected data in the table on the slide. Limewater will stay clear. No chemical change.

Slide 16: Part 2 Observing Physical and Chemical Properties of Products

- Review the procedure for Part 2 "Observing Physical and Chemical Properties of Products." Point out that students will be using powdered calcium carbonate for this part of the procedure to get the fastest reaction possible.
- Review and record collected data in the table on the slide.
- If time allows, review the "Quick Check" questions with students.
  - Compare the unknown product to the reactants. Does the unknown product have different properties than the reactants? What type of change occurred: chemical or physical? Why?
    - *Yes, the unknown product does have different properties than the reactants. It reacts with limewater while the other reactants did not and is a gas while the reactants were solid and liquid. This means that a chemical change occurred because a new substance with different properties was created.*

Slides 17, 18, 19, 20: The Law of Conservation of Matter

- The same number and types of atoms are present on the reactant side and the product side, but they are rearranged. No matter is lost or created.

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