# IC2 Storyline: How Can I Make New Stuff from Old Stuff?

## Unit Overview

<table>
<thead>
<tr>
<th>Anchoring Phenomenon</th>
<th>Students observe two materials (copper chloride solution and aluminum foil before and after putting them together and later, fat and soap), to think about old and new stuff.</th>
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</thead>
<tbody>
<tr>
<td>Driving Question</td>
<td>How Can I Make New Stuff from Old Stuff?</td>
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<tr>
<td>Unit Goal</td>
<td>The unit builds on 6th grade core ideas including the particle nature of matter, phase changes, and substances and their properties. In this unit, students learn that when chemical reactions occur, the atoms in the original substances (the old stuff) rearrange to form new substances with new properties (the new stuff). The unit also introduces the concept of conservation of matter.</td>
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</table>

### Learning Set 1

**Question:** How is Stuff the Same and Different

**Learning Goals:** Students will:
- Carry out investigations on fat and soap to determine their properties.
- Construct a formal written explanation using evidence from their investigations to answer the question, “Are fat and soap the same substance?”

#### Learning Set 2

**Question:** How Can I Make New Substances?

**Learning Goals:** Students will:
- Investigate a chemical reaction to understand that new substances are made with new properties
- Develop molecular models to understand that new substances are made when the atoms of old substances rearrange to form new molecules
- Analyze and interpret data from phase changes and mixtures

#### Learning Set 3

**Question:** Do New Substances Always Come from Old Substances?

**Learning Goals:** Students will:
- Carry out investigations in both open and closed systems
- Use models to explain the Conservation of Mass
- Apply their understanding of properties to their new soap to determine if it qualifies as a new substance
- Design a solution for how to make their homemade soap better

## Lesson Overview

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## Learning Set 1: How is Stuff the Same and Different?

**Activity** | **Phenomenon** (what Ss experience to figure out the question in the last column and to ask new ones) | **What students (Ss) DO in this Activity** (Science and Engineering practices are underlined) | **What students (Ss) have FIGURED OUT by the end** (Scientific Principles are numbered and bolded) | **Additions to the Word Wall and Driving Question Board (DQB)** (WW words are italicized) | **Assessing Ss Thinking** (How do I know what they figured out?) | **What Do We Still Have to Figure Out?** (This is what Ss will investigate next.)
---|---|---|---|---|---|---
**Crosscutting Concepts** are highlighted in green

### Lesson 1 – How is This Stuff the Same and Different? (3 periods) Students will generate original questions as they observe a chemical reaction. They will carry out an investigation to set a foundation for learning about the properties of matter as unique characteristics that help identify a substance and distinguish one substance from another macroscopically.

**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.

**MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society (Reading 1.1).

**PS1.A Structure and Properties of Matter**
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) (MS-PS1-3)

**PS1.B: Chemical Reactions**
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2) (MS-PS1-3)

**A 1.1** An aluminum foil ball placed in a copper chloride solution

| Patterns that Ss should notice are: Before—The copper chloride is a bluish-green colored liquid at room temperature, and the aluminum foil is a silver, shiny, and flexible metal. After—The liquid is dirty, but still a clear color, and it is hot. The shiny, silver foil seems to have become brown, flaky stuff. Some of the foil seems to have rusted |
| Observations Prior to the unit, set up the DQB according to the TE (see A.1.1). **OPTIONAL:** Many teachers leave off the Learning Set sub questions until after Ss generate and group their questions because most Ss questions are about what caused the changes they observe in A.1.1. The teacher can guide Ss to group similar questions. The data table can be used to assess Ss ability to make detailed observations and ask questions based on those observations. Use the DQB with Ss sticky note questions to determine what Ss are curious |

**IMPORTANT NOTE:** Most of the questions Ss develop from this anchoring phenomenon will not be answered until

*Refer to the DQB and use Ss questions similar to the ones listed in this column to...*
| A 1.2 | Two unknown substances that look the same (crisco and soap) | Ss investigate and analyze two unknown substances (fat and soap) to determine if and how they’re different. (AFTER A.1.2) **Reading - What Is Important about the Stuff I Use?** Ss obtain information about why substances that look similar (Structure) may actually be different and be used differently (Function). Accurate data collection can help us get closer to figuring out how the two unknowns are different (and what they are). Qualitative
Quantitative Property After Ss do A.1.2 and the reading, they should generate more questions about fat and soap and about properties of “stuff” more generally. If you chose to wait until after Ss generate these questions, add questions together and label them based on the kind of change it’s about (e.g. “Color change,” “Change in Temp,” “Presence of bubbles,” etc.). The teacher then adds the “How Can I Make New Substances?” subquestion above the grouped questions so Ss know they will explore these changes (and whether they indicate a new substance) in Learning Set 2. While using the DQB, in order to reinforce listening, Ss who want to add to the DQB should connect their new question to another Ss question (“Mine is like Sara’s when she asked __, but I added...”) about (see next column - What will we figure out next) and use the structure of the DQB (i.e. the Learning Set subquestions) to anticipate when Ss might be able to answer their specific questions. | Use the development of the whole-class data table to assess Ss descriptions for precision. You may also use the suggested prompts on why scientists make | How can we tell if stuff is the same or different? A 1.2 | Two unknown substances that look the same (crisco and soap) | Ss investigate and analyze two unknown substances (fat and soap) to determine if and how they’re different. (AFTER A.1.2) **Reading - What Is Important about the Stuff I Use?** Ss obtain information about why substances that look similar (Structure) may actually be different and be used differently (Function). Accurate data collection can help us get closer to figuring out how the two unknowns are different (and what they are). Qualitative
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### IC2 Storyline: How Can I Make New Stuff from Old Stuff?

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| **A 1.3** | **A piece of chalk** | **Ss analyze different pieces of chalk to review the concepts of substances, properties and mixtures.**  
**AFTER A.1.3** |  
**Reading - What Makes a Substance a Special Kind of Stuff?** Ss obtain information about how the concepts of properties and mixtures can be seen in their everyday lives.  
**Wrapping up the Lesson:**  
Ss look for **patterns** of evidence across lesson 1 to construct **explanatory conclusions** (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions based on what they learned. |
|   |   | **We can examine a substance’s macroscopic properties to identify it (Patterns).**  
**Wrapping up the Lesson:**  
1. **Properties are unique characteristics that help identify a substance and distinguish one substance from another.**  
2. **A substance is made of only one type of material (atoms or molecules) all the way through.**  
3. **A mixture is made of more than one substance (or more than one type of atom or molecule).**  
**IMPORTANT NOTE:** The Scientific Principles listed throughout this storyline may differ in wording or may be numbered differently depending on your IQWST version, but the big idea is always the same.  
**Substance** | **Mixture**  
**Atom** | **Molecule**  
**Add a piece of chalk to the DQB or Word Wall to represent a substance.**  
**Add a baggie of trail mix to the DQB to represent mixtures.**  
**Introduce Scientific Principles as "our best understanding of what we know at this point, supported by evidence." Give Ss time to look at lesson 1 to identify evidence that helps them construct Principles 1-3 (in their own words) in their SE and write it on the class Scientific Principles List or DQB.  
**The discussion in which Ss develop the principles (in their own words) can be used to assess whether Ss are able to generalize using evidence from their activities.**  
**What properties do substances have that allow us to tell them apart?** |
|   |   |   |
Lesson 2 – Do Fat and Soap Dissolve in the Same Liquid? (1 period) Students carry out and plan an investigation of solubility in order to expand their conception of substances and their properties. They analyze and interpret data about properties of substances to identify how the substances are the same or different.

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<tr>
<th>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.</th>
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<td>PS1.A Structure and Properties of Matter</td>
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<td>● Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are reorganized into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)</td>
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A 2.1 Testing the solubility of butter, baking soda, and calcium chloride

- Ss observe a procedure for measuring solubility and take notes as part of planning of their investigation in the next lesson. Ss interpret solubility data of butter, baking soda, and road salt in water and in oil.
- Solubility is a property. It can be measured qualitatively to compare different substances in order to tell them apart (Structure and Function).
- Substance (revised)
  - Solubility
  - Solute (optional)
  - Solvent (optional)

A 2.2 Testing the solubility of fat and soap in oil and water

- Students plan and carry out an investigation on solubility and analyze the solubility data of fat and soap in oil and water.
- Soap is not soluble in oil but is slightly soluble in water. Fat is soluble in oil but not in water. This is one piece of evidence that suggests fat are soap really are different substances (Structure and Function).
- Wrapping up the Lesson: 4. Solubility is the capacity of a substance to dissolve in another substance.
- You may decide to take photos of the soap and fat in both oil and water to hang on the DQB.
- Use the Pressing for Understanding suggested prompts to assess Ss understanding of solubility as a property.
- Use the Making Sense question to assess how Ss use solubility as evidence for how soap and fat are different.
- The following questions can be used to assess Ss understanding of solubility (after the reading): Why does soap help to wash greasy stuff off your hands? Since scientists use more than one property to identify a substance, what other properties can we investigate to claim that soap and fat are different substances?

Use the Pressing for Understanding suggested prompts to assess Ss understanding of solubility as a property.

Solubility is a property. It can be measured qualitatively to compare different substances in order to tell them apart (Structure and Function). Use the Pressing for Understanding suggested prompts to assess Ss understanding of solubility as a property.
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<th>Lesson 3 – Do Fat and Soap Melt at Different Temperatures? (2-3 period) Students collect melting point and hardness data, and use data as evidence to argue that the two substances are not the same. They carry out an investigation to determine whether the size of a sample affects its properties. Students use data to construct an explanation of the relationship between amount and properties.</th>
</tr>
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</table>
| MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. (Reading 3.1) 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. PS1.A Structure and Properties of Matter  
  - Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)  
  - Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) PS1.B Chemical Reactions  
  - Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2) |
| A 3.1 | The melting points of soap and fat | Ss carry out an investigation on melting point and interpret graphical data on the melting point of different amounts of fat and soap. Ss explain how the amount of the substance affects its property. | Melting point is a property of a solid substance. We can measure the property of melting point quantitatively by using a thermometer or temperature probe. Soap and fat have different melting points, indicating they are different substances. (Structure and Function) The amount of substance does not affect its melting point. | Based on your understanding, is it correct to say that sugar is soluble? Why? |
| | Melting Point | Hardness | Use the Making Sense questions. You may also ask, “Do all substances have a melting point?” to assess Ss understanding of melting point. | If the amount of a substance doesn't affect its melting point, can we generalize that the amount of any substance doesn't affect its properties? |
| A 3.2 | The hardness of two different lengths of zinc | Ss carry out an investigation on hardness and analyze data from two different lengths of zinc to determine whether the amount of a substance affects its property (hardness). Reading - Which Properties Can I Use When? Ss obtain information about when to use hardness to help identify a substance (Structure and Function). Wrapping up the lesson: Ss look for patterns of evidence across lesson 3 to construct explanatory conclusions (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions based on what they learned. | Hardness is a property of solid substances. The amount of a substance does not affect its properties. Wrapping up the lesson: 5. Hardness and melting point are both properties of substances. Melting point is the temperature at which a solid substance starts to become a liquid. 6. Properties of a given substance are the same regardless of the amount of the substance. Add the two lengths of zinc to the DQB. Give Ss time to construct scientific principles #5 and 6 based on the evidence they gathered in lesson 3 and post on the class Scientific Principles List or DQB. Use the DQB to ask, “How does properties help us think about the driving question?” The discussion in which Ss develop the principles (in their own words) should be used to assess whether Ss are able to generalize using evidence from the melting point activity and the hardness activity. Since scientists use many properties to identify a how substances are different, what other properties can we investigate to claim that soap and fat are different substances? |

Lesson 4 – What Other Properties Can Distinguish Soap from Fat? (2 periods) Students will collect, analyze, and interpret data, then use data as evidence to distinguish properties from non-properties of substances.

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.

PS1.A Structure and Properties of Matter
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2)

PS1.B Chemical Reactions
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)
| A 4.1 | The mass and volume of three different sized pieces of chalk | Ss carry out an investigation on three different sized pieces of chalk, analyze their mass and volume for patterns, and calculate their densities (Scale, Proportion, and Quantity). Properties give us evidence to help distinguish how substances are the same and different because properties do not change based on the amount of the substance. Mass and volume are not properties because they change based on the amount of a substance. Thus, mass and volume are not useful for distinguishing one substance from another. Density, however, is a property of a substance (but not mixtures). Use the Making Sense questions to assess Ss understanding of density as a property of a substance, but that mass and volume are not properties. You may use the questions in the reading 4.1 to assess Ss ability to calculate and understand density as a ratio. Do fat and soap have the same density? |
| --- | --- | --- | --- | --- |
| A 4.2 | The density of fat and soap | Ss carry out an investigation on density of soap and fat, analyze their mass and volume, and calculate their densities (Scale, Proportion, and Quantity). Soap and fat do not have the same density. Fat is more dense than soap. This is another piece of evidence that suggests fat and soap are different (Structure and Function). Give Ss time to construct scientific principle #7 based on the evidence they gathered in lesson 4 and post on the class Scientific Principles List or DQB. At the end of A.4.2, ask: “How does what we’ve learned about properties (e.g. hardness, melting point, solubility, density) help us answer the driving question (DQ) so far?” This provides a review, but also reminds Ss why they’re doing what they’re doing. This review should include time for Ss to answer their Learning Set 1 questions before constructing an explanation in Lesson 5. Use Making Sense question #1 to assess how students determine evidence from their data in A.4.2 to use as support for their argument that soap and fat are different substances. The discussion in which Ss develop the principle (in their own words) can be used as an assessment. How can we use data on the properties of fat and soap to make a scientific argument that soap and fat are not the same? |
Lesson 5 – How are Soap and Fat Different? (1 period) Students will use data as evidence to construct an argument that it is properties of matter that must be used to distinguish substances from one another scientifically.

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<tr>
<th>A 5.1</th>
<th>Ss previous activities from lessons 1-4</th>
<th>Ss evaluate three written explanations, then construct an evidence-based explanation on how soap and fat are different and argue during peer review as a means to improve each other’s explanation.</th>
</tr>
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<tbody>
<tr>
<td><strong>Reading - What Evidence Would I Use to Tell if the Stones in a Ring Are the Same or Different?</strong> Ss obtain information about scientific explanations and write an argument.</td>
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<tr>
<td>(BEFORE A.6.1) <strong>Reading - Could Someone Change Straw into Gold?</strong> evaluate whether straw (old) can be made into gold (new).</td>
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<tr>
<td>Ss identify patterns in their data from previous investigations and identify certain data as evidence to support their claim that soap and fat are different substances (Structure and Function). They use the scientific principles they constructed to support their reasoning.</td>
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<td>Add a sample CER explanation with peer written feedback to the DQB. It is important to highlight the crucial role of communicating and evaluating science ideas in order to build knowledge as a scientific community.</td>
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<td>Ss should use the Explanation Checklist to assess each other’s written explanations for a clear claim, appropriate and sufficient evidence, and reasoning.</td>
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<td>The reading on stones in a ring provides another opportunity for Ss to practice constructing an argument using CER.</td>
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<td>At this point, Ss could be asked to write a response to the Learning Set question.</td>
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<tr>
<td>Now that I can tell substances apart, how can I tell a new substance from an old substance?</td>
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### Learning Set 2: How Can I Make New Substances?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Phenomenon (what Ss experience to figure out the question in the last column and to ask new ones)</th>
<th>What students (Ss) DO in this Activity (Science and Engineering practices are underlined)</th>
<th>What students (Ss) have FIGURED OUT by the end (Scientific Principles are numbered and bolded)</th>
<th>Additions to the Word Wall and Driving Question Board (DQB) (WW words are italicized)</th>
<th>Assessing Ss Thinking (How do I know what they figured out?)</th>
<th>What Do We Still Have to Figure Out? (This is what Ss will investigate next.)</th>
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<tr>
<td>Lesson 6 – What Happens to Properties When I Combine Substances? (2 periods)</td>
<td>Students carry out an investigation and analyze data to determine whether what happened meets the criteria for a chemical reaction.</td>
<td><strong>Crosscutting Concepts</strong> are highlighted in green</td>
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**Lesson 6 – What Happens to Properties When I Combine Substances?**

- **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.
  - **PS1.A Structure and Properties of Matter**
    - Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2)
  - **PS1.B Chemical Reactions**
    - Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)

**A 6.1**

- **Baking soda, calcium chloride, and water mixed in a plastic sandwich bag**
  - Ss carry out an investigation using baking soda, calcium chloride, and water and analyze the results. Ss construct a scientific explanation and argue from evidence to determine whether they made a new substance.
  - **Reading - What Is a Chemical Reaction?** Ss obtain information about the process of baking a cake and explain their plastic bag experiment as a chemical reaction.
  - To determine whether a new substance was made, we must first look at the substances before and after a process. A change in properties is one way to tell if a new substance was formed through a chemical reaction.
  - Ss should begin thinking about the molecular aspect of chemical reactions.
  - Wrapping up the Lesson: **8. A chemical reaction happens when two or more substances**
  - **Chemical Reaction Precipitate**
    - Ask Ss how we could change the DQ to make it more scientific (e.g. How Can I Make New Substances from Old Substances?). Add the sandwich bag chemical reaction to the DQB
    - Use the DQB to ask Ss: “How is this experiment similar to the one with the aluminum and copper chloride? Why do you think you saw bubbles, temp
  - **Use the Making Sense question.**
    - In the reading Ss write, peer review, and revise an argument for whether or not a chemical reaction occurred in the plastic bag experiment. This assesses Ss understanding of chemical reactions and their ability to interpret and use new data as
  - **Given that a change in properties helps us determine if we have a new substance, does burning create a change in properties?**
Wrapping up the Lesson: Ss look for **patterns** of evidence across lesson 6 to **construct explanatory conclusions** (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to **ask new questions** based on what they learned.

**Lesson 7 – Is Burning a Chemical Reaction?** (1 period) Students will collect and analyze data about the properties of magnesium before and after burning it, and use the data as evidence to argue whether burning is a chemical reaction. Students will develop and use models to represent chemical reactions - word equations, chemical formulas, and molecular models.

**MS-PS1-1.** Develop models to describe the atomic composition of simple molecules and extended structures.

**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.

**MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (Reading 1)

**PS1.A Structure and Properties of Matter**
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) (MS-PS1-3)

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- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2) (MS-PS1-3)

**A 7.1** The properties of a piece of magnesium ribbon before and after being burned

<table>
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<th>Reactant</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atoms</td>
<td>Molecules</td>
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The macroscopic properties before burning magnesium are different from the properties after burning magnesium, meaning burning is a chemical reaction (**Patterns**). We can represent chemical reactions using models. Add a drawing of the molecular models and the chemical formula to the word wall.

Refer to Ss arguments in the Making Sense section. In the reading, Ss models can be used to assess their understanding of What other processes can create a change in properties?
**IC2 Storyline: How Can I Make New Stuff from Old Stuff?**

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<tr>
<th>Reading - Is Burning a Chemical Reaction?</th>
<th>(Systems and System Models). Chemical equations allow us to see that the atom present in the reactants are present in the products (Energy and Matter).</th>
<th>Add a picture of the burning magnesium or add the &quot;before burning/after burning&quot; properties table to represent burning as a chemical reaction on the DQB.</th>
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<tr>
<td>Ss obtain information about sparklers and fireworks as an example of a chemical reaction.</td>
<td>Wrapping up the Lesson: 9. Burning is a chemical reaction in which a substance reacts with oxygen to form water and carbon dioxide. 10. A reactant is a starting substance in a chemical reaction. A product is the substance made by a chemical reaction.</td>
<td>Give Ss time to construct scientific principles #9 and 10 based on the evidence they gathered in lesson 7 and post on the class Scientific Principles List or DQB.</td>
</tr>
<tr>
<td>Wrapping up the Lesson: Ss look for patterns of evidence across lesson 7 to construct explanatory conclusions (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions based on what they learned.</td>
<td>chemical reactions at the molecular level. The discussion in which Ss develop the principles (in their own words) can be used to assess whether Ss are able to generalize using evidence from their activities.</td>
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**Lesson 8 – Does Acid Rain Make New Substances? (2 periods)** Students will conduct an investigation using data as evidence to explain why the Statue of Liberty and a piece of copper “turn green” in the rain. They construct and use models (word equations, chemical formulas, molecular representations) to explain what happens at the molecular level in a chemical reaction.

**MS-PS1-1.** Develop models to describe the atomic composition of simple molecules and extended structures.

**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.

**PS1.A Structure and Properties of Matter**
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**PS1.B Chemical Reactions**
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)
| A 8.1 | Everyday instances of shiny copper surfaces turning green over time (e.g. rooftops, the Statue of Liberty) | Ss first obtain information about how acid rain affects the Statue of Liberty in Reading 8.1 - Why Is the Statue of Liberty Green? Ss then develop a scaled down model to carry out an investigation on whether acid (vinegar) affects a strip of copper (Scale, Proportion, and Quantity). | The green substance on the Statue of Liberty is the product of the chemical reaction between the copper and acid rain. | Control Experiment Closed System Acid Rain Scale Add a picture of the Statue of Liberty to the DQB. Add a baggie with a marshmallow model to the DQB. Or add a picture representation of the model to the DQB. | Use the Prediction section. | Does acid rain turn an old substance (copper) into a new substance (the green stuff)? |
| A 8.2 | Placing a copper square in a device with acetic acid (vinegar) | Ss carry out an investigation on the properties of the scaled down model of acid rain (vinegar) and copper and interpret the results to determine whether a chemical reaction occurred (Scale, Proportion, and Quantity). Ss construct an explanation and argue to improve their explanations. Reading - Does Acid Rain Make New Substances? Ss obtain information about chemical reactions and critique 3 different scientific explanations. | Ss should argue that this is a chemical reaction because the substances they started with (copper and vinegar) are different from the substances they ended with (copper acetate). Ss should use properties from their data table to support their claim. | Add photos of the copper as it changed over time to the DQB. | Making Sense question 1 can assess Ss understanding of the chemical reaction between vinegar and copper and to assess their ability to argue from evidence. Making Sense question 2 can assess Ss ability to represent the chemical reaction atomically using a chemical equation. | How can we model the chemical reaction between copper and acetic acid? |
| A 8.3 | The chemical reaction between copper and acetic acid | Ss develop different models (word equations, chemical formulas, and molecular models) to represent the chemical reaction between vinegar and copper. | In a chemical reaction, atoms are not created or destroyed, instead they come together in new ways (Energy and Matter). | Give Ss time to construct scientific principle #11 based on the evidence they gathered in lessons 7 and 8 and post on the class Scientific Principles List or Use Ss models of copper and acetic acid and of copper acetate. Question 10 asks | Does a chemical reaction always involve two reactants? |
Reading - What Are the Many Ways of Representing Any Chemical Reaction? Ss obtain information about all the ways to represent a chemical reaction and explain how burning magnesium is similar to and different from burning methane.

Wrapping up the Lesson: Ss look for patterns of evidence across lesson 8 to construct explanatory conclusions (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions based on what they learned.

Different representations of chemical reactions might be helpful for different reasons (Systems and System Models).

Wrapping up the Lesson: 11. A chemical reaction occurs when substances interact and their atoms combine in new ways to form new substances. The new substances and the old substances are made of the same atoms, but those atoms are arranged in new ways. As a result, the new substances have different properties from the original materials.

DQB. OPTION: Some teachers simply ask Ss to revise their existing scientific principle on chemical reactions (#8) to include evidence from Lessons 7 and 8.

Ss to apply their molecular understanding of chemical reactions to revise their existing definition of a chemical reaction. This question along with discussion (developing the scientific principle in their own words) can be used to assess whether Ss are able to generalize using evidence from their activities.

Lesson 9 - Is This a New Substance? (2 periods) Students carry out an investigation to determine whether a single substance can undergo a chemical reaction. They analyze data and use it as evidence to support an argument that a chemical reaction can also occur when only one reactant’s atoms rearranging into two products.

| MS-PS1-1 | Develop models to describe the atomic composition of simple molecules and extended structures. |
| 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. |
| MS-PS1-4 | Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (Reading 9.1) |

**PS1.A Structure and Properties of Matter**
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2)

**PS1.B Chemical Reactions**
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)

**PS3.A Definitions of Energy**
- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer...
of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary to MS-PS1-4)

| A 9.1 | The electrolysis of water | Ss carry out an investigation on the electrolysis of water to determine whether it is a chemical reaction, then construct molecular models and written explanations of the reaction. **Reading - What Is the Same and Different about Boiling Water and Electrolysis?** Ss obtain information about what is the same and different about boiling water and electrolysis. Wrapping up the Lesson: Ss look for **patterns** of evidence across lesson 9 to construct explanatory conclusions (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions based on what they learned. A chemical reaction does not need two or more reactants. One substance can be broken down into something new. Boiling water is a phase change and not a chemical reaction. Wrapping up the Lesson: **12. A chemical reaction is the process of one substance breaking down or two or more substances interacting and their atoms combine in new ways to form new substances with different properties from the old substances** (Energy and Matter). **Electrolysis** Give Ss time to construct scientific principle #12 based on the evidence they gathered in lessons 9 and post on the class Scientific Principles List or DQB. **OPTION**: Some teachers simply ask Ss to **revise their existing scientific principle on chemical reactions (#11)** to include evidence from Lesson 9. Use the DQB to refer Ss to the baking soda/calcium chloride/water investigation from lesson 6 and the aluminum foil/copper chloride investigation from lesson 1. Pose the lesson question: Is this a new substance? How do you know? Allow time for Ss to answer old questions (e.g. from the lesson 1 or lesson 6 reaction) and to ask new questions. **Lesson 10 - How is a Mixture Different from a Chemical Reaction?** (2-3 periods) Students will carry out an investigation and use data as evidence to argue whether combining drink mix and water is a chemical reaction. Use the Making Sense question. The last question in the reading asks Ss to revise their definition of chemical reaction in light of evidence from lesson 9. This question along with discussion (developing the scientific principle in their own words) can be used to assess whether Ss are able to generalize using evidence from their activities.

**MS-PS1-1.** Develop models to describe the atomic composition of simple molecules and extended structures. (Reading 1)
### 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.

### MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

#### PS1.A Structure and Properties of Matter
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)

#### PS1.B Chemical Reactions
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)

#### PS3.A Definitions of Energy
- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary to MS-PS1-4)

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<table>
<thead>
<tr>
<th>A10.1</th>
<th>Powdered drink mix and water</th>
<th>Ss carry out an investigation on a powdered drink mix and water, calculate the density, and interpret data on properties from before and after the experiment to determine whether a chemical reaction occurred.</th>
<th>One way to decide whether substances interact to form new substances or make a mixture is to separate the substances after combining them to see if they retained their original properties. If the properties remain the same, a chemical reaction did not occur.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading - What Happens to Atoms and Molecules When I See Different Processes?</strong></td>
<td>Ss obtain information about and explain the difference between substances and mixtures at the molecular level.</td>
<td><strong>Wrapping up the Lesson:</strong> Ss look for patterns of evidence across lesson 10 to construct explanatory conclusions (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions.</td>
<td><strong>Phase Change</strong> Add a picture of the investigation to the DQB. Add the completed table of Process, Phase Change, Mixtures, and Chemical Reactions to the DQB. Give Ss time to construct scientific principles #13 and 14 based on the evidence they gathered in lesson 10 and post on the class Scientific Principles List or DQB.</td>
</tr>
<tr>
<td><strong>Wrapping up the Lesson:</strong> One can make a new substance like soap from an old substance like fat?</td>
<td><strong>Energy and Matter</strong></td>
<td><strong>Making Sense</strong> Can I make a new substance like soap from an old substance like fat?</td>
<td></td>
</tr>
</tbody>
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**DO NOT SHARE**
Lesson 11 - How Can I Make Soap from Fat? (2 periods) Students will carry out an investigation in which they collect data as evidence that a chemical reaction can turn surprising “old stuff” into “new stuff”.

<table>
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<tr>
<th>questions based on what they learned.</th>
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**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.

**MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

**PS1.A Structure and Properties of Matter**
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) (MS-PS1-3)

**PS1.B: Chemical Reactions**
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2) (MS-PS1-3)

<table>
<thead>
<tr>
<th>A 11.1 Making soap from fat and sodium hydroxide</th>
<th>A 11.2 The new white solid substance (soap) that formed from mixing fat and sodium hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ss plan and carry out an investigation to make soap (new stuff) from fat and sodium hydroxide (old stuff).</td>
<td>Ss continue to carry out the investigation of making soap from A.11.1. They remove their soap from the container, rinse it and let it sit for several days to complete its reaction and harden.</td>
</tr>
<tr>
<td>Reading - Do People Really Make Soap from Fat? Ss obtain information about how soap is made today compared to how it was made in the 17th and 18th centuries.</td>
<td>This is the end of Learning Set 2. Ask Ss: “What does what we’ve learned about new substances help us think about the DQ? Which questions on the DQB can you now answer?” Allow time for Ss to answer questions from Learning Set 2 or to re-categorize them before moving on to It will take another week for Ss to be able to gather data from their processing soap.</td>
</tr>
<tr>
<td>We can make new stuff (soap) from old stuff (fat, sodium hydroxide). Based on the formation of a white solid precipitate, we may be able to say that a chemical reaction occurred. Ss may suggest that we test its properties to be sure (Structure and Function), but they will need to wait several days for their soap to process.</td>
<td>After a week, Ss will be able to test the properties of their soap and compare it to the commercially made soap (Structure and Function) - see Learning Set 3.</td>
</tr>
<tr>
<td>Photograph the process of soapmaking and hang these on the DQB. Or, if possible, store the beakers with the processing soap around the DQB (or near the second sub-question).</td>
<td>This is the end of Learning Set 2. Ask Ss: “What does what we’ve learned about new substances help us think about the DQ? Which questions on the DQB can you now answer?” Allow time for Ss to answer questions from Learning Set 2 or to re-categorize them before moving on to It will take another week for Ss to be able to gather data from their processing soap. At this point, Ss could be asked to write a response to the Learning Set question.</td>
</tr>
<tr>
<td>Use the Making Sense questions to assess Ss ideas about whether they created something new and whether they need more evidence (and how to get that evidence).</td>
<td>What are the properties of this new white solid substance?</td>
</tr>
</tbody>
</table>

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## Learning Set 3: Do New Substances Always Come From Old Substances?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Phenomenon (what Ss experience to figure out the question in the last column and to ask new ones)</th>
<th>What students (Ss) DO in this Activity (Science and Engineering practices are underlined)</th>
<th>What students (Ss) have FIGURED OUT by the end (Scientific Principles are numbered and bolded)</th>
<th>Additions to the Word Wall and Driving Question Board (DQB) (WW words are italicized)</th>
<th>Assessing Ss Thinking (How do I know what they figured out?)</th>
<th>What Do We Still Have to Figure Out? (This is what Ss will investigate next.)</th>
</tr>
</thead>
</table>

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Lesson 12 – Does Mass Change in a Chemical Reaction? (2 periods) Students will design and carry out an investigation to investigate what happens at the macro- and micro- levels in a chemical reaction in an open system and a closed system, thus experiencing conservation of matter. Students use data as evidence to construct an explanation of the principle of conservation of mass.

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

PS1.A Structure and Properties of Matter
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)

PS1.B Chemical Reactions
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-5)
- The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)

<table>
<thead>
<tr>
<th>A 12.1a</th>
<th>Making gloop</th>
<th>If the mass of the new substances and the old substances stayed the same, this would be evidence that new substances come from old substances. When the gloop chemical reaction occurs, the mass of the products stays the same as the mass of the reactants (Energy and Matter).</th>
<th>Add a baggie of gloop to the DQB.</th>
<th>Use the Making Sense question 1.</th>
<th>Does mass always stay the same in chemical reactions?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 12.1</td>
<td>Alka seltzer tablets in water (in an open system)</td>
<td>Ss carry out an investigation using Alka seltzer tablets in water and analyze data to determine whether mass stays the same before and after the reaction.</td>
<td>When a chemical reaction occurs in an open system, the mass of the products is less than the mass of the reactants if a gas is one of the products (Energy and Matter).</td>
<td>Open System</td>
<td>Add a baggie of Alka seltzer tablets to the DQB</td>
</tr>
</tbody>
</table>

In the reading, Ss are asked what happened to the mass in the previous plastic bag experiment. This can be used to assess their understanding of the concept of mass conservation.
## IC2 Storyline: How Can I Make New Stuff from Old Stuff?

| A 12.2 | Alka seltzer tablets in water (in a closed system) | Ss plan and carry out an investigation to account for the mass before and after the seltzer tablet reaction in a closed system. Ss interpret their data, explain their results, and apply their understanding to all the chemical reactions from the unit. **Reading - What Happens to Mass during a Chemical Reaction in a Closed System?** Ss obtain and evaluate information about everyday reactions in a closed system and about the conservation of mass. **Wrapping up the Lesson:** Ss look for patterns of evidence across lesson 12 to construct explanatory conclusions (i.e. scientific principles). Ss revisit the DQB to answer posted questions and to ask new questions based on what they learned. | In a closed system the measured mass always stays the same and scientists call this concept the conservation of matter (Systems and System Models). The conservation of matter states that the total mass before the reaction is equal to the total mass after the reaction in a closed system (Energy and Matter). This is always true. New substances always come from old substances. What you end up with depends on what you start with. **Closed System Conservation of Matter** Add a copy of a group’s plan for an investigation in a closed system that accounts for the mass of all products of the reaction. The plan will contain a data table. Give Ss time to construct scientific principle #15 based on the evidence they gathered in lesson 12 and post on the class Scientific Principles List or DQB. **Wrapping up the Lesson:** 15. Atoms cannot be created or destroyed. In a chemical reaction, the number of atoms stays the same, therefore matter and mass are always conserved. | Use the Procedure section to check Ss experimental design. Use the Making Sense section to assess how Ss use evidence and reasoning to argue that mass is conserved in a chemical reaction. The last two questions from the reading assess Ss understanding of chemical reactions and the conservation of mass in a closed system. At this point, Ss could be asked to write a response to the Learning Set question. |

**Lesson 13 – Is My Soap a New Substance?** (2 periods) Students plan and carry out an investigation in which they gather data about the properties of their soap, and use those data as evidence to construct an explanation that a chemical reaction explains how fat and sodium hydroxide can interact to become soap.
<table>
<thead>
<tr>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS1.A Structure and Properties of Matter</strong></td>
</tr>
<tr>
<td>• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2)</td>
</tr>
<tr>
<td><strong>PS1.B Chemical Reactions</strong></td>
</tr>
<tr>
<td>• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A 13.1</th>
<th>The soap Ss made in lesson 11</th>
<th>Ss carry out investigations on their new soap’s properties (color, hardness, solubility, melting point, density) to determine if it is a new substance. Ss must consider potential experimental error (e.g. purity) while analyzing their data and writing their explanation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading - How Does My Soap Compare with Colonial Soap and Modern Soap? Ss obtain information about soap from colonial times.</td>
<td>This soap is a new substance because it has different properties than the old substances (fat and sodium hydroxide). (Structure and Function)</td>
<td>Add a sample piece of soap to the DQB. Add data tables of the properties of their new soap to the DQB.</td>
</tr>
</tbody>
</table>

Lesson 14 - How Does My Soap Compare or How Can I Improve My Soap? (3 periods) Students will plan and carry out an investigation in which they compare soaps, or improve their own soap, as they apply what they have learned about properties and scientific investigation to a new problem-solving task.

| Lesson 14 - How Does My Soap Compare or How Can I Improve My Soap? (3 periods) Students will plan and carry out an investigation in which they compare soaps, or improve their own soap, as they apply what they have learned about properties and scientific investigation to a new problem-solving task. |
|---|---|---|---|
| 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. |
| MS-PS1-6. Undertake a design project to construct test, and modify a device that either releases or absorbs thermal energy by chemical processes. |
| **PS1.A Structure and Properties of Matter** |
| • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) |
| • Some chemical reactions release energy, others store energy. (MS-PS1-6) |
### IC2 Storyline: How Can I Make New Stuff from Old Stuff?

#### PS1.B Chemical Reactions
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2)

#### ETS1.B Developing Possible Solutions
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-PS1-6)

#### ETS1.C Optimizing the Design Solution
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. (MS-PS1-6)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-PS1-6)

| A 14.1 | The soap Ss made | Ss define a design problem and carry out investigations to compare their soap with commercially made soap. Ss may obtain information from Internet research to generate ideas for comparison tests and eventually explain which soap is “better.”

*Reading - The Science behind Rumpelstiltskin*
Ss evaluate information in the story of Rumpelstiltskin and using their understanding of the scientific principles.

| A 14.2 | The soap Ss made | Ss obtain information from Internet research to generate ideas for designing a solution to improve their soap. Ss carry out an investigation to demonstrate their improved procedure for soap-making. Ss then analyze their data and use it to explain if/why their new soap is “better.”

Ss may suggest some of the following possibilities:
- substitute an oil (coconut or olive oil) for the Crisco
- use a combination of an oil and Crisco
- add a scent (vanilla, peppermint) to the existing procedure
- increase or decrease the heating time

| | There are several qualities Ss could compare in the two difference soaps: ability to clean or remove dirt, bubbles or lather, fragrance, how soft it makes their skin, or how non-drying it is, etc. *(Structure and Function)*.

| | Review concepts of substance, property, chemical reaction, atoms, molecules, conservation of mass using the word wall.

| | Have students draw pictures of practical benefits of chemical reactions and put them on the DQB

| | Review the scientific principles and use them to help students answer the Driving Question.

| | There may be several questions left unanswered that could go into a "big book of science questions" to be accumulated throughout a school year. Unanswered questions may also be turned into an independent research or investigative project.

| | Use the Procedure section to check Ss improved design. Use the Making Sense section to assess their conclusions.

| | Use the Procedure section to check Ss experimental design. Use the Making Sense section to assess their conclusions.

| | How can I improve my soap?

*See DQB*
The lessons in the appendix enable students to consider chemical reactions in light of real-world applications and solving real-world problems. Lesson 1 addresses developing ethanol from plants (a natural resource), and Lesson 2 engage students in making a bioplastic from natural materials. An optional activity within Lesson 2 has students apply heat to melt and recycle plastic grocery bags, should you be in a location that uses them and should you choose to undertake such a project that further illustrates the difference between a chemical reaction and phase change.

Appendix Lesson 1 could be done any time after Lesson 6. Appendix Lesson 2 could be done any time after Lesson 10, including in place of making soap (Lesson 11), or as an additional engineering design project for some or all students.

**Lessons 1 and 2**
*Performance Expectation MS-PS1-3*
*Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*

**Lesson 2**
*Performance Expectation MS-ETS1-1*
*Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*
Performance Expectation MS-ETS1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.