5E Integrated STEM Lesson Plan

Lesson Title: Presenting...Ferrum Food Network **Author:** Lisa Angell

Topic: Conservation of Mass, Measuring Mass and Temperature, Data Collection and Analysis, Engineering Design Process, Reading Comprehension of Functional Text/Oral Presentations

Targeted Grade Level: 4-5 **Time Needed:** Five 60+ minutes lessons

Subject Integration: Science (Matter); English (Reading Nonfiction Text); Engineering (Design Process)

Justification: Science, specifically matter, is central theme of this lesson. While learning about mixtures, solutions, and changing matter, students learn and practice other content knowledge and skills. Although not explicitly taught, the math skills students use include measuring mass, time, and temperature, as they mix different ingredients to see if the mass of these materials is constant. Students record these measurements to practice data analysis. As stated in the Virginia Standards of Learning, "Data analysis should include opportunities to describe the data, recognize patterns or trends, and make predictions." Engineering standards are addressed in several areas of the lesson. Students use the Engineering Design Process (EDP) to create filters and solar ovens. Students plan and present a cooking show to showcase their learning. Prior to that time, students learn about the elements of a presentation.

Standards:

- Virginia Standards of Learning Science Curriculum Framework page 7-8, 17-18
- Virginia Standards of Learning Math Curriculum Framework page 28
- Virginia Standards of Learning English Curriculum Framework
- NGSS Structure and Properties of Matter page 28

Science & Engineering Practices Copied from Virginia's Standards of Learning 2018 and NGSS	**Disciplinary Core Ideas** Copied from Virginia's Standards of Learning 2018 and NGSS	**Crosscutting Concepts** Copied from NGSS 5.Structure and Properties of Matter
5.1 The student will demonstrate an understanding of scientific and engineering practices by a) asking questions and defining problems b) planning and carrying out investigations c) interpreting, analyzing, and evaluating data d) constructing and critiquing conclusions and explanations e) developing and using models f) obtaining, evaluating, and communicating information **5-PS1 Matter and Its Interactions** Develop a model to describe phenomena. (5-PS1-1) Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (5-PS1-4) Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (5-PS1-3) Measure and graph quantities such as weight to address scientific and engineering questions and problems. (5-PS1-2)	5.7 The student will investigate and understand that matter has properties and interactions. Key ideas include b) substances can be mixed together without changes in their physical properties; and c) energy has an effect on the phases of matter. **5.Structure and Properties of Matter** 5.Structure and Properties of Matter Students who demonstrate understanding can: 5-PS1-1. 5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. 5-PS1-3. Make observations and measurements to identify materials based on their properties. 5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.	Cause and Effect Cause and effect relationships are routinely identified, tested, and used to explain change. (5-PS1-4) Scale, Proportion, and Quantity Natural objects exist from the very small to the immensely large. (5-PS1-1) Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2),(5-PS1-3)

Virginia State Standards		
English: The student will ● 5.2 create multimodal presentations that effectively communicate ideas. a) Effectively use verbal and nonverbal communication skills to plan and deliver collaborative and individual, formal, and informal interactive presentations.; b) Maintain eye contact with listeners.; c) Organize content sequentially around major ideas.; d) Use language and style appropriate to the audience, topic, and purpose.; e) Ask and answer questions to gather or clarify information presented orally. ● 5.6 read and demonstrate comprehension of nonfiction. ; a) Use text organizers, such as type, headings, and graphics, to predict and categorize information. ; b) Identify structural patterns found in nonfiction. ; d) Identify cause-and-effect relationships. ; f) Skim materials to develop a general overview of content and to locate specific information. ; g) Identify new information gained from reading.		

Measurable Student Learning Objectives: Resource used Understanding Depth of Knowledge and Cognitive Complexity

- Science Objectives The student will be able to
  - examine and explain that substances can be mixed together without changes in their physical properties. (engage- separating mixtures/solutions investigation)
  - design and construct a way to show that substances can be mixed together without changes in their physical properties. (explore-designing filters)
  - design and construct a way to demonstrate that energy has an effect on the phases of matter (explore- freezing and heating samples; elaborate/evaluate- solar oven construction/testing/presentations)
- English Objectives The student will be able to
  - sequence a nonfiction reading passage (explain- Symbaloo learning module)
  - synthesize learning to create multimodal presentations that effectively communicate ideas (elaborate/evaluation- solar ovens preparation and presentations)
- Engineering Objectives The student will be able to
  - design a prototype to solve a real-life problem (explore-designing filters; elaborate- designing solar ovens)
  - construct a prototype to solve a real-life problem (explore-designing filters; elaborate- designing solar ovens)
  - design a fair way to test the effectiveness of a prototype to solve a real-life problem (explore-designing filters; elaborate- designing solar ovens)

Nature of STEM:

The Nature of Science

The basic understandings addressed in this lesson include:

- Scientific Investigations Use a Variety of Methods (guided investigations, engineering practices)
- Scientific Knowledge is Based on Empirical Evidence (guided investigations, engineering practices, data collection)
- Scientific Knowledge is Open to Revision in Light of New Evidence (students form arguments based on data, then revise arguments as new information is learned)
- Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena (Law of Conservation of Mass, based on investigations)
- Science is a Way of Knowing (students learn through a variety of methods: investigations and data analysis, activities, challenges, readings, discussions)
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science is a Human Endeavor (working in teams to solve a real problem of how to harnass solar energy for cooking)
- Science Addresses Questions About the Natural and Material World (students ask questions and investigate to discover)

NSTA Science and Engineering Practices

Although the nature of engineering is difficult to define, below is a list of engineering practices that should be incorporated K-12. During the proposed lesson, student engage in these practice when designing a filter and a solar oven.

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Engaging Context/Phenomena: Cooking shows can be very entertaining. Students watch an episode of Alton Brown's show. Students reflect on the elements of the show and the science behind food preparation. Also students watch a salt crystal dissolve. Students connect the two phenomena.

Data Integration: No NASA data is used in this lesson. Students are collecting and analyzing data during all parts of the lesson. The data serves several purposes: comparing/contrasting initial and final mass after matter is changed to a different phase, tracking temperature changes and how matter is affected. In the engage and explore phases, students are weighing mass before and after the investigations to determine if mass changes when matter is mixed or changes phases. In the elaborate phase, students collect data on how temperatures effect the phases of matter. Analysis is done to determine the temperature at which matter changes to another phase.

Differentiation of Instruction: To increase equity, students have access to modifications to assist them in accessing the curriculum. These modifications are included in each part of the lesson and include, but are not limited to, paper copies of electronic learning materials, scribes or note takers, extended time, students readers or audio (when available), math aids (such as calculators, manipulatives; as identified in IEPs).

Real-life Connection: All student have experiences with food and cooking. Food provides a sense memory, a technique often used by actors to illicit emotions. Learning is often tied to emotional responses. Educators can provide safe learning experiences by constructing investigations that build new positive emotions. Also, students learn about third world cultures who do not have electricity, providing a real problem faced by people around the world.

Possible Misconceptions: Students may have a difficult time understanding that mass changes when evaporation occurs, because the water vapor escapes into the air. It is difficult to understand that water vapor is still matter that has mass. The Law of the Conservation of Mass is best demonstrated in a closed container experiment, so that no water vapor can escape. Another possible misconception is what happens to substances that are dissolved, because sugar and salt seem to disappear. Students may not know that sugar and salt do not evaporate when heated. Once the water is gone, the sugar or salt is left behind.

Lesson Procedure:

5E Model	5E Objectives
Engage	**Procedure** Students follow a recipe to make trail mix and lemonade. Students design a way to separate the trail mix and lemonade (filters). Here they are learning the vocabulary mixture, solution, dissolve. Part I 1. Students are working in groups and watch dissolving salt crystal in water, then ask questions about this phenomena. 2. The teacher shows Alton Brown's show on making french toast. What is the connection between the two videos? The teacher makes a KWL chart as the class discusses the phenomena, how to follow recipes and personal experiences with recipes. Students may create a personal KWL to use throughout the lesson. 3. **Focus Question:** How can we separate ingredients after mixing them together? *Teachers may want to also ask, "Is mixing or separating the ingredients changing what they are?" 4. The teacher provides copies of the recipes for trail mix and lemonade. Students read the recipes and ask clarifying questions. Since the recipes are an example of functional text, the teacher highlights each feature (such as titles, headings, step by step procedures, and bullets) using different colors. Students do the same on their copies. 5. In groups, students gather ingredients and make observations about each ingredient. Students follow the procedure to complete each snack. Students make new observations about the ingredients, noting similarities and differences. (This could be a stopping point, the teacher could provide additional instruction on reading functional text.) 6. Students separate the two snacks into parts. Discuss how successful they are, reminding them that the crumbs and sugars must also be separated. Ask critical questions: How did the ingredients change? What happened to the lemon powder? Has it changed into a new material? Why or why not? What can we do to separate the materials better? 7. The teacher introduces the words matter, mixture, solution, dissolve, transform, with students providing examples from the investigation and beyond. Student discuss Three Phases of Matter from NASA and make connections to the investigation. 8. Add new information, including vocabulary word, to the KWL chart. Ask the focus question again.

	Part II (Idea derived from Water Filtration Challenge from JPL NASA, can use this resource for more information) 1. Reiterate the focus question: How can we separate ingredients after mixing them together? The teacher introduces the filter challenge and leads a discussion to determine how groups will know if they are successful. The teacher monitors and observes as students work. The teacher asks relevant, thought provoking questions to working groups. 2. Groups use the EDP to research filters work. Groups complete a technical drawing of a filtration system in their design notebooks (or paper), keeping in mind the materials available. Students present drawings using a feedback protocol (options: gallery walk, oral presentations, hot seat). Changes to the drawings can be made, based on class feedback. 3. Groups create a prototype filtration system based on the technical drawing. After building the first iteration, another feedback protocol can be used. 4. Groups design testing procedures, then test the filter prototype, recording data. Data collected is the mass, in grams, collected by each filter. This information is compared to the original mass to determine the success. Students need to test the trail mix first. Once they test the lemonade, the filter will not be able to be used on the trail mix because it will be wet. Students analyze results and decide on the changes that can be made to filter better. 5. Students present final results. Discuss what the results mean, based on what they know about mixtures and solution. (Students should not be able to separate the lemonade without evaporation. This needs to be a discussion point and can be demonstrated, if needed.) 6. The teacher asks the critical questions again: How did the ingredients change? What happened to the lemon powder? Has it changed into a new material? Why or why not? 7. Students add to the KWL chart. 4. Exit ticket: Students will answer the focus question. What are the next steps? **Modifications** paper copies of electronic learning materials, scribes or note takers, extended time, students readers or audio (when available), math aids (such as calculators, manipulatives; as identified in IEPs) **Standards Addressed** VA Standards of Learning ● Science 5.7b plan and conduct a way to separate matter ● Engineering 5.1 demonstrate an understanding of scientific and engineering practices

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- English 5.6 read and demonstrate comprehension of nonfiction

Formative/Summative Assessments Exit tickets

Resources per group

- chart paper for KWL chart
- all ingredients and tools listed on each recipe
- recording sheet for observations/data collection
- design notebooks (or paper for drawing the filter design)
- copies of the recipes and 4 colored highlighters
- digital scale to measure mass
- 4-5 plates for separately ingredients
- filter items: chicken wire, mesh screen, coffee filter, rubber bands, 2 empty 2L bottles, cut in half)

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<tr><td><u>Explore</u></td><td>

Procedure

Part I
Groups of students complete an investigation to see how taking heat energy away affects matter and mass. Students make freezer pops (using a lemon solution, sugar solution, salt solution, plain water) to learn that different solutions have different freezing points. Students also learn that freezing matter does not change its mass. The teacher is observing, questioning, and listening for science vocabulary (matter, mixture, solution, dissolve, transform) in student discussions.

1. Review by referring to the KWL chart. **Focus Question:** What happens to the mass of solutions when they change from one phase to another?
2. Students weigh 8 grams of each solid item (lemon powder, sugar, epsom salt) and 100 grams of water (separated into 4 containers of water). The initial mass is already on the data sheet (page 2).
3. Students label each container. They create each solution by adding the solid matter to the water and using a popsicle stick to stir until the solid matter dissolves. The fourth container is the control, which contains plain water.
4. Students record the temperature and mass of the four test items. Observations about each test item are made. Students make predictions based on prior knowledge, such as
    - Which container freezes first?
    - How long does it take to freeze each item?
    - At what temperature does each item freeze?
    - How does the mass of each item change after freezing?

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	5. Students put each test item in the freezer. A standard testing protocol is established. The protocol is a. The temperatures of the test items are checked and recorded at regular intervals. Quick observations are made. This process takes time, so it's recommended to set timers as a reminder to check on the investigation. b. After 3-4 hours, the final temperature readings and observations are recorded. c. The mass of each test item is measured and recorded. d. Students reflect on their findings and how the findings confirm or conflicts with the predictions. 6. Students form arguments to explain their findings based on the collected data. Students may need to explain anomalies in their findings (opening the freezer for long periods of time, not accurately measuring the mass of each item, space between test items). These are shared during a class discussion. 7. The class creates a statement about the freezing point of each test item. The class also creates a statement about how mass doesn't change. 8. Keep the frozen samples. They are used in part II of this investigation. Ask critical questions: How did the ingredients change? What happened to the solid materials? Have they changed into a new material? Why or why not? Are the freezing points the same? Why or why not? 9. Add to the KWL chart, as needed. Part II Groups of students use the frozen samples to investigate how adding heating energy changes matter. Mass is measured before and after adding heat energy. The teacher is observing, questioning, and listening for science vocabulary (matter, mixture, solution, dissolve, transform) in student discussions. 1. After reviewing the KWL chart, students predict how matter will change when heat energy is added. Students make predictions based on prior knowledge, such as ○ Do you think all of the test items will melt at the same rate? Why? ○ How long does it take for each test item to melt? Why? ○ What should the mass of each item be after melting? How do you know? ○ What is the difference (in seconds) between how long it takes for the test item that melts the fastest and the one that melts the slowest? 2. The frozen test items are removed from the freezer. Students observe and measure the mass of each item to see if changes occured since the last test.

3. Students use a hotplate (or place the items outside) to melt the frozen items. A standard testing protocol is established. The protocol is
    - The temperatures of the test items are checked and recorded at regular intervals. Quick observations are made. This process takes time, so it's recommended to set timers as a reminder to check on the investigation.
    - Once the last item has completely melted, the final temperature readings and observations are recorded.
    - The mass of each test item is measured and recorded.
    - Students reflect on their findings and how the findings confirm the prediction or conflicts with their predictions.
4. Students form arguments to explain their findings. Students may need to explain anomalies in their findings (not accurately measuring the mass of each item, space between test items, why the mass may have slightly changed). These are shared during a class discussion.
5. The class creates a statement about how mass doesn't change. Ask critical questions: How did the ingredients change? What happened to the solid materials? Have they changed into a new material? Why or why not?
6. Each student will add what they've learned to the KWL chart.

Modifications
paper copies of electronic learning materials, scribes or note takers, extended time, students readers or audio (when available), math aids (such as calculators, manipulatives; as identified in IEPs)

Standards Addressed VA Standards of Learning

- Science 5.7b plan and conduct a way to separate matter; c explain the role of energy in changing the phase of matter of a substance; c measure and graph quantities to demonstrate that, regardless of the type of change that occurs when heating, cooling, or mixing substances, the total mass of matter is unchanged
- Engineering 5.1 demonstrate an understanding of scientific and engineering practices
- English 5.6 read and demonstrate comprehension of nonfiction

Formative/Summative Assessments Data collection sheets,class discussion of findings, teacher observation

Resources per group

- 8 grams lemon powder, sugar, epsom salt
- 4 small plastic cups
- 4 containers with 25 grams water
- ice trays (could also use muffin tins)

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4 popsicle sticks for stirring
digital scale
access to a freezer and hotplate
KWL chart
thermometer
data collection sheet/graph paper
stopwatch

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<tr><td>Explain</td><td>
Procedure Students learn and share information about matter, mixtures/solutions/changing matter.

1. After reviewing the KWL chart, students go through a learning module on Symbaloo that consists of videos and reading passages about matter. Each step has quizzes or questions students must answer.
2. The final module is a Flipgrid video (included in the Symbaloo learning path) where students share their learning. The teacher is listening for science vocabulary (matter, mixture, solution, dissolve, transform). Topics discussed include
○ what matter is.
○ how you can separate mixtures and solutions.
○ how energy is used to change the phases of matter.
3. Students view at least 3 other Flipgrid videos, taking notes on things they learn.
4. Students add to the KWL chart as needed.

Modifications
paper copies of electronic learning materials, scribes or note takers, extended time, students readers or audio (when available), math aids (such as calculators, manipulatives; as identified in IEPs)

Standards Addressed VA Standards of Learning
● Science 5.7b plan and conduct a way to separate matter; c explain the role of energy in changing the phase of matter of a substance; c measure and graph quantities to demonstrate that, regardless of the type of change that occurs when heating, cooling, or mixing substances, the total mass of matter is unchanged
● Engineering 5.1 demonstrate an understanding of scientific and engineering practices
● English 5.6 read and demonstrate comprehension of nonfiction

Formative/Summative Assessments Flipgrid videos

Resources
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	● Chromebooks or laptop ● KWL chart ● paper/pencil
Elaborate	**Procedure** Students use the Engineering Design Process to design, build, and test a container that will add heat energy to matter, transforming it from one state to another. Determine success criteria by analyzing the challenge to see what is required. *In Virginia, students do not need to understand chemical changes, so this focuses only of a state change. 1. Review the KWL chart. Introduce the project. *There are places in the world without electricity. How do these areas cook? One option is using fire, however that can be dangerous and harmful to the environment. Open flames can catch clothes on fire and burn down homes. Burning wood also releases greenhouse gases into the atmosphere. How can "off the grid" places cook or bake that is 100% sustainable and harmless to the environment? Your challenge is to bake eggless cookies (recipe) using solar energy.* *The teacher may need to prepare the recipe prior to class to save money and time. The teacher also needs to keep food allergies in mind. Another idea is that students make the recipe as a math or reading activity. The challenge would be to halve it, which introduces division into the lesson. 2. In groups, students ask questions about the challenge. Some questions can be answered, while others might be answered while completing the challenge. Students research alternative energy sources, keeping in the mind the materials available. If needed, the teacher can focus groups on research about solar energy. Groups learn how solar energy changes matter by adding heat energy. The teacher may even want to share this "how to" video on making a solar oven. Students take notes on important ideas in their design notebooks (or paper.) 3. In design notebooks, groups complete a technical drawing with materials lists and scientific vocabulary. Students may follow the same feedback protocol they practiced with the filter challenge. Changes to the drawings can be made, based on class feedback. Students complete additional research, as needed. 4. Students create a solar oven prototype based on the technical drawing (students wear gloves when touching the part that contains food). After completion, students participate in a gallery walk. Students analyze other groups' prototypes and write down positive (glows) and negative (grows) feedback. Groups have a few minutes to change their prototype based on feedback. Remind students that feedback is kind, helpful, and specific. "Good job" is not feedback. 5. Groups design testing protocols (how often they record data, what they will measure). Then students test the prototype to bake part of the cookie mixture, recording temperature and observation data at regular intervals.

Students analyze results and decide on changes to improve the oven. If time, students will test 2-3 iterations and have several cookie samples to observe.

6. Students presents final results. The teacher leads the discussion about what the results mean, based on what they know about matter, mixtures, and solution.
7. Ask critical questions: How did the ingredients change? What happened to the solid materials? Have they changed into a new material? Why or why not?
8. Add to the KWL chart as needed.

Modifications

paper copies of electronic learning materials, scribes or note takers, extended time, students readers or audio (when available), math aids (such as calculators, manipulatives; as identified in IEPs)

Standards Addressed VA Standards of Learning

- Science 5.7c explain the role of energy in changing the phase of matter of a substance; c measure and graph quantities to demonstrate that, regardless of the type of change that occurs when heating, cooling, or mixing substances, the total mass of matter is unchanged
- Engineering 5.1 demonstrate an understanding of scientific and engineering practices
- English 5.6 read and demonstrate comprehension of nonfiction

Formative/Summative Assessments

Resources

- Chromebook or laptop
- design notebooks or paper
- ingredients and tools listed in the recipe

For the solar oven

- colored construction paper
- newspaper
- tape
- oven mitts
- copies of the challenge
- pencil
- aluminum foil
- thermometer
- serving gloves
- options for plastic cover (plastic wrap, transparency film, oven cooking bags)

	● various size boxes with 4 flaps; may need additional cardboard if the box does not have 4 flaps
Evaluate	**Procedure** Groups plan and organize a final demonstration of their solar oven as a cooking show. Each demonstration is less than 5 minutes. 1. Review the KWL chart. 2. **Prior to class,** students find an easy recipe that does not use eggs. No eggs can be used due to allergies, but also risk of salmonella poisoning. Due to the lengthy cook time, baked samples need to be prepared prior to the demonstration, just like a real cooking show. Groups use the planning document to prepare a presentation in the format of a cooking show. Students share the final design and explain how it transforms matter, using science vocabulary (matter, mixture, solution, dissolve, transform). 3. Groups practice the show and complete a self assessment (use the same rubric), with comments on what improvements they should make. 4. **During class,** students present their cooking show. Presentation options include: a. Pretape the demonstrations. Students can show the food cooking in the solar oven as a time-lapse video clip. If the school has greenscreen technology, a kitchen background can be added to increase authenticity. These will be viewed in class or shared on Google Classroom. *Video production can be taught with a quick mini lesson during a previous learning experience. b. Students can present live. All requirements are the same. 5. Students are graded using a rubric. 6. Students review the KWL chart and make final additions. **Modifications** paper copies of electronic learning materials, scribes or note takers, extended time, students readers or audio (when available), math aids (such as calculators, manipulatives; as identified in IEPs) **Standards Addressed** VA Standards of Learning ● 5.7c explain the role of energy in changing the phase of matter of a substance

	• 5.7c measure and graph quantities to demonstrate that, regardless of the type of change that occurs when heating, cooling, or mixing substances, the total mass of matter is unchanged **Formative/Summative Assessments** Presentation rubric **Resources** • student supplies a copy of student recipe, final prototype • cooking show planning document • desk or table • rubric • optional: video capability using Ipads or tablets with greenscreen app (such as Doink), props (aprons, chef's hats)

Teacher Background:

From the Virginia Department of Education,

- matter is defined as "anything that has mass and takes up space."
- Mass is "the amount of matter in an object."

Excerpt taken from the Curriculum Framework

"Sometimes when two or more substances are combined, they do not lose their identifying characteristics. These substances are called mixtures. Examples of mixtures include soil, concrete, and a mud puddle (5.7 b). Solutions are a special type of mixture in which one substance is uniformly dissolved in a liquid. Examples include sugar water, salt water, and soda (5.7 b). Students are not responsible for the terms solubility, solute, and solvent. Many kinds of matter change from a solid to a liquid to a gas when undergoing a temperature increase. As temperature decreases, that matter changes from a gas to a liquid to a solid (5.7 c). Matter does not gain or lose mass during phase changes (5.7 c). explain the role of energy in changing the phase of matter of a substance (5.7 c) measure and graph quantities to demonstrate that, regardless of the type of change that occurs when heating, cooling, or mixing substances, the total mass of matter is unchanged (5.7 c)."

Other information:

- Matter can physically change by mixing two or more materials, but the mass will not change. This is called the Law of the Conservation of Mass.
- *Article Dissolving Sugar in Water: Chemical or Physical Change?*
- *Law of Conservation of Matter Lab: Teacher Notes*