Chapter 5: Milk & Cheese

TRANSFORMATION STATION

Milk, cheese, yogurt, and ice cream are all part of the dairy group. Drinking milk helps build strong bones. Unfortunately, most Americans do not drink or eat enough foods from the dairy group every day. For this reason, it is important to learn about the science and nutrition of dairy foods. In this chapter, students will explore milk by learning about the importance of the digestive enzyme lactase, the role of bacteria in yogurt production, how cheese is made, the effect of pH on the formation of curds and whey, and the many health benefits associated with consuming dairy products.

FOOD EXPLORATION LABS

Lab I: Explicit Enzymes

- Teacher Preparation
- Teacher Lab Answer Key
- Student Lab

Lab II: Magnificent Microbes

- Teacher Preparation
- Teacher Lab Answer Key
- Student Lab

Lab III: Maintaining Mass

- Teacher Preparation
- Teacher Lab Answer Key
- Student Lab

INVESTIGATING YOUR HEALTH

Magnificent Milk

- Teacher Answer Key

Try This At Home: Fresh Yogurt

Charming Cheese

- Teacher Answer Key

Try This At Home: Simple Cheese Sauce

SUPPLEMENTAL MATERIALS

Teacher Preparation Slides
Student Pre-Lab Slides & Video
Glucose Reference Color Chart

Food Explorations Lab I:
Explicit Enzymes

TEACHER LESSON PREPARATION

Lesson Focus

Understand nutritional components of milk (carbohydrate) by exploring enzymatic activities in digestion.

Lesson Description

Students will test three types of milk for the sugar glucose before and after adding the digestive enzyme lactase to determine which milk(s) contain the sugar lactose.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table).

R-10 Read and comprehend complex literary and informational texts independently and proficiently.

W-2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

SL-1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade (6-8) topics, texts, and issues, building on others' ideas and expressing their own clearly.

L-1 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Next Generation Science Standards

Performance Expectations

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-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

Disciplinary Core Ideas

PS1.A Structure and Properties of Matter: Each substance has characteristic physical and chemical properties that can be used to identify it; and

PS1.B Chemical Reactions: Substances react chemically in a characteristic way. 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.

CLS1.C Organization for Matter and Energy Flow in Organisms: Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy

Science and Engineering Practices

Analyzing and Interpreting Data:

- Analyze and interpret data to determine similarities and differences in the findings.
- Scientific knowledge is based on logical and conceptual connections between evidence and explanation.

Background Information

Different types of milk vary in nutritional composition (i.e. protein, lipid, carbohydrate). Milk from mammals (e.g. cows, goats) contains the carbohydrate **lactose** (milk sugar). Milk from plants contains other dietary sugars, for example, soy milk contains **sucrose** and rice milk contains glucose. Almonds and coconuts are also sources of milk. Almond and coconut milk contain no cholesterol or lactose, coconut milk, however, is very high in saturated fat and consumption should be moderated. Both lactose and sucrose are **disaccharides**. A sugar composed of two simple sugars is a disaccharide. A molecule of lactose is made up of the two **monosaccharides**, glucose and **galactose**. One simple sugar unit is a monosaccharide. A molecule of sucrose is made up of the monosaccharides glucose and fructose. The human digestive system uses specific **enzymes** to breakdown the disaccharide molecules into their component monosaccharides, which are then absorbed and utilized by the

body. Enzymes are protein molecules that change the rate of a reaction without being depleted in the process. Lactase is the enzyme that acts on lactose, and sucrase acts on sucrose. Digestion of this nature occurs primarily in the small intestine. People who are lactose intolerant lack a sufficient amount of lactase to breakdown the lactose sugar.

The following factors influence the curdling properties of milk:

Bacteria: Bacteria can be added when making cheese or yogurt, but can also develop as milk begins to sour.

Acids: Acids can be found in juices or vegetables. The addition of an acid will result in the precipitation of casein, the most abundant milk protein. Acid produces a soft and spongy texture due to the decreased pH.

Tannins: Tannins can be found in coffee or tea. They will curdle milk in the presence of acid and heat. For example, if you add slightly old milk to coffee, you may see curdles form.

Dipping the glucose strip in the rice milk should automatically allow for the identification of rice milk. Since the glucose in soy milk (glucose + fructose = sucrose) and cow's milk (glucose + galactose = lactose) is bound, rice milk is the only milk type with free or unbound glucose. Bacteria will convert lactose to lactic acid causing milk to curdle. This process can take from 4 to 16 hours to complete. Milk curdled by bacteria has similar characteristics as milk curdled with acid. Additional information regarding the role of bacteria in yogurt production is included in the *Suggested Instructional Plan for Food Explorations Lab II: Magnificent Microbes.*

Students may wonder if the enzyme drops or solutions have glucose in them. Allow students to test the drops with the glucose strips to test concentration. Students will find that the drops are negative for glucose.

The lactase enzyme works best at room temperature. This enzyme will break down the carbohydrate in milk, lactose. Our bodies need lactase to digest lactose. Without this enzyme, our bodies cannot break down this disaccharide into two monosaccharides, glucose and galactose. Simple sugars that cannot be broken down are called monosaccharides.

Materials

Teacher Materials

NOTE: Teacher material list is based on 6 groups of 4-5 students (24-30 students total).

120 mL (1/2 cup) Cow's Milk (skim preferred)
120 mL (1/2 cup) Soy Milk
120mL (1/2 cup) Rice Milk
6 test tube racks or beakers
Glucose solution
18 test tubes with stoppers (any size - 3 per group)
18 test tube labels
1 black permanent marker
6 kitchen timers or stopwatches
30, 2-4 oz. plastic cups for sampling different milk types (optional)

Student Materials

NOTE: Student material list is based on 1 group of 4-5 students. Refer to the FoodMASTER Middle "Equipment and Material Lists by Chapter" for whole class estimates (24-30 students divided into 6 groups) on perishable and nonperishable materials.

3 test tubes (any size) with stoppers containing 20 mL of unknowns A (rice), B (cow), and C (soy)
test tube rack or beaker
12 glucose strips
1 Glucose Reference Color Chart (provided)
safety goggles
1 ½ crushed lactase enzyme pills
2-3 paper napkins or paper towel
1 kitchen timer or stopwatch
aprons (optional)

Teacher Pre-Lab Preparation

1. Review teacher background information, teacher preparation slides, student pre-lab slides/videos, student introduction, suggested instructional plan, and the student *Food Exploration* lab investigation procedures.

2. Prepare materials for each group. It is recommended that you plan approximately one-week ahead to allow time to gather needed materials.

3. For this investigation, be sure to use fresh milk (milk that has not been previously used/opened) and the same amount of milk in each tube. Cow and soy milk can be found in the refrigerated section of the grocery store. Eggs are often stored nearby. Rice milk will be found in a non-refrigerated section, such as the baking or juice isle; however, location can vary.

4. When purchasing glucose strips make sure the chart provided on the bottle matches the chart provided in the curriculum. If you are unable to match strips, students will need to use the chart provided on the glucose strip bottle (vs. the one provided) for the investigation.

5. Prepare milk type samples (1 sample per type per group). Fill each test tube with 20 mL of milk. Disguise each milk type's identity by labeling the prepared samples: A = Rice Milk, B = Cow's Milk, C = Soy Milk. Plug each test tube.

6. To ensure the glucose test strips work properly, test them prior to teaching the lesson with positive and negative controls. Follow the directions on your brand of strip. Dip a strip into a) glucose solution (positive control), and b) water (negative control). Wait for the length of time specified by strip directions. Compare color changes to the key on the bottle to determine glucose concentrations. If the strips indicate no glucose (or less than 2%) is present in the glucose solution, discard or return the strips, they are defective. New strips must be obtained to proceed with the investigation. The results obtained from these control tests can be explained to the class and recorded on the board for reference. If time allows, you may consider having students participate in this step.

Suggested Instructional Plan

1. Review scientific vocabulary and knowledge prerequisites:

Lactose	**Lactase**	**Monosaccharaides**
Digestion	**Carbohydrate**	**Disaccharides**

2. Consider having your students' research digestion (breakdown) mono- and disaccharides, focusing on the relationship between lactose and lactase, prior to beginning the lab investigation (see *Exploring Your Environment).*

3. Distribute Materials:

   It is recommended that materials are organized into stations for easier distribution. Materials are recommended based on the amount needed for 1 class of 30 students. Students should be arranged in small groups of 4-5.

   Each group should receive:

   - Student Lab Investigation Worksheets (1 per student)
   - Student Lab Materials

4. Ask students to read *Transformation Station.*

5. Before beginning the lab investigation:

   a. Require students to wash their hands.

   b. Allow students to taste each milk type prior to beginning or after investigation procedures. This process is important for increasing student exposure to healthy foods and decreasing the likelihood that students will be tempted to taste foods included as investigation materials.

   c. Emphasize the importance of practicing good food safety behaviors by not consuming substances used as part of the lab investigation.

6. Launch lab by asking students to make a prediction about which milk type will react with the lactase drops. Students should also predict what will happen to the glucose concentrations of each milk type. Encourage students to refer to the table in the reading when making predictions.

7. Show students the provided video lab demonstration, *Lab I: Explicit Enzymes.* The video will help students understand how to read a negative and positive test for glucose.

   a. *Rice Milk* (Unknown A): Before adding lactase, rice milk should be positive for glucose. After adding lactase, rice milk will still be positive for glucose. Rice milk is made from rice and is composed of primarily glucose. Glucose is a monosaccharide and cannot be broken down further.

   b. *Cow's Milk* (Unknown B): Before adding lactase, cow's milk should be negative for glucose. After adding lactase, cow's milk should be positive for glucose. Cow's milk contains the disaccharide lactose. The enzyme lactase breaks down lactose (disaccharide) into its component monosaccharides (glucose + galactose). This breakdown results in the release of glucose, which is why a positive test results after adding the enzyme. Similar reactions occur in the body (digestion) after consuming dairy products. When individuals lack the lactase enzyme they may have difficulty digesting dairy foods, particularly milk.

   c. *Soy Milk* (Unknown C): Before adding lactase, soy milk should be negative for glucose. After adding lactase enzyme, soy milk will still be negative for glucose. Soy milk is made from

soybeans and is primarily composed of sucrose. Lactase cannot break down sucrose. Instead, the enzyme sucrase would be needed to break down the disaccharide further.

8. Allow students to work in small groups on the Student Lab Investigation worksheet to further explore the topic and respond to lab questions. Encourage students to refer to the table in the reading to help support their conclusions.

9. (Optional) Launch the lab extension by allowing students to share their data to complete a class comparison of their results.

10. Follow-up with a class discussion about enzymes and their role in digestion. Follow-up this lesson with the *Investigating Your Health i*nvestigation. See *Teacher Bites* for ideas on how to further extend this lesson.

Teacher Bites: Lesson Extension

- Enzymes are sensitive to pH changes. To further explore enzymes, investigate with varying temperatures and pH levels. After manipulating temperature or pH of cow's milk, repeat the investigation by adding lactase and measuring glucose concentrations.

- Enzymes are sensitive to temperature changes. At cold temperatures the test strips will detect glucose but to a lesser extent. Very hot temperatures will deactivate the enzyme and it will not work at all. The test strip will not detect glucose at high temperatures.

Food Explorations Lab II:
Magnificent Microbes

TEACHER LESSON PREPARATION

Lesson Focus

Understand the role of bacterial fermentation and other factors (i.e. fat and lactose content) in the production of yogurt

Lesson Description

Students will use bacterial fermentation to produce yogurt. Fat content, sugar content (lactose), and temperature will be the variables tested.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table).

R-10 Read and comprehend complex literary and informational texts independently and proficiently.

W-2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

SL-1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade (6-8) topics, texts, and issues, building on others' ideas and expressing their own clearly.

L-1 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Next Generation Science Standards

Performance Expectations

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-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

MS-LS2-2 Construct an explanation that predicts patterns and interactions among organisms across multiple ecosystems.

Disciplinary Core Ideas

PS1.A Structure and Properties of Matter: Each substance has characteristic physical and chemical properties that can be used to identify it.

PS1.B Chemical Reactions: Substances react chemically in a characteristic way. 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.

LS2.A Interdependent Relationships in Ecosystems: Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environment, both living and non-living, are shared.

Science and Engineering Practices

Analyzing and Interpreting Data:

- Analyze and interpret data to determine similarities and differences in the findings.
- Scientific knowledge is based on logical and conceptual connections between evidence and explanation.
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.

Crosscutting Concepts

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Patterns can be used to identify cause and effect relationships.

Background Information

When milk is **fermented** with bacteria, the sugar in milk, lactose, will turn into **lactic acid**. The lactic acid will cause the milk to curdle and thicken. This process is used to make certain dairy products, like **yogurt**. Yogurt is made my mixing two types of bacteria, **Lactobacillus bulgaricus** and **Streptococcus**

thermophilous. In mass yogurt production, bacteria are added to milk and the mixture is heated. The heating process promotes fermentation and helps the yogurt develop the desired consistency, flavor and acidity. Once the desired consistency has been reached, the fermentation process is stopped. The yogurt can then be chilled or heated. Chilling allows the bacterial culture or active culture to stay alive. If the yogurt is heated, the cultures are destroyed. Consuming these products will help maintain and/or restore normal intestinal bacteria.

Materials

Teacher Materials

NOTE: Teacher material list is based on 6 groups of 4-5 students (24-30 students total).

2-3 hot plates or 1 double burner
3 thermometers (Celsius or Fahrenheit)
3 or 4 medium to large pots
4 heavy-duty plastic bottles to hold hot water (8 ounces or larger)
1 liquid measuring cup (1 cup or larger)
aluminum foil cut into 4x4 inch squares
water
6 small paper or plastic cups
2 medium or large coolers for incubation (20 oz. or larger)
plain yogurt (1 - 6 ounce container provides enough yogurt for 1 class)
Ice (enough for 1 cooler)
lactose-free milk (heat 2 cups per class)
skim milk (heat 2 cups per class)
whole milk (heat 4 cups per class) (see *Suggested Instructional Plan step 4*)
2 styrofoam cups labeled "whole milk- cold"

Student Materials

NOTE: Student material list is based on 1 group of 4-5 students. Refer to the FoodMASTER Middle "Equipment and Material Lists by Chapter" for whole class estimates (24-30 students divided into 6 groups) on perishable and nonperishable materials.

NOTE: Milk needed for the investigation is listed under teacher materials. Students will be directed to obtain their assigned milk from the teacher in the lab procedure.

Safety goggles
1 Styrofoam cup
1 black permanent marker
1 thermometer (Celsius or Fahrenheit)
1 cup of assigned heated milk
aprons (optional)
1 liquid measuring cup
1 tablespoon
1 - 4x4 square aluminum foil
1 paper cup containing slightly more than 1 tablespoon of plain yogurt

Lab Extension Materials

active culture sample (store bought plain yogurt)
1 microscope
1 medicine dropper
1 microscope slide and cover slips
cell stain
1 small cup of water

Teacher Pre-Lab Preparation

NOTE: This lab investigation will take <u>two days</u> to complete. Students will set up the lab investigation on day 1 and will complete the investigation on day 2.

1. Review teacher background information, teacher preparation slides, student pre-lab slides/videos, student introduction, suggested instructional plan, and the student Food Exploration lab investigation procedures.

2. Prepare materials for each group. It is recommended that you plan approximately one-week ahead to allow time to gather needed materials. You will need to have coolers and ice on hand the day the investigation begins. Additional coolers may be needed if you plan to complete the lesson with multiple classes.

3. Assign each group a milk type. During the investigation, each group should receive 1 cup of their assigned milk type. For example, if you have six groups, two groups will receive 1 cup of lactose-free milk, 2 groups will receive 1 cup of skim milk, and 2 groups will receive 1 cup of whole milk.

4. During the investigation you will heat 2 cups Whole, 2 cups of Lactose-Free, and 2 cups Skim milk, each to 175°F. Total amounts of milk will be determined by the number of groups in your classroom. For example, if you have six groups of students, you will need to heat 2 cups of each milk type.

5. You will also need to heat an additional 2 cups of Whole Milk for student observations of heated whole milk placed in a cold environment. After heating the milk to 175°F, allow it to cool to 120°F. Pour 1 cup of milk into two separate Styrofoam cups. Stir in 1 Tbsp. of plain yogurt.

6. Toward the end of the investigation:

   - Boil enough hot water to fill the four heavy-duty plastic bottles with very hot water and place them in one of the coolers. This will act as an incubator for the warm environment.
   - Fill the second cooler with enough ice to fill half way. This cooler will act as the cold environment. If accessible, a refrigerator can be used as an alternative to the cooler.

7. Each group will leave 1 cup of their assigned milk type (Whole Milk, Lactose-Free Milk, or Skim Milk) in the warm cooler. For the class to observe, you should also place 2 cups, filled with heated whole milk, in a cold cooler (ice-filled) overnight.

8. Students will record observations the following day.

Suggested Instructional Plan

1. Review scientific vocabulary and knowledge prerequisites:

   Bacteria **Active Cultures** **Fermentation** **Yogurt**

2. Consider having your students' research bacteria, fermentation, and yogurt production prior to beginning the lab investigation (see *Investigating Your Health*).

3. Distribute Materials:

   It is recommended that materials are organized into stations for easier distribution. Materials are recommended based on the amount needed for 1 class of 30 students. Students should be arranged in small groups of 4-5.

   Each group should receive:

   - Student Lab Investigation Worksheets (1 per student)
   - Student Lab Materials

4. If applicable, ask students to read *Transformation Station*.

5. Before beginning the lab investigation:

   a. Require students to wash their hands.

   b. For food safety reasons, DO NOT allow students to taste any of the yogurt samples. It is not safe to taste sample due to the inability to complete control contamination from bacteria present in the surrounding environments. If you would like your students to taste different types of yogurt, purchase pre-packaged yogurt from a store. Packaged yogurt should be refrigerated until tasting.

   c. Emphasize the importance of practicing good food safety behaviors by not consuming substances used as part of the lab investigation.

6. Launch **Day 1** of the lab by asking students to make a prediction about which milk type will produce the most yogurt and why.

7. You (teacher) should prepare the milk (see *Teacher Pre-Lab Preparation*). Students will allow milk to cool and then mix in plain yogurt.

8. Yogurt is produced from bacterial fermentation of milk. The lactose in milk is **fermented** by the bacteria. Bacteria or **"yogurt cultures"** used to make the yogurt in this lab are obtained from the addition of the plain yogurt. The bacteria will ferment the lactose present in the milk and produce lactic acid. The lactic acid will act on the milk protein, providing yogurt with its characteristic texture and tang.

9. Instruct students to make visual observations of their assigned milk type. Students should specifically observe the texture, color, and odor. Groups should then be allowed to share their assigned milk types to allow students to complete Table A.

10. Begin **Day 2** of the lab by showing students the provided video lab demonstration, *Lab II: Magnificent Microbes*. The video will review the previous lab and will help students understand what they should see in their milk mixtures on day two of the lab.

11. Instruct students to make observations of their assigned milk type. Students should specifically observe differences in texture, color, and odor. Do not forget to pass out the cold storage whole milk samples for students to observe.

    a. *Lactose-free Milk* (Warm Storage): Students should observe a small amount of liquid on top of the milk. When stirring, the milk should have a thick texture; however, compared to skim and whole milk the texture will be less thick. This milk type will be less thick compared to skim and whole milk due to the absence of lactose. Typically in yogurt production, lactose is fermented by the bacteria producing the lactic acid needed to produce yogurt.

    b. *Skim Milk* (Warm Storage): Students should observe very little liquid on top and the thickness should between Lactose-Free and Whole Milk-Warm.

    c. *Whole Milk* (Cold Storage): Students should observe no formation of yogurt, however, a small amount of liquid may be produced.

    d. *Whole Milk* (Warm Storage): Students should observe formation of a thick yogurt with little to no liquid produced on top. The comparison between the cold and warm storage will demonstrate the role of temperature in yogurt production. Warm temperatures are needed to encourage bacterial growth. Temperatures that are too hot or cold will negatively impact bacterial growth and may cause denaturation of the milk proteins.

12. Allow students to work in small groups on the Student Lab Investigation worksheet to further explore the topic and respond to lab questions. Encourage students to refer to the table in the reading to help support their conclusions.

13. (Optional) Launch the lab extension by allowing students to observe an active yogurt culture under a microscope.

14. Follow-up with a class discussion about fermentation and its role in yogurt production. It may also be a good time to discuss good and bad bacteria. Yogurt production is an excellent example of good bacteria at work. Explore an example of potentially harmful bacteria by completing Chapter 2: Food Safety, *Food Explorations Lab III: Multiplying Organisms*. Students further explore bacteria in this lab by observing mold growth in aerobic and anaerobic environments. Follow-up this lesson with the *Investigating Your Health* investigation. See *Teacher Bites* for ideas on how to further extend this lesson.

Teacher Bites: Lesson Extension

- Explore the effects of temperature on yogurt. Put a tablespoon of yogurt in 2 different containers. Place one in a warm, dark environment like a cabinet and place the other one in the refrigerator. After 24 hours, put a sample of each on a microscope slide with a drop of water and compare. Observe the bacteria under the microscope. Draw the bacteria.

- Explore bacteria in yogurt with and without *live/active* cultures. Use a microscope to observe the bacteria in yogurt. Prepare a slide using a drop of water and yogurt with active cultures and a slide using a drop of water and yogurt without active cultures. What shape are the bacteria? Draw the bacteria.

- Bring in a variety of yogurt types for tasting – compare and contrast nutritional content, flavors, and textures.

Food Explorations Lab III:
Maintaining Mass

TEACHER LESSON PREPARATION

Lesson Focus

Understand the Law of Conservation of Mass by exploring environmental factors that can impact protein coagulation in milk (cheese-making process)

Lesson Description

Students will make qualitative and quantitative observations as they test three possible methods of making curds and whey. They will determine if their measurements support the Law of Conservation of Mass.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table).

R-10 Read and comprehend complex literary and informational texts independently and proficiently.

W-2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

SL-1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade (6-8) topics, texts, and issues, building on others' ideas and expressing their own clearly.

L-1 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Next Generation Science Standards

Performance Expectations

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-PS1-5 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.

Disciplinary Core Ideas

PS1.A Structure and Properties of Matter: Each substance has characteristic physical and chemical properties that can be used to identify it.

PS1.B Chemical Reactions:

- Substances react chemically in a characteristic way. 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.
- The total number of each type of atom is conserved and thus the mass does not change.

Science and Engineering Practices

- Analyze and interpret data to determine similarities and differences in the findings.
- Develop a model to describe unobservable mechanisms.
- Scientific knowledge is based on logical and conceptual connections between evidence and explanation.
- Laws are regularities or mathematical descriptions of natural phenomena.

Crosscutting Concepts

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Matter is conserved because atoms are conserved in physical and chemical processes.

Background Information

A lactic-acid producing bacterium is added to milk to begin the cheese making process. This allows the milk to separate into curds and whey. The **curds** are then cut into smaller pieces allowing the liquid portion, **whey**, to escape. Whey is the watery portion of milk that separates from the curds when cheese is being made. Heat is applied to the curds to speed up the separation of whey. After the whey has been separated, the curds are drained, stretched, salted, and pressed to form a more concentrated cheese.

To give each cheese its own unique properties, it is then **cured** ("aged") or **ripened** to complete the process. Cheese that needs to be cured is not ready for consumption after being prepared.

Depending on the desired characteristics, the cheese is held for a certain amount of time, at a specific temperature, and under certain conditions. Most cheeses we consume are ripened, unless they are fresh, such as fresh mozzarella or ricotta. Fresh cheeses can be consumed right after they are made. Ripening is considered the changes that occur between the formation of curd and the development of the desired characteristics such as aroma (smell), flavor, texture, and composition.

There are many factors that contribute to the cheese making process. The composition of milk is considered the most important factor affecting the curd formation. More specifically, milk's fat and protein concentration impact curd formation because curds are primarily coagulated casein (protein). If whole milk is used, fat globules are also entrapped in the curd.

The type of acid used and temperature of milk during **coagulation** can also impact curd formation. Coagulation is the breakdown and reformation of proteins by heat. The curd formed at this point is soft. For example, **rennet** is the general term for any enzyme used to make cheese. Rennet can be found in the lining of a calf's stomach. Scientists have been able to duplicate an artificial version of rennet to be used in larger amounts.

The following factors influence the curdling properties of milk:

- *Bacteria:* Bacteria can be added when making cheese or yogurt, but can also develop as milk begins to sour.
- *Acids:* Acids are found in fruits, fruit juices, and some vegetables (e.g. tomatoes). The addition of an acid will result in the precipitation of casein, the most abundant milk protein. Acid produces a soft and spongy texture due to the decreased pH.
- *Tannins:* Tannins are found in coffee and tea. They will curdle milk in the presence of acid and heat because they readily bond with protein. For example, if you add slightly old (soured) milk to coffee, you may see curdles form. The acidity of the soured milk and heat cause the milk's protein to bond with the tannins (and itself) to form curdles.

Materials

Teacher Materials

NOTE: Teacher material list is based on 6 groups of 4-5 students (24-30 students total).

Pre-Lab Preparation

1 tablespoon
3 quarts 2% milk
6 labeled small cups containing 1 tbsp of baking soda (6 tbsps. total)
6 labeled small cups containing ½ cup of vinegar (3 cups total)
1 liquid measuring cup
1 black permanent marker

Demonstration *(see Suggested Lesson Plan steps 6-10)*

Safety goggles
1 cup 2% milk
1 hot plate or double burner
1 small saucepan
1 whisk or metal spoon
1 medium bowl
1 small strainer (very thin mesh)
Apron (optional)
2 small clear plastic cups (labeled "curds" and "whey)
1 cup for massing the milk
1 triple beam balance
1 black permanent marker
1 plastic spoon

Student Materials

NOTE: Student material list is based on 1 group of 4-5 students. Refer to the FoodMASTER Middle "Equipment and Material Lists by Chapter" for whole class estimates (24-30 students divided into 6 groups) on perishable and nonperishable materials.

Safety goggles
3 plastic spoons
1 triple beam balance
1 medium bowl
1 black permanent marker
1 small cup containing 1 tbsp. of baking soda
1 small cup containing ½ cup of vinegar
Aprons (optional)
1 small strainer (very thin mesh)
4 Styrofoam cups
1 liquid measuring cup
2% Milk

Teacher Pre-Lab Preparation

1. Review teacher background information, teacher preparation slides, student pre-lab slides/videos, student introduction, suggested instructional plan, and the student Food Exploration lab investigation procedures.

2. Prepare materials for each group.

3. Baking soda and vinegar should be premeasured in cups.

4. In the investigation below, you (the teacher) will be using a hot plate to demonstrate the curdling properties of milk proteins. Students will investigate the curdling properties of milk protein through non-heat methods.

TIMESAVERS: Review scale "taring" and instruct students to weigh and label empty containers before performing the lab. Practicing measurement is important for students. However, if time is a concern, students may be provided teacher-determined masses of 1 tbsp. of baking soda and 1/2 cup of vinegar, if desired. Additionally, milk may be poured into pitchers for easier access by students. If time is a limitation, use the demonstration video in the student pre-lab materials in place of the in-class teacher-led demonstration. Provide students with the mock data below after your class has viewed the video.

Table B	Treatment (grams)		Uncoagulated Milk (grams)	Curd Protein (grams)	Whey Protein (grams)
2% fat Milk	Vinegar				
	Baking Soda				
	Heat	N/A	409g	3g	402g

Suggested Instructional Plan

1. Review scientific vocabulary and knowledge prerequisites:

Curds	**Whey**	**Protein**
Tare	**Coagulation**	**Casein**

2. Consider having your students research how cheese is made prior to beginning the lab investigation.

3. Distribute Materials:

   It is recommended that materials are organized into stations for easier distribution. Materials are recommended based on the amount needed for 1 class of 30 students. Students should be arranged in small groups of 4-5.

   Each group should receive:

   - Student Lab Investigation Worksheets (1 per student)
   - Student Lab Materials

4. Ask students to read *Acid Adventure*.

5. Before beginning the lab investigation:

   a. Require students to wash their hands.

   b. Emphasize the importance of practicing good food safety behaviors by not consuming substances used as part of the lab investigation.

   c. For food safety reasons, DO NOT allow students to taste any casein or whey byproducts.

6. Launch the lab by completing the **teacher demonstration**. The demonstration will show students how to find the mass of the coagulated protein, while revealing that milk will curdle after exposure to high heat.

7. Using a triple beam balance, mass 1 cup of 2% milk. Remember to mass the empty cup first. Record the mass in a location visible to the class to help demonstrate conservation of mass. Have students record the mass of the milk only in Table B under "Un-coagulated Milk" for the "Heat" treatment. **Hint: This is a good time to review rules for massing liquids and powdered solids on a balance.**

8. At high heat, quickly heat the milk to a boil in a small saucepan. Use a whisk or metal spoon to stir the milk as it heats to prevent the milk from burning.

9. Once the milk has begun boiling, continue to let it boil for 5 minutes. Be careful to continue whisking the milk as it heats. If the milk gets too hot and is not stirred, it will boil over.

10. To determine the quantity of coagulated proteins you will strain and determine the masses of the both the coagulated proteins and the liquid remaining.

    - *STEP 1:* Place a clean, clear small cup on your scale. A clear cup is preferred so that students can easily see any coagulated proteins. *Determine the mass of the cup.*
    - *STEP 2:* Next, place a strainer over a medium bowl and pour the heated skim milk into the strainer. If present, the strainer will catch any coagulated proteins. Using a plastic spoon, scrape the coagulated proteins out of the strainer with a plastic spoon and place them in the clean cup measured in STEP 1.
    - *STEP 3:* Place the clear cup containing the milk proteins that you just scraped from the strainer on your balance. You may need to scrape some coagulated protein from your pot too. The coagulated proteins are called **curd proteins**. Subtract the mass of the cup from the mass of the cup and curds. Have students record the mass of the curd proteins in Table B under the column labeled "Curd Protein."
    - *STEP 4:* The left over fluid in your bowl is called **whey protein**. Determine the mass of a second clean, clear cup. Pour the liquid whey protein into a clear cup. Subtract the mass of the cup from the mass of the cup and whey. Have students record the mass of the whey in Table B under the column labeled "Whey Protein."

11. Begin the student lab investigation by asking students to observe and make a prediction about treatments that may cause milk to curdle. Based on the teacher demonstration, students should already know that heat would cause milk to curdle.

    a. *Heat:* Students should observe clear curdling. When milk is heated, a precipitate will form. The heat-sensitive coagulated proteins are mostly whey and can generally be observed on the bottom and sides of the cooking pan. Curd proteins will not form as readily when milk is heated. Milk may have to be heated to higher temperatures (212°F, 100°C) for longer time periods to observe curd formation.

    b. *Vinegar:* Students should observe clear curdling. When an acid is added to milk it causes the normal pH (6.5 – 6.7) to fall. A lower pH causes the milk proteins to destabilize. Curd proteins will precipitate and be observable. Whey proteins are not as sensitive to acid as curd proteins and will remain in a colloidal suspension (fluid state).

    c. *Baking Soda:* No curdling should be observed. The addition of baking soda will result in an

increase in pH. Milk proteins will remain stable.

12. Allow students to work in small groups on the Student Lab Investigation worksheet to further explore the topic and respond to lab questions.

13. Allow students to share data between groups. Students should seek to complete their data tables with information for the treatment they were not originally assigned.

14. Follow-up with a class discussion about the impact of various environments on proteins (e.g. heat, acidic, basic) and the relevance to the cheese-making process. Follow-up this lesson with the *Investigating Your Health* investigation. See *Teacher Bites* for ideas on how to further extend this lesson.

Teacher Bites: Lesson Extension

- Make cheese with the class. Use the FoodMASTER Intermediate curriculum as a resource (www.foodmaster.org).
- Bring in a variety of cheese for your students to taste test.
- Discuss the water activity properties of different cheese types. Which type of cheese will mold the fastest? (See *Chapter 2: Food Safety*)
- Have students' research the role of rennet in the making of cheese.

Investigating Your Health:
Magnificent Milk

STUDENT HEALTH INVESTIGATION

Lesson Focus

Explore the nutritional composition and health benefits of consuming milk. Students will research food sources of calcium, vitamin D, and phosphorus and devise ways to add bone-strengthening food to their diet.

Lesson Description

Students will compare and contrast Nutrition Facts labels for four types of milk including whole, reduced fat, low-fat, and fat-free. They may find labels in the grocery store or use USDA's on-line database. Students will also plan three meals and snack that contain bone-strengthening foods.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-10 Read and comprehend science/technical texts in the grades 6-8 text.

W-2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

W-7 Conduct short research projects to answer a question (including a self-generated question) drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

W-9 Draw evidence from informational texts to support analysis, reflection, and research.

Next Generation Science Standards

Performance Expectations

MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

Disciplinary Core Idea

LS1.C Organization for Matter and Energy Flow in Organisms: Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.

Science and Engineering Practices

Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in the findings.

Suggested Instructional Plan

1. Review Scientific Vocabulary and Knowledge Prerequisites:

   Calcium **Vitamin D** **Phosphorus** **Osteoporosis**

2. Instruct students to research the role calcium, vitamin D, and phosphorus play in bone formation prior to beginning the investigation. Students should seek to identify specific dairy food sources of calcium, vitamin D, and phosphorus and the health benefits of consuming low-fat dairy products.

3. Using the provided student background or information learned from researching dairy, students should examine the food labels of milk with varying fat content (i.e. whole, reduced fat, low-fat, and skim).

4. Students can find food labels in the grocery store, they can access the USDA's nutrient database (http://ndb.nal.usda.gov/ndb/search/list), or use the labels provided.

5. If completed in-class, allow students to work in small groups on the Investigation worksheet to further explore the topic and respond to questions.

6. Follow-up with a class discussion about student findings related to the health benefits of dairy foods and student generated ideas for increasing consumption of "bone-strengthening" foods in their diet.

Milk Nutritional Facts

	Whole Milk	2% fat Milk	Low-fat Milk (1% fat)	Fat-Free Milk (0% fat)
Calories	150	130	110	90
Total Fat	8g	5g	2.5g	0g
Calcium	30%	30%	30%	30%
Vitamin D	25%	25%	25%	25%

Investigating Your Health:
Charming Cheese

STUDENT HEALTH INVESTIGATION

Lesson Focus

Explore the health benefits of including cheese in the diet. Students will identify and compare nutritional information of cheeses varying in fat, calcium, and moisture content.

Lesson Description

Students will compare and contrast Nutrition Facts labels for three types of cheese including cheese made with whole, 2%, and fat-free milk. They may find labels in the grocery store or use USDA's on-line database. Students will also analyze cheese based on fat and calcium content.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table).

R-10 Read and comprehend complex literary and informational texts independently and proficiently.

W-2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

SL-1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade (6-8) topics, texts, and issues, building on others' ideas and expressing their own clearly.

L-1 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Next Generation Science Standards

Performance Expectations

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-PS1-5 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.

Disciplinary Core Ideas

LS1.C Organization for Matter and Energy Flow in Organisms: Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.

PS1.A Structure and Properties of Matter: Each substance has characteristic physical and chemical properties that can be used to identify it.

PS1.B Chemical Reactions:

- Substances react chemically in a characteristic way. 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.
- The total number of each type of atom is conserved and thus the mass does not change.

Science and Engineering Practices

- Analyze and interpret data to determine similarities and differences in the findings.
- Develop a model to describe unobservable mechanisms.
- Scientific knowledge is based on logical and conceptual connections between evidence and explanation.
- Laws are regularities or mathematical descriptions of natural phenomena.

Crosscutting Concepts

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Matter is conserved because atoms are conserved in physical and chemical processes.

Suggested Instructional Plan

1. Review Scientific Vocabulary and Knowledge Prerequisites:

   Cheese

2. Instruct students to research different types of cheese prior to beginning the investigation. Students will compare cheese types based on fat, calcium, and moisture content.

3. Using the provided student background or information learned from researching cheese, students should examine the food labels of different types of cheese and compare them based on fat and calcium content.

4. Students can find food labels in the grocery store, USDA's nutrient database (http://ndb.nal.usda.gov/ndb/search/list), or use the labels provided.

5. If you choose to use the provided cheese food labels, see the Teacher Edition workbook for answers to the *Investigating Your Health* lab questions. Answers to questions based on other food labels will vary.

6. To standardize serving size across nutrition labels, students will need to convert each serving size into the same value (cups, tablespoons, etc.). Students will then need to convert all fractions to a decimal. Finding the largest decimal, the students will then divide it by one of the others. Multiply each number in the nutrition facts label using this answer. For example: ¾ = .75, .75 ÷ .5 = 1.5. Repeat these steps with the other labels. Please see the example below:

Nutrition Facts

Serving Size	**¾ cup**
Calories	**70**
Total Fat	**0g**
Sodium	**0mg**
Total Carbohydrates	**19g**
Dietary Fiber	**2g**
Sugars	**14g**
Protein	**0g**

Vitamin A 2%	Vitamin C 130%
Vitamin E 0%	Calcium 2%
Iron 0%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 0%	

Nutrition Facts

Serving Size	**⅓ cup**
Calories	**140**
Total Fat	**0g**
Sodium	**85mg**
Total Carbohydrates	**35g**
Dietary Fiber	**1g**
Sugars	**31g**
Protein	**0g**

Vitamin A 0%	Vitamin C 0%
Vitamin E 0%	Calcium 2%
Iron 2%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 2%	

Nutrition Facts

Serving Size	**¾ cup**
Calories	**318**
Total Fat	**0g**
Sodium	**193mg**
Total Carbohydrates	**79g**
Dietary Fiber	**2g**
Sugars	**70g**
Protein	**0g**

Vitamin A 0%	Vitamin C 0%
Vitamin E 0%	Calcium 2%
Iron 2%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 2%	

Conversion Factors (CF)

3/4 = .75 1/3 = .33 1/2 = .5

.75/.33 = 2.27

.75/.5 = 1.5

1/3 cup x CF: .33 x 2.27 = .75

Calories: 140kcal x 2.27 = 318kcal

Sodium: 85mg x 2.27 = 193mg

Carbohydrate: 35g x 2.27 = 79g

Dietary Fiber: 1g x 2.27 = 2g

Sugars: 31g x 2.27 = 70g

7. If completed in-class, allow students to work in small groups on the Investigation worksheet to further explore the topic and respond to questions.

8. Follow-up with a class discussion about student findings related to the health benefits of including cheese in the diet.

Cheese Food Labels

	Whole Milk	2% Milk	Fat-free Milk
Calories	110	80	45
Total Fat	9g	6g	0g
Saturated Fat	6g	3.5g	0g
Sodium	180mg	230mg	280mg
Calcium	20%	40%	25%

Parmesan

Nutrition Facts

Serving Size	**1 oz**
Calories	**100**
Total Fat	**7g**
Sodium	**180mg**
Total Carbohydrates	**1g**
Dietary Fiber	**0g**
Sugars	**0g**
Protein	**9g**

Vitamin A 4%	Vitamin C 0%
Vitamin E 0%	Calcium 30%
Iron 0%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 0%	

Cheddar

Nutrition Facts

Serving Size	**1 oz**
Calories	**110**
Total Fat	**9g**
Sodium	**180mg**
Total Carbohydrates	**1g**
Dietary Fiber	**0g**
Sugars	**0g**
Protein	**7g**

Vitamin A 6%	Vitamin C 0%
Vitamin E 0%	Calcium 20%
Iron 0%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 0%	

Mozzarella

Nutrition Facts

Serving Size	**1 oz**
Calories	**80**
Total Fat	**6g**
Sodium	**170mg**
Total Carbohydrates	**1g**
Dietary Fiber	**0g**
Sugars	**0g**
Protein	**8g**

Vitamin A 4%	Vitamin C 0%
Vitamin E 0%	Calcium 20%
Iron 0%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 0%	

Swiss

Nutrition Facts

Serving Size	**1 oz**
Calories	**100**
Total Fat	**8g**
Sodium	**60mg**
Total Carbohydrates	**1g**
Dietary Fiber	**0g**
Sugars	**0g**
Protein	**8g**

Vitamin A 6%	Vitamin C 0%
Vitamin E 0%	Calcium 25%
Iron 0%	Thiamin 0%
Niacin 0%	Folate 0%
Vitamin B_{12} 0%	Zinc 0%
Magnesium 0%	