The Case of the Cookie Mystery

Grade Level: 5

Key Concepts
Physical Properties of Matter * Chemical and Physical Changes

Mathematics Strands
Measurement

Skills
Observation * Organizing and Analyzing Data * Predicting
Drawing Conclusions

Nature of Science
Problem Solving * Real-Life Application * Collaboration

Science	**Scientific investigation and exploration of the properties of matter * Physical and chemical changes**
Technology	**Use of measurement instruments * lab safety videos * content videos**
Engineering	**Design of container for heating**
Mathematics	**Measurement of mass and volume**

Time:
Two 45-60 minute sessions

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Overview

In this problem-based lesson, students are led through a series of hands-on activities to observe and test six substances in order to gather information about their physical and chemical properties. The tests are constructed as a structured inquiry in which the question under investigation is: "What is the effect of combining each of the six powders with _____ (vinegar, water, iodine, or heat)?" The investigations are in service to a larger "problem" in which the students need to investigate a "Cookie Mystery." In the Cookie Mystery scenario, the ingredients for the cookie recipe (the six powders) have been mixed and the students need to figure out how to identify the substances in the unknown mixtures.

The manipulations students will use during the inquiry portion of the lesson will provide observational data, which will be used in the problem-based investigation. The information students will gather draws on prior knowledge of mixtures and solutions, physical and chemical changes, and the effects of heat on matter.

After gathering data during the structured inquiry investigations, students will apply the same physical and chemical tests to "mystery" mixtures in order to identify the components. They will use a logical "if…, then…" framework to apply knowledge they have gained through their initial investigations to make sense of the novel situation of identifying the components in the mixtures.

Objectives

Know

- Matter exists in three basic phases: gas, liquid, and solid.
- As temperature increases, many kinds of matter undergo a phase change, for example from a solid to a liquid, or from a liquid to a gas.
- A mixture is a combination of two or more substances that do not lose their identifying characteristics when combined.
- A solution is a mixture in which one substance dissolves into another substance.

Understand

- Substances are identified by their physical and chemical properties.
- In a physical change, matter changes in size, shape, or physical appearance, but remains the same substance.
- In a chemical change, the molecules that make up the substance undergo rearrangement, producing a new substance or substances.
- Science is based on evidence, both observational and experimental.

Do

- Conduct an investigation to identify physical and chemical properties of white powders.
- Use appropriate safety practices for handling known and unknown substances and heat sources.
- Measure substances in grams and milliliters using appropriate instruments.
- Make predictions and draw conclusions based on evidence.
- Communicate results and conclusions based upon experimental evidence.

Standards

Virginia Standards

Review of Science 3.3 The student will investigate and understand that objects are made of materials that can be described by their physical properties. Key concepts include

a) objects are made of one or more materials;
b) physical properties remain the same as the material is changed in visible size; and
c) visible physical changes are identified.

Science 5.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

g) data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements;
h) predictions are made using patterns from data collected, and simple graphical data are generated;
i) inferences are made and conclusions are drawn.

Science 5.4 The student will investigate and understand that matter is anything that has mass and takes up spaces; and occurs as a solid, liquid, or gas. Key concepts include

a) distinguishing properties of each phase of matter;
b) the effect of temperature on the phases of matter;
e) mixtures including solutions.

Mathematics 5.2 The student will

a) recognize and name fractions in their equivalent decimal form and vice versa; and
b) compare and order fractions and decimals in a given set from least to greatest and greatest to least.

Mathematics 5.8 d) The student will estimate and then measure to solve problems, using U.S. Customary and metric units.

National Standards

SCIENCE AS INQUIRY, Content Standard A (grades K-4)
As a result of activities in grades K-4, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

PHYSICAL SCIENCE, Content Standard B (grades K-4)
As a result of activities in grades K-4, all students should develop an understanding of

- Properties of objects and materials

Preparation

What You Need

For the class (shopping/gathering list):

- ☐ 1 package of 50 2-oz plastic cups with lids (condiment size)
- ☐ 1 box of baking soda (½ lb)
- ☐ 1 can of baking powder (10 oz)
- ☐ 1 box of corn starch (1 lb)
- ☐ 1 bag of all-purpose flour (1 lb)
- ☐ 1 bag of powdered sugar (1 lb)
- ☐ 1 bag of rice flour (24 oz)
- ☐ 1 bottle of white vinegar (32 oz)
- ☐ 2 boxes of toothpicks (approx. 200)
- ☐ 1 box of disposable plastic gloves (approx. 50)
- ☐ 6 plastic spoons
- ☐ 6 bottles of iodine (1 oz)
- ☐ 6 votive candles
- ☐ 6 votive candle holders
- ☐ 6 lighters
- ☐ 1 roll of waxed paper
- ☐ 1 roll of aluminum foil
- ☐ 1 box of Ziploc® snack-size bags
- ☐ 12 eye droppers
- ☐ lab safety goggles (one per student)
- ☐ 6 balance scales
- ☐ 6 sets of gram weights
- ☐ 6 graduated cylinders
- ☐ 6 metal tweezers
- ☐ Paper towels
- ☐ 1 tablespoon

*The materials listed in "For each group" are the amounts **out of** the "For the class" materials (that is, use the "For the class" list to gather everything, then use the "For each group" list to divide it all up).*

For each group:

- ☐ 2 T of baking soda in a plastic cup (labeled "Baking Soda")
- ☐ 2 T of baking powder in a plastic cup (labeled "Baking Powder")
- ☐ 2 T of cornstarch in a plastic cup (labeled "Cornstarch")
- ☐ 2 T of all-purpose flour in a plastic cup (labeled "Flour")
- ☐ 2 T of powdered sugar in a plastic cup (labeled "Powdered Sugar")
- ☐ 2 T of rice flour in a plastic cup (labeled "Rice Flour")
- ☐ 1 plastic spoon
- ☐ 1 bottle of iodine

- [ ] 1 lighter
- [ ] 1 balance scale
- [ ] 1 set of gram weights
- [ ] 1 graduated sylinder
- [ ] Metal tweezers
- [ ] 2 droppers
- [ ] 1 paper towel
- [ ] 6 4x4 pieces of waxed paper
- [ ] Aluminum foil
- [ ] 1 bag of 2 T of each Mystery Powder (Day Two)
- [ ] 1 permanent marker

For each student:

- [ ] Lab Safety Goggles
- [ ] Plastic gloves
- [ ] *Pre-assessment*
- [ ] *Student Data Collection Sheet, Day 1*
- [ ] *Powder Testing Procedure: Instructions for Investigators* handout
- [ ] *Student Data Collection Sheet, Day 2*
- [ ] *Cookie Mystery* handout (choose appropriate holiday, if desired)
- [ ] *Post-Assessment*

Good Laboratory Practice dictates that lab safety goggles be worn by students whenever there is a risk of splash. Regular prescription eyewear should not be used as a substitute for lab safety goggles.

In the case that your school does not have one pair of goggles per student, you may offer goggles at the needed stations and allow sharing of goggles. Good Laboratory Practice encourages cleaning the goggles between uses to avoid the spread of skin-borne infections.

Getting Ready

Before the day of the activity

1. A few days to a week before implementing the lesson, give students the provided *Pre-lesson Assessment* and mark it using the *Pre-Assessment Answer Key*.
   a. Questions 1-6 assess students' understanding of the properties of matter. If students struggle with these questions, additional instruction is necessary.
   b. Questions 8-9 assess students' familiarity with lab practice and safety. If this lesson will be the students' first time handling and manipulating substances, this is a good opportunity to teach proper materials handling and laboratory safety rules. Before beginning the lesson, go over rules of good laboratory practice (see Day One).
      i. For an optional paper-pencil assessment of student understanding of lab safety, have students underline the broken safety rules in the document at: http://sciencespot.net/Media/scimthdsafety.pdf
   c. Plan to group students so that all members of a group begin at a similar level of conceptual understanding. You may also wish to place less confident students with their more confident peers. If there are discipline and/or safety concerns, group with those considerations in mind to be most effective.

2. Gather and prepare investigation materials.

   a. Day 1:
      i. Label the plastic cups with the names of the six powders (1 set of all 6 powders for each group)
      ii. Measure 2 tablespoons of each powder into the labeled cups.
      iii. Cut waxed paper into 4"x4" pieces, 6 per group.

   b. Day 2: Prepare the Mystery Samples in the Ziploc® snack-size bags: measure about 2/3 T of each of the powders, for a total of 2 T of each Mystery Sample:
      i. Mystery Sample A: flour, cornstarch, powdered sugar
      ii. Mystery Sample B: flour, baking soda, powdered sugar
      iii. Mystery Sample C: flour, baking soda, rice flour

One option for additional instruction on the properties of matter is to show the video clip on properties of matter (part 1, clips 3 & 4) at Discovery Education (requires a subscription): http://player.discoveryeducation.com/index.cfm?guidAssetId=6BAA6AFA-8229-4AAF-AFD9-01EC31E9FD05&blnFromSearch=1&productcode=US

We recommend providing each group with all six powders and allowing them to do all four of the tests (water, vinegar, iodine, and heat).

If possible, it is helpful to have more than one adult in the classroom during the investigations. An additional adult can support monitoring the heat testers and helping with materials in general.

Day One: Testing Known Samples

Getting Ready

1. **Have materials ready**
   a. Have the samples for Day One measured (2T each) in the labeled and lidded plastic cups. Make sure to have enough for one full set for each group.
   b. Have the testing materials ready: permanent marker, toothpicks, water, vinegar, iodine bottles (one per group), droppers (2 per group), candles and candleholders (1 per group), wax paper squares, and aluminum foil. Have ready empty plastic cups in which students may aliquot and carry water and vinegar.
   c. Distribute goggles, balance scales, gram weights, graduated cylinders, and metal tweezers to the testing stations.
   d. Have a roll of paper towels accessible.

   If there is not a sink in the classroom, it may be useful to have a tub of water accessible for students to wash their hands.

   e. Make copies of the *Cookie Mystery* sheet (one per group), the *Student Data Collection Sheets* (one per student), and the *Powder Testing Procedure* sheets (one per student). Also make one copy of each of these that can be used with your overhead projector or other device.

Introduction

1. **Generate ideas:** Guide a class discussion on the physical properties of matter and generate student ideas as to how physical properties can be used to identify matter.
   a. To open the discussion, brainstorm for adjectives that describe the physical properties of an object of your choice.
   b. Bring in and pass around some different kinds of matter (ex: a rock; a bottle of water; a piece of wood) and have students write down their observations.
   c. Circulate through the room, asking guiding questions to reinforce the importance of careful observation and observation in different domains: ex: “What color is it?” “What phase of matter is it?”
   d. When students have finished recording their observations, they will share them in a class discussion. Give useful feedback to encourage careful observation.
   e. Note any students who have difficulty understanding phase change, or making careful detailed observations. Make sure to visit these students often during the investigation.

2. **Introduce the investigation:** Explain that students will use their observation skills and perform several tests to identify the physical properties of a set of six powders.

3. **Lab safety:** Go over good laboratory practice for the first time or as a review. Remind students that anytime they see something unsafe to tell the teacher.

   a. Laboratory safety rules:
      - Substances should never be tasted in the laboratory.
      - The wafting technique should be used to identify the smell of the substances.
      - Special care is needed when handling iodine to avoid staining hands and clothing. If available, students should use gloves when testing with iodine.

   b. Fire safety rules (during the heat test using the votive candles)
      - No loose clothing
      - Roll up sleeves
      - Tie back hair
      - Wear goggles
      - No papers or flammable materials around the flame
      - Only one person at a time over the candle
      - Extinguish flame when testing is complete

4. Divide the class into the groups you have decided on based on the *Pre-Assessment.*

5. Hand out one *Cookie Mystery* sheet to each group and place one on the digital presenter, document camera, or overhead projector. Read it together (silently or aloud) as a class and answer any questions.

6. Hand out one *Student Data Collection Sheet, Day One* to each student. Read the question from the top of the *Student Data Collection Sheet, Day One*: *How can you use physical properties to identify an unknown mixture?*

7. Hand out one *Powder Testing Procedure* sheet to each student and place one on the digital presenter, document camera, or overhead projector. Have students read the procedures carefully.

Write the investigation question on the board:
What is the effect of combining each of the six powders with _____ (vinegar, water, iodine, or heat)?

Gloves, especially ill-fitting gloves, should NOT be worn by students during the heat testing.

Make sure you and all other adult assistants know where your fire extinguisher is and how to use it, in case of an accident with the candle.

8. **Discuss the procedures.** Solicit any questions about the protocol or safety practices.
   a. During the discussion, ask students to consider which safety procedures might need to be followed for which tests.

9. Define laboratory roles and assign one (or more) to each student in the groups (or have the students choose them). Roles include:

   - Materials gatherer(s**)**
     - Gathers the materials. One student may gather the powders and one the testing materials.
     - At the end of the investigation, the same student(s) will dispose of waste and return materials to the teacher.

   - Measurer
     - Measures 10 grams of each powder and divides it into quarters.

   - Tester(s)
     - This job may rotate among members of the group. One may do the Water Test, one the Vinegar Test, one the Iodine Test, and one the Heat Test.

   - Lab Safety Checker
     - Makes sure lab safety rules are being followed.

   - Data Recorder
     - Writes down the results of the Water Test, Vinegar Test, Iodine Test, and Heat Test on the *Data Collection Sheet: Day 1*.
     - Shares these results with the rest of the group to ensure accuracy.

If there is time, consider showing some video clips that reinforce lab safety rules:

Discovery Education (requires subscription):
http://player.discoveryeducation.com/index.cfm?guidAssetId=7B304B8E-3924-4005-8088-BE9DB856CB96&blnFromSearch=1&productcode=US

Mrs. Matthew's 5th Grade Science Class:
http://matthews.watchknowlearn.org/Video.aspx?VideoID=25270&CategoryID=6942

School Tube:
http://www.schooltube.com/video/7919c4774838219091e7

Keep the investigation question on the board:
What is the effect of combining each of the six powders with _____ (vinegar, water, iodine, or heat)?

Do the Investigation

1. Invite the Materials Gatherers to gather the materials and bring them to their station.

2. Once materials are gathered, suggest that the other group members make sure they have all that is necessary, by checking off each item on their *Powder Testing Procedure* handout.

3. Using the balance scales and gram weights that are already at their stations, Measurers will measure 10 grams of each powder and place it on a square of waxed paper. They will divide each powder

into fourths to perform each test.

4. All the students will observe the materials closely and carefully and discuss their physical properties with their group members, then record their observations in the appropriate column on their *Student Data Collection Sheet, Day 1*.

We suggest that the Measurer place the waxed paper squares on top of paper towels. This makes for easier cleanup and stabilizes the slippery waxed paper. In addition, paper towel may be labeled to avoid misidentifying powders.

5. Monitor groups by asking guiding questions. Some useful questions might include:
   - What is the color of this powder?
   - Does the powder have an odor?

6. (*optional*) Hold a brief class discussion to share observations. This will reinforce student understanding of how to make good observations and address any confusion before moving on to more observing the tests. Let students know that they can add to their data sheets to make their descriptions more complete.
   - Take notes about student understanding of, and facility with, observation. Make sure to revisit any students who are finding careful observation difficult or confusing.

Consider modeling testing one powder, or one series of tests.

Tell students that if they do not get a chance to perform a test today, they may switch roles tomorrow and perform a test then.

7. After all students in the group have completed the observations of physical properties, Testers will perform the liquid tests on all the powders, one at a time. Data Recorders will record their observations in the appropriate column of their *Student Data Collection Sheet, Day 1*, and share them with the rest of their group so that all agree on the accuracy of the results.

Good Laboratory Practice dictates that a wafting technique be used for smelling substances in the lab. You can demonstrate this for your students.

8. Circulate through the room, asking questions and sharing observations to scaffold learning. Guiding questions might include:
   - Has the texture changed?
   - Was there any reaction when the liquid was added?
   - Do you notice any physical or chemical changes?
   - Note any misconceptions or confusion in student responses to these questions. Revisit those students as they continue to perform tests and gather data.

Emphasize often that the powder samples should not be mixed.

9. Tell students that the last test they will perform requires them to design containers made of the aluminum foil for each of the substances. They will put the powder in their containers and hold it over a candle flame.

10. Testers will conduct the heat test on their powders and Data Recorders will record their observations in the appropriate column of their *Student Data Collection Sheet, Day 1*.

If there is time, hold a short discussion after the liquid

tests.

11. Groups will go over their *Data Collection Sheets* to make sure their results agree. They will then discuss in their groups how they might answer the prompt at the bottom of their *Data Collection Sheets: "Based on the data you collected in this investigation, predict how you will know which mystery mixture will have the correct ingredients for the cookie recipe."*

12. **Clean up:**
    - Materials Gatherers will throw away garbage (plastic cups, leftover powders, etc).
    - Groups will clean up their stations as directed by the teacher.
    - Groups will re-organize the balance scales, gram weights, goggles, tweezers, iodine bottles, permanent markers, candles, and aluminum foil and leave them at their stations. Let the class know that they will be using the same testing procedure tomorrow to solve the Cookie Mystery problem, this time with mystery mixtures.

Sharing Results

Making predictions is an important part of the scientific process. DO take time for this part of the investigation. Encourage students to elaborate on their thinking and to use prior knowledge and experience to give support to their prediction.

1. Record student observations in a way that everyone can see: put a blank *Student Data Collection Sheet* on the digital presenter, document camera, or overhead projector and fill it in according to student prompts.

2. Guide a class discussion on the results.
    - Discuss how each substance behaved during the tests. Ask students to compare results across the different powders. For example, how does flour behave differently when tested with water compared to iodine? Ask the students to compare results across the different tests. For example, how does vinegar interact with sugar as compared to baking powder? Elicit from the students the idea that the properties of these substances can be used, through careful observation, to characterize the substance.
    - If all groups got similar results, discuss the reliability of systematic observation and testing. Discuss the importance of a scientific community.
    - If groups get different results, discuss error analysis in the context of experimentation. Factors that might come up in discussion are variations in amounts of liquid or in the time a substance was held over the candle flame. Bring up the idea that more trials give us a more reliable result. Again, emphasize the importance of a scientific community for assessing results. Be sure to distinguish between errors (procedures that were not followed or mistakes in measuring

that can be identified) and variance (differences in results that are a natural part of the experimental process and may not be readily identified). Discuss how observational differences (use of language and detail) can be one type of variance in this kind of experiment.

This discussion may begin on Day 1 and continue to Day 2, be reviewed on Day 2, or take place entirely on Day 2, depending on timing.

3. At the end of the lesson, each student should have written results on his/her *Data Collection Sheet* that will be used as a reference guide in the Day 2 investigation of the mystery mixtures.

4. Ask the students how they answered the question at the bottom of the *Student Data Collection Sheet, Day 1*: "*Based on the data you collected in this investigation, predict how you will know which mystery mixture will have the correct ingredients for the cookie recipe."*
   - Guide students in interpreting their data as a series of causal relationships (i.e., if heat *causes* sugar to turn brown, then a mixture that contains sugar would turn brown.)

Listen to the students' answers but do not prompt the "correct answers." Do prompt them to articulate their evidence. What have they observed that leads them to make their claim? If their predictions are wrong or if they are confused, they will figure them out in the testing or in the discussion afterward. Continue to prompt with questioning throughout the lesson.

When discussing the nature of science, be sure to discuss the idea of data integrity. Data that was collected in error – wrong protocol, wrong measurement, etc – can be disregarded. However, data that was collected in earnest cannot be ethically disregarded. This is why scientists repeat experiments for verification of results.

Day Two: Identifying the Mystery Mixture

Review and Predict

1. Reread the *Cookie Mystery* to the students, focusing on the powdered ingredients needed for the cookie recipe: flour, baking soda, and powdered sugar.

2. Reintroduce the problem from the *Data Collection Sheet, Day One*: *How can we use physical properties to identify the unknown cookie mixture?*

3. Have the class split up into the same groups as in Day One.

4. Give the groups time for a Think/Pair/Share activity in which they will generate ideas as to which of the tests conducted on Day One would help to identify which of the three mystery mixtures is the correct sample of cookie ingredients. Remind them (or introduce this framework) to interpret Day One test results as "if…then" causal statements.

5. Have a classroom discussion, asking:
   - How will you know if flour is in a mystery mixture? What tests suggest that flour is possible and what tests tell us for sure?
   - How will you know if baking soda in a mystery mixture? What tests suggest that baking soda is possible and what tests tell us for sure?
   - How will you know if powdered sugar in a mystery mixture? What tests suggest that powdered sugar is possible and what tests tell us for sure?
   - What do you predict will be the test results of the correct mystery mixture? Out of all possible tests and results, which do you think would be conclusive? Which would not?

Write the Cookie Mystery problem on the board and keep it there throughout the lesson:
How can we use physical properties to identify an unknown cookie mixture?

Continue to prompt the students to use evidence to justify their responses. Probe student understanding with additional questions.

Conduct the *Cookie Mystery* Investigation

1. The Gatherers from each group will gather the materials needed for today's tests:
   - One sample of each of the three mystery mixtures.
   - The testing materials, scales, etc, that were left at each station at the end of Day One.

2. Using the balance scales, Measurers will follow the same procedure as on Day One: they will measure 10 grams of each powder and place it on a square of waxed paper. They will divide each powder into fourths to perform each test.

Students may want to change roles. In particular, Lab Safety Checkers and Data Recorders may want to do some testing. If so, encourage them to switch roles.

3. Students will observe the materials closely and carefully, and will discuss their observations with their groups. Students will then record their observations in the appropriate column on their *Student Data Collection Sheet, Day Two*.

4. After all students in the group have completed their observations of the samples, Testers will perform the liquid tests on the mystery samples. Data Recorders will record their observations in the appropriate column of their *Student Data Collection Sheet, Day Two*, and share them with the rest of their group so that all agree on the description of the results.

Remind Measurers again to label their squares of waxed paper, this time numbering them 1, 2, or 3.

5. Students will engineer aluminum foil containers for the heat test. They may use a different design today, based on their thoughts about the container's performance on Day One.

6. Testers will conduct the heat test on their powders and Data Recorders will record their observations in the appropriate column of their *Student Data Collection Sheet, Day Two*.

7. Groups will clean up their stations, following the same procedure as in Day One.

Listen to students' small group discussions for a continuation of the discussions from Day One. Listen particularly for students to talk about data collection, variables, controls, trials, and use of descriptive vocabulary. If you do not hear the Day One concepts coming up in the small group discussions, prompt the groups with probing questions to elicit those discussions. For example, "If one person observed bubbles but another person did not, what does that mean for your results?"

8. Groups will analyze and discuss the test results and will make a conclusion about which of the three mystery samples is the correct mixture of cookie ingredients. Use of evidence is important.

Sharing Results

1. Hold a class discussion and invite students to share their results using evidence from the tests on Day Two that supports those conclusions. Ask if the predictions they had made on Day One were supported or if the predictions were not supported. Encourage the students to reflect on their thinking over time.

2. Ask "What ingredients are needed to make the cookies?" and "What data was gathered about these ingredients that would help determine which mystery bag contains those ingredients"?

3. Guide discussion to a more general review of what they have learned about the properties of matter and how an understanding of those properties can be used in real life.

4. Resolve the problem scenario by asking the students which mystery mixture is the cookie recipe. Clarify any confusion or conflicting results. Consider discussing again the reliability of scientific experimentation, the importance of a scientific community, and the reasons for experimental error and variance.

5. Administer the *Post-lesson Assessment*.

Students may believe that their predictions need to "come true" in order to feel validated. Be sure to dispel that notion of science by putting more emphasis on the use of evidence and critical consideration of the data. Emphasize reflective thinking over time, and evidence based decision-making over "being right."

As described in our preparation, the answer is sample bag B; however, the "correct" answer is not as important as the student's careful use of evidence to support his/her answer. Consider all answers provided and probe for understanding based on evidence.

Going Further

Making Cookies

Students will use their correctly identified mystery mixture to actually put together a batch of cookies. Alternatively, they will make cookies at home, using the recipe in the handout. Instead of making enough cookie dough for 6 dozen cookies (the yield listed on the recipe), ask them to make enough, or to write a recipe for enough, for ten cookies, or for two. This will lead to a discussion of fractions and proportions.

Make-Your-Own Mystery

Groups will design their own mystery mixtures for other groups to solve. Challenge them to challenge each other by making the mixtures as difficult as possible to solve. If they choose mixtures that are unsolvable, they must explain why they are unsolvable; what the two possible answers would be; and what other tools (hypothetical or real) they might need to distinguish between the options.

Literature Connections

Books

1. Wiese, J. (1996). *Detective science: 40 crime-solving, case-breaking, crook-catching activities for kids*. Wiley.

2. Taris, J. R. and Taris, L. J. (2006). *Hands-on science mysteries for grades 3-6: Standards-based inquiry investigations.* Jossey-Bass.

3. Schulz, K. (2008) *CSI Expert!: Forensic Science for Kids*. Prufrock Press.

Websites

1. Video clip on the properties of matter (part 1, clips 3 & 4) at Discovery Education (requires a subscription): http://player.discoveryeducation.com/index.cfm?guidAssetId=6BAA6AFA-8229-4AAF-AFD9-01EC31E9FD05&blnFromSearch=1&productcode=US

2. (2012). Compounds and mixtures. In *BrainPOP*. Retrieved June 7, 2012 from http://www.brainpop.com/science/matterandchemistry/compoundsandmixtures

3. (2012). Matter changing states. In *BrainPOP*. Retrieved June 7, 2012 from http://www.brainpop.com/science/matterandchemistry/matterchangingstates

4. Adams, W., Beale, P, Blanco, J., McKagan, S., Perkins, K, Podolefsky, N, & Loeblein, T. States of matter: Atomic bonding, chemistry, heat. Retrieved June 11, 2012 from http://phet.colorado.edu/en/simulation/states-of-matter

Behind the Scenes

Mixtures

A mixture is formed when two or more substances are combined but no reaction takes place. Examples of mixtures are trail mix, white light, and a tossed salad. A mixture can be separated into its original parts. Mixtures can be separated by physical means. For example, trail mix could be separated into its component parts through separation by color, shape, size, etc. White light can be separated into its component parts by diffraction through a prism. A sand screen for example could be used to separate a mixture of sand and sea shells. The sand screen uses size as the physical property for the separation.

A solutions is a special type of mixture that is created when one substance is dissolved into another. Examples of solutions are lemonade, salt water, and blood. In a solution, the substance that is dissolved is called the solute, and the substance into which it is dissolved is called the solvent. The solute is usually present in a small amount, and the solvent is usually present in a large amount. In a salt water solution, for example, the salt is the solute and the water is the solvent. Solutions can be separated by physical means. For example, we can use boiling point (a physical property) to boil the water out of a salt water solution, leaving the salt behind in the pan.

Properties of Matter

Matter can be changed in two ways: physically and chemically. In a physical change, matter changes in color, odor, size, shape, or physical appearance. Despite these changes, the matter remains the same substance and can change back to its original state. An example of a physical change would be to cut a piece of paper in half. Another example of a physical change is when an ice cube melts, or a pan of water turns to steam. Phase changes (solid to liquid, or liquid to gas) are physical changes.

In a chemical change, there is a change in the actual molecules that make up the substance. Chemical change results in a new substance or substances. A chemical reaction is taking place. Energy is an important part of a chemical change. In some reactions energy is needed to get the reaction started. An example of this type of chemical change is bread baking in the oven. In other types of chemical changes, energy is produced. An example of this type of chemical change is the reaction that happens in a glow stick, producing light energy when the molecules are mixed.

In this lesson, your students may see an example of a chemical change when baking soda reacts with vinegar, producing bubbles of carbon dioxide gas. Your students may also see a chemical reaction, if they are watching very carefully, when the sugar and flour are heated. Sugar and flour can both be driven to decomposition with enough heat, producing a small amount of steam (water) and leaving behind a black crusty substance (pure carbon). Because of the differences in the structures between sugar and flour, the rate at which the decomposition occurs is different; therefore your students may or may not notice the decomposition reaction. Finally, your students may also see a chemical reaction between flour and iodine, and between cornstarch and iodine. Starches react with the iodine to produce a blue colored product.

Your students may notice a physical change in the sugar when heated, as it will melt first (phase change from solid to liquid) before it undergoes the decomposition reaction (chemical change, turns black).

Lesson Sequence

Getting Ready:

1. Make one copy for each student of: *Pre-Assessment*; *Cookie Mystery* (choose the appropriate holiday, if desired); *Powder Testing Procedure*; *Student Data Collection Sheet, Day One and Two*; *Post-Assessment*.
2. Gather materials. Measure out samples for Day One and compile mystery samples for Day Two.
3. Administer and score the *Pre-Assessment.* Remediate as needed, using the suggested video clips in the lesson plan.
4. Group students so that all members of a group scored similar results on the *Pre-Assessment*. Other possible grouping principles: group less confident students with more confident students; group heterogeneously if there are discipline and safety concerns.

Day One:

1. Discuss the properties of matter.
2. Introduce the Cookie Mystery problem. Brainstorm with the class and discuss the problem, *How can we use physical properties to identify an unknown mixture?*
3. *Introduce the inquiry investigations:* What is the effect of combining each of the six powders with _____ (vinegar, water, iodine, or heat)?"
4. Remind students of (or introduce) lab safety rules, especially those for using iodine and candles. Assign or have students choose roles.
5. Students will observe and test six (known) powders in four tests. They will record observations.
6. Discuss results in a whole-group setting.

Day Two:

1. Review results from Day One and have students share and explain their results. Have students make predictions and rationalize their predictions using data from Day One.
2. Remind students of lab safety.
3. Students will test three mystery mixtures, using the same procedure as on Day 1.
4. Share results and draw conclusions as a class.
5. Administer, collect, and score *Post-Assessments.*

Assessment

Objectives

The overall learning objective of this lesson plan is for students to use observations to classify substances and to understand that mixtures retain the identifying characteristics of their individual components. Through this investigation, students will explore physical and chemical changes and learn about proper safety procedures with chemicals and heat. Students will also gain a deeper understanding of the properties of matter, hone skills such as making predictions and drawing conclusions, and use proper measurement tools.

Pre-Assessment

The purpose of the pre-assessment is two-fold: to determine students' readiness for the lesson and to establish a baseline of understanding that can be compared with the post-assessment to determine how well the lesson objectives were met. The pre-assessment will identify preconceptions and misconceptions about matter and lab protocols. The pre-assessment results can be used to determine which areas might need clarification or support lessons prior to the core lesson, or which students might need particular attention and guidance during and after the core lesson. Pre-assessment results can also be used to group students so that all in a group are at a similar level of understanding of matter and experimental procedures.

Formative Assessments:

1. ***Student Data Collection Sheet, Day One and Two*:** Using these sheets, students record test results (observations) and make predictions based on results. Collect these at the close of the investigation to gain a sense of students' observational skills (detail, nuance, characterizations) and students' abilities to organize those data through the investigation process.

2. **Class discussions** and teacher monitoring of group activities give an opportunity for identifying misconceptions and providing ongoing feedback.

3. **Anecdotal observations** will generate qualitative data on the students' involvement, understanding of concepts, and data collection. The anecdotal record will also provide further insights as to any further instruction or direction that might be necessary.

Summative Assessments:

1. *Cookie Mystery:* Students share their findings and discuss the conclusions drawn based on the data. They will revisit their predictions and reflect on their thinking in light of the final conclusions.

2. *Post-Assessment*: is used to gauge students' mastery of the key lesson objectives. These results should be carefully analyzed to determine if further clarification of concepts is necessary. These results can be compared to the Pre-lesson Assessment to determine gains in understandings across the class.

Appendices

1. *Cookie Mystery* sheets (x4 samples, tailored to specific school holidays)
2. Pre-Assessment
3. Pre-Assessment Answer Key
4. Post-Assessment
5. Post-Assessment Answer Key
6. Student Data Collection Sheet: Day One
7. Student Data Collection Sheet: Day Two
8. Powder Testing Procedure

Culinary Bureau of Investigations

Case of the Cookie Mystery

Chef Matter needs your help! The powders he uses for making his famous sugar cookies have been tampered with.
A note was left with three mystery bags of white powder. The Culinary Bureau of Investigations has provided samples of the following powders: flour, baking soda, baking powder, powdered sugar, rice flour, and corn starch found in Chef Matter's kitchen.
You have been hired to identify which mystery bag contains the correct ingredients for the cookies. Without your help, Chef Matter will not be able to make his cookies! Help him so he can make his delicious cookies!

Part 1: Follow the directions to test each sample (1-6) with water, vinegar, iodine, and heat. Record your observations on the Day 1 Student Data Collection Sheet.

Part 2: Follow the same directions to test the three Mystery Mixtures. Record your observations on the Day 2 Student Data Collection Sheet.

Chef Matter's Cookie Recipe

Mix 15 cups of flour, 6 teaspoons of baking soda, 6 cups of powdered sugar, 3 pounds of butter, and 12 eggs in a large bowl. Add lots of tender loving care and a bit of magic dust, then bake until golden brown. Recipe yields 6 dozen cookies.

Romantic Bureau of Investigations
Case of the Valentine Cookie Mystery

Cupid needs your help! Every year, during the few weeks before Valentine's Day, Cupid starts making batches of his special heart shaped cookies for boys and girls to give to their sweethearts on Valentine's Day. A naughty little Leprechaun snuck into Cupid's kitchen and messed up all the special baking powders.

He has left a note with three mystery bags of white powder. The Romantic Bureau of Investigations has provided samples of the following powders: flour, baking soda, baking powder, powdered sugar, rice flour, and corn starch found at Cupid's house and the three mixtures left by the Leprechaun.

You have been hired to identify which mystery bag contains the correct ingredients for Cupid's cookies. Without your help, Cupid will not be able to make his cookies! Help Cupid so he can make his delicious cookies!

Part 1: Follow the directions to test each sample (1-6) with water, vinegar, iodine, and heat. Record your observations on the Day 1 Student Data Collection Sheet.

Part 2: Follow the same directions to test the three Mystery Mixtures. Record your observations on the Day 2 Student Data Collection Sheet.

Cupid's Special Sweetheart Cookie Recipe

Mix 15 cups of flour, 6 teaspoons of baking soda, 6 cups of powdered sugar, 3 pounds of butter, and 12 eggs in a large bowl. Add lots of tender loving care and a bit of magic dust, then bake until golden brown. Recipe yields 6 dozen cookies.

Mayflower Bureau of Investigations
Case of the Thanksgiving Cookie Mystery

Mrs. Gobbler needs your help! Each Thanksgiving Mrs. Gobbler makes a batch of her special cookies to give to all the pilgrims. A flock of wild turkeys flew into the kitchen and messed up all of the special baking powders.
They left a note with three mystery bags of white powder. The Mayflower Bureau of Investigations has provided samples of the following powders: flour, baking soda, baking powder, powdered sugar, rice flour, and corn starch found at Mrs. Gobbler's house and the three mixtures left by the turkeys.
You have been hired to identify which mystery bag contains the correct ingredients for Mrs. Gobblers' cookies. Without your help, Mrs. Gobbler will not be able to make her cookies! Help Mrs. Gobbler so she can make her delicious cookies!

Part 1: Follow the directions to test each sample (1-6) with water, vinegar, iodine, and heat. Record your observations on the Day 1 Student Data Collection Sheet.

Part 2: Follow the same directions to test the three Mystery Mixtures. Record your observations on the Day 2 Student Data Collection Sheet.

Mrs. Gobblers' Special Sugar Cookie Recipe

Mix 15 cups of flour, 6 teaspoons of baking soda, 6 cups of powdered sugar, 3 pounds of butter, and 12 eggs in a large bowl. Add lots of tender loving care and a bit of magic dust, then bake until golden brown. Recipe yields 6 dozen cookies.

North Pole Bureau of Investigations
Case #1225: Case of the Christmas Cookie Mystery

Mrs. Claus needs your help! Each Christmas, Mrs. Claus makes a batch of her special cookies to give Santa all of the energy he needs to deliver presents to the good little boys and girls around the world. A bad little elf has snuck into the kitchen and messed up all of the special baking powders. He has left a note with three mystery bags of white powder. The North Pole Bureau of Investigations has provided samples of the following powders: flour, baking soda, baking powder, powdered sugar, rice flour, and corn starch found at Santa's house and the three mixtures left by the elf.

You have been hired to identify which mystery bag contains the correct ingredients for Mrs. Claus' cookies. Without your help, Mrs. Claus will not be able to make her cookies! Help Mrs. Claus so she can make her delicious cookies!

Follow the directions to test each sample (1-6) with water, vinegar, iodine, and heat. Record your observations on the Day 1 Student Data Collection Sheet.

Part 2: Follow the same directions to test the three Mystery Mixtures. Record your observations on the Day 2 Student Data Collection Sheet.

I am a bad little elf,

That's plain to see;

There will be no cookies this year,

Mrs. Claus' Special Sugar Cookie Recipe

Mix 15 cups of flour, 6 teaspoons of baking soda, 6 cups of powdered sugar, 3 pounds of butter, and 12 eggs in a large bowl. Add lots of tender loving care and a bit of magic dust, then bake until golden brown. Recipe yields 6 dozen cookies.

vvvbbn

Pre-Assessment Name:_____

1. What are the three phases of matter? _____

2. Which phase of matter has a definite shape and volume?
a. solid b. liquid c. gas

3. Describe the properties of a liquid. _____

---

4. Using as many of the following properties of matter as you can, describe your pencil.
mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

_____

_____

5. *I am solid that stretches. My mass is about one gram. I am made of rubber and make a continuous circle. What am I?* _____

6. Put an **X** on all of the properties below that are used to identify the object in #5.

mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

7. What metric unit of measure is used to find the mass of matter? _____

8. On the back of your paper, draw a picture of an appropriate tool to measure a liquid.

9. List one safety rule when conducting a science investigation. _____

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10. When adding heat, which of the following may occur:

a. ice changes to water b. water changes to ice c. steam changes to water

11. Put an M on the picture(s) if it is a mixture. Put an S on the picture(s) if it is a solution. Put an X on the picture if it is neither.

mixed nuts glass of lemonade tossed salad corn flakes




Pre-Assessment Answer Key Name:_____

1. What are the three phases of matter? Solid, liquid, and gas
2. Which phase of matter has a definite shape and volume?
   a. solid b. liquid c. gas

3. Describe the properties of a liquid. Sample answers: molecules are packed looser than those in a solid, you can't hold it in your hands, it does not have its own shape but takes the shape of the container, has mass and volume

4. Using as many of the following properties of matter as you can, describe your pencil.
mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

If students do not have an adequate understanding of matter properties, you may direct them to view clips of the video, Properties of Matter, Part 1, clips 3 & 4:
http://player.discoveryeducation.com/index.cfm?guidAssetId=6BAA6AFA-8229-4AAF-AFD9-01EC31E9FD05&blnFromSearch=1&productcode=US

5. *I am solid that stretches. My mass is about one gram. I am made of rubber and make a continuous circle. What am I?* rubberband

6. Put an **X** on all of the properties below that are used to identify the object for #5. (all must be marked to be correct)

Mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

7. What metric unit of measure is used to find the mass of matter? grams
8. On the back of your paper, draw a picture of an appropriate tool to measure a liquid.
   Students should draw a graduated cylinder or a beaker.

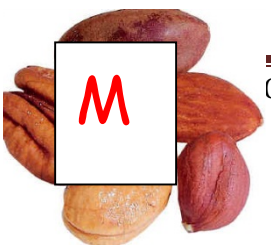
9. List one safety rule when conducting a science investigation. Student responses may vary. If students do not have an adequate understanding of lab safety rules, you may have them view clips at:
http://player.discoveryeducation.com/index.cfm?guidAssetId=7B304B8E-3924-4005-8088-BE9DB856CB96&blnFromSearch=1&productcode=US

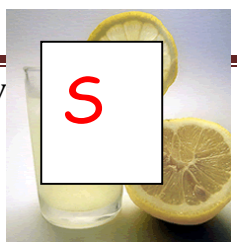
10. When adding heat, which of the following may occur:

a. ice changes to water b. water changes to ice c. steam changes to water

11. Put an M on the picture(s) if it is a mixture. Put an S on the picture(s) if it is a solution. Put an X on the picture if it is neither.

mixed nuts glass of lemonade tossed salad corn flakes





Student

Post- Assessment Name:_____

1. Using as many of the following properties of matter as you can, describe a banana.

mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

_____

_____

2. *I am a solid. I weigh about one kilogram. I have a rectangular shape. I am made of paper and can be found in your desk. What am I?* _____

3. Put an **X** on all of the properties below that are used to identify the object in #2.

mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

4. What metric unit of measure is used to find the volume of liquid matter? _____

5. On the back of your paper, draw a picture of an appropriate tool to measure mass.

6. List one safety rule when conducting a science investigation. _____

_____

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7. When adding heat, which of the following may occur:

a. Ice changes to water b. Water changes to ice c. Steam changes to water

8. Put an M on the picture(s) if it is a mixture. Put an S on the picture(s) if it is a solution. Put an X on the picture of it is neither.

Mixed nuts Glass of lemonade Tossed salad Corn flakes

Post- Assessment Answer Key Name:_____

1. Using as many of the following properties of matter as you can, describe a banana.

mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

Student answers may vary.

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2. *I am a solid. I weigh about one kilogram. I have a rectangular shape. I am made of paper and can be found in your desk. What am I?* book or notebook

3. Put an **X** on all of the properties below that are used to identify the object in #2. (all must be marked to be correct)

mass volume color shape weight length phase

reactivity odor texture flexibility hardness size

4. What metric unit of measure is used to find the volume of liquid matter? Liters/milliliters

5. On the back of your paper, draw a picture of an appropriate tool to measure mass.
Students should draw a picture of a balance scale.

6. List one safety rule when conducting a science investigation. Student answers may vary.

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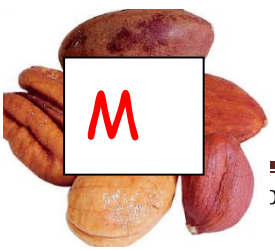
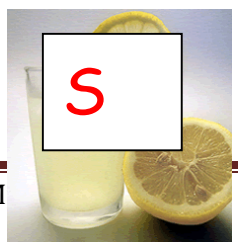
7. When adding heat, which of the following may occur:

a. Ice changes to water b. Water changes to ice c. Steam changes to water

8. Put an M on the picture(s) if it is a mixture. Put an S on the picture(s) if it is a solution. Put an X on the picture if it is neither.

Mixed nuts Glass of lemonade Tossed salad Corn flakes





Student Data Collection Sheet **Day 1** **Name _____**

How can you use physical properties to identify an unknown mixture?

Sample	Description	Water Test	Vinegar Test	Iodine Test	Heat Test
Flour					
Baking Soda					
Powdered Sugar					
Corn Starch					
Rice flour					
Baking Powder					

Based on the data you collected in this investigation, predict how you will know which mystery mixture will have the correct ingredients for the cookie recipe. _____

Day 2 Name _____

Student Data Collection Sheet

Sample	Description	Water Test	Vinegar Test	Iodine Test	Heat Test
A					
B					
C					

1. Which mystery mixture is the special cookie mix? _____

2. How did you use the physical properties you discovered in the investigation to identify the unknown mixture?

_____

_____

Powder Testing Procedure
The Case of the Cookie Mystery
Instructions for Investigators

Dear Investigators,

Your investigation begins with testing the 6 powders that were found in the kitchen. These were flour, baking soda, baking powder, powdered sugar, rice flour, and cornstarch. As the Investigator, you need to know more about these materials. Remember DO NOT ALLOW SAMPLES TO MIX TOGETHER! This is very important.

Step 1: First, collect your materials.
You will need:

- **One container of each of the 6 powders that were found in the kitchen**
- **6 toothpicks (one for each powder)**
- **Water (20 mL)**
- **Vinegar (20 mL)**
- **Iodine bottle**
- **2 droppers**
- **Candle/candle holder**
- **aluminum foil to make 6 containers to perform the heat test on each powder**
-

Step 2: Measure 1 gram of each powder and place them onto the waxed papers. Divide each powder into fourths to perform each test.

Step 3: Get Ready. Once you start your tests, you need to describe and write your observations in the chart on the Day 1 Data Collection Sheet. Get your Data Collection Sheet and a pencil ready to go. Look over the sheet so that you know where to record your observations in the chart in the appropriate column.

Step 4: <u>For testing with liquids (water, vinegar, or iodine):</u> Add 4 to 5 drops of the liquid to each pile and mix using a clean toothpick.
Caution: Goggles must be worn! IODINE WILL STAIN CLOTHING, HANDS, AND ANYTHING IT TOUCHES!

<u>For the heat test:</u> Using the aluminum foil, design and create 6 containers to hold each of your powders when heating. Hold the sample over the candle flame while performing this investigation.

Caution: Use care when working with heat! Long hair must be tied back. Sleeves must be rolled up. Keep papers and anything flammable away from the flame. Goggles must be worn!

Investigators: Remember to record your observations on your Data Collection Sheet.
PLEASE CLEAN UP YOUR AREA BEFORE YOU LEAVE!