Session 1

What Is Matter? Properties and Classification of Matter

What is matter? This question at first seems simple—matter is all around us. Yet how do we define it? What does a block of cheese have in common with the Moon? What are the characteristics of matter that set it apart from something that is *not* matter?

Matter is one of the big ideas in science. Most areas in physical science can be discussed and explained in terms of matter or energy, and matter is a subject that naturally bridges to the other sciences (chemistry, life, Earth science, etc.). In this session, we'll build a working definition of matter, learn to distinguish between its "accidental" and "essential" properties, and explore it through classification, an activity that has a rich history in science.

The Video

The video opens with a conversation among first and second graders and their teacher Joanie Grisham at the Fayerweather Street School in Cambridge, Massachusetts. After they sort through a variety of meanings for the word "matter," they begin to make a list of criteria that can be used to decide whether something is or is not matter.

The program continues as children are presented with a variety of phenomena and are asked to decide whether they are matter or "not matter." In what is called the "Science Studio," children in different grade levels are observed and interviewed in a clinical setting to uncover their ideas about these and other concepts throughout the course. While listening to Joanie's students' ideas and the ideas of the students in the Science Studio, we begin to build a working definition of matter, using a graphic organizer.

We then visit Dr. Alberto Martinez, a science historian at the Dibner Institute for the History of Science and Technology at the Massachusetts Institute of Technology (MIT). He points out the importance of classification in science and how it helps us make sense of the "wealth of experience that is available to us." Later Dr. Martinez traces our classification schemes for matter back to Aristotle's theory that everything is made up of earth, air, fire, and water, with each element behaving in a manner consistent with what he called its "natural place."

Then, children in the Science Studio apply *their* classification skills to a favorite form of matter—candy. We visit Boxborough, Massachusetts, where Cindy Plunkett leads her first graders in a lesson from the Science and Technology for Children (STC) curriculum, *Solids and Liquids*, in which they sort a variety of solids by their observable properties.

We continue with a visit to another classroom, this time in Salem, Massachusetts, where Chris Bash's fourth and fifth graders explore a "mystery substance" that challenges our working definitions of solids and liquids.

The video ends with a visit to the MIT Plasma Science and Fusion Center where plasma physicist Bob Granetz and his colleagues apply temperatures hotter than the Sun to hydrogen gas to create a fourth state of matter, plasma, which makes up 99% of our universe.

Learning Goals

During this session, you will have an opportunity to build understandings to help you:

- Recognize the criteria that make something "matter"
- Differentiate between essential and accidental properties of matter
- Understand some of the history behind the classification of matter
- Begin to build a model that differentiates between solids, liquids, and gases

On-Site Activities

Getting Ready (60 minutes)

Activity One—Track Your Understanding (30 minutes)

One way to assess your own learning at the end of this course is to start by documenting what you know now. The following are questions related to the physical science concepts being addressed during this course. Answer them as best you can—this is not a test! At the final session, you'll be able to track how your understanding has changed.

Facilitators: Please collect participants' answers and bring them to Session 8.

Physical Science Questions

1. What distinguishes something that is matter from something that is not matter?
2. What criteria would you use to distinguish between a solid, liquid, and gas? Are these the only states of matter? Explain your answer.
3. Is it possible to subdivide a piece of solid matter infinitely (e.g., a piece of aluminum foil)? Why or why not?
4. On a particle level, what are the differences between the states of matter?
5. What is the difference between a physical change and a chemical change? Give some examples of each.
6. Where does water go when it evaporates?
7. What is the difference between melting and dissolving?
8. What is meant by the statement "Matter cannot be created or destroyed"?
9. Explain the difference between boiling and burning.
10. Complete the following: Atom is to element as molecule is to _____.
11. Distinguish between the concepts of volume, weight, and density.
12. What does matter of different densities look like on the particle level?
13. What factors determine whether an object rises or sinks in water? In other liquids?
14. Explain the concept of "buoyancy."
15. What effect does heat have on solids, liquids, and gases? Explain your answer.
16. Describe the relationship between heat and temperature.

Activity Two—Matter or Not? Solid, Liquid, or Gas? (30 minutes)

1. Working alone, write a definition of "matter."

Facilitators: Distribute assorted candies to participants.

2. Choose a sorting scheme for the candy. Sort them into groups and then ask a partner to guess the scheme by looking at the groupings. Share and discuss your schemes with the whole group. How many different kinds of criteria were used to sort the candies?
3. With a partner, discuss what makes something a solid, a liquid, or a gas. Look around the room and point out examples of each state of matter. Record the criteria you are using to distinguish among the states of matter. As a whole group, compare how you defined each state of matter and discuss the criteria that are most important in your classification scheme.

On-Site Activities, cont'd.

Watch the Video (60 minutes)

As you view the video, think about the following focus questions:

1. What two criteria for defining matter are presented in the video?
2. As you watch Cindy Plunkett's class work with different solids, listen to the properties on which they base their classification schemes. According to Aristotle, are they focusing on the solid's accidental or essential properties?
3. The children in the Science Studio reason aloud as they define solids, liquids, and gases. How do their definitions compare with your own?

Going Further (60 minutes)

1. After viewing the video, join your partner and revisit your definitions of matter. Together, revise your ideas and write new definitions. Talk about how, if at all, your thinking about the question "What is matter?" has changed.
2. As a whole group, discuss whether the examples presented in the video are adequate for distinguishing accidental from essential properties of matter. What are some additional examples of each?
3. With the group, compare some of the ideas that your students have about solids, liquids, and gases. Which seem to be the most challenging to address? Why?

   Facilitators: Distribute the mystery substance you prepared for today's session.

4. With a partner, explore the "mystery substance," and discuss where you think it belongs in the video's graphic organizer that classifies solids, liquids, and gases by their properties. What makes it a useful substance for challenging students' classification skills? Can you think of other substances that your students might find difficult to classify?
5. With a partner, discuss what questions you still have about matter. Record your work.

Between Sessions

Homework

All participants should complete assignments marked by the *.

About the Reading Assignments

The reading assignments for this course are meant to expose you to the research literature on children's ideas about physical science, as well as to encourage you to compare your ideas to those of your students. Do you hold some of the same ideas represented in the readings? Are there ideas expressed that you understand to be scientifically inaccurate, but are not sure why? Asking these questions of yourself as you read can help you assess your own content knowledge.

In some cases, there will be a specific homework task associated with a reading. In all cases, you will have an opportunity to discuss the assigned readings at the next session.

Unless otherwise noted, the assigned readings are available in the Appendix.

* Reading Assignment

Nussbaum, Joseph (1993). "Teaching about Vacuum and Particles, Why, When and How: A research report." *Proceedings of the Third International Seminar Misconceptions and Educational Strategies in Science and Mathematics, Vol. I.* J. Novak. Ithaca, Cornell University.

As you read, reflect on the history of the development of a particle model of matter and how elementary school students' imaginations can be starting places for discussions about the microscopic explanation for macroscopic behaviors.

About Guided Journal Entries

As you proceed through this course, one way of constructing meanings and connecting understandings is through written reflection. As part of each session's homework, a question or situation will be proposed to guide a journal entry. At the end of the course, these entries should help you see how your ideas have progressed.

Guided Journal Entry

Aristotle's theory of four elements held sway for over a thousand years. Explain your understanding of this theory. What properties or behaviors of matter can you think of that aren't convincingly explained by this theory? What are the contemporary correlates to Aristotle's elements?

About the Channel-Talk Posting

Although this is a course designed to help enhance your understandings of physical science concepts, the intention is for you to use this knowledge to inform your teaching. Often, a community of learners who are also teachers can collaborate to support one another in transforming content knowledge into successful classroom action. In each session, one or more questions will be suggested to guide a discussion on Channel-Talk to facilitate this type of collaboration among participants.

Guided Channel-TalkPhysicalSci Posting

The answer to the question "What is matter?" has applications at many grade levels. In this Channel-TalkPhysicalSci posting, discuss how this question applies to the science curriculum in your classroom.

Between Sessions, cont'd.

Textbook Reading Suggestions

The following are suggestions for several reading topics that may provide additional background and enrichment information. These topics are likely to be addressed in any college-level physics textbook, and can usually be located in some form in the table of contents and/or index.

- Properties of matter
- Solids
- Liquids
- Gases and plasmas

* Preparing for the Next Session

For "Getting Ready"

Starting with the next session, we're going to look at how matter is classified from the microscopic scale to the macroscopic scale. Think about the smallest piece of the tip of a pencil you can imagine. What would it look like at this scale?

Materials Needed for Next Time

- Roll of aluminum foil
- Scissors
- Tweezers
- Magnifying glasses
- Large plastic syringe or empty jar with a lid
- Small water dropper
- Beaker, drinking glass, or clear plastic cup
- Food coloring