Lesson 2-3
What happens to materials that we can't see anymore?

Lesson Overview

1. Timeframe: 2 class periods

2. Learning Performances
   Students develop models of matter to describe that solid and liquid matter is made of particles too small to see.

   SEP *Developing and using models:* *Develop and/or use models to describe and/or predict phenomena.*

   DCI *PS1.A:* *Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means.*

   DCI *PS1.A:* *Measurements of a variety of properties can be used to identify materials.*

   CCC *Energy and matter – flows, cycles, and conservation:* *Matter is made of particles.*

3. Overview
   This lesson introduces students to scientists' model of matter as made of particles too small to see. The lesson establishes the idea that matter is made of particles.

   Day 1
   - Students complete Investigation 2-3: Sugar and Water, mixing solid sugar with liquid water.
   - Students develop an individual model of mixing solids and liquids in their SEN.
   - Teacher introduces scientists' model of matter as made up of particles too small to see.

   Day 2
   - Through a class demonstration, students model that matter is made of particles.
   - Groups develop and share Model: Solids and Liquids (on paper) to represent that solids and liquids are made of particles too small to see.
   - Students revise their individual models in their SEN.

Materials

For each student:	**For each group:**
○ 1 Science and engineering notebook (SEN)	○ 1 Electronic scale ○ 1 Graduated cylinder

○ 1 Pencil ○ 1 Copy of Article: *What is Matter Made of?* ○ 1 Copy of Investigation 2-3: Sugar and Water (Day 1)	○ 1 Plastic spoon ○ 2 Clear plastic cups (any size, approx. 10 oz) ○ Sugar (1 spoonful) ○ 1 Water supply cup (filled with water) ○ 2 Permanent markers (different colors) ○ 1 Sheet of paper

For the class:
- Water supply
- Masking tape
- Video Lesson 2-3: Particles (Day 1)

Introducing the Lesson

Predicting and Communicating if Matter Exists

Say, *Our driving question is, What happens to our garbage? The landfill is full of many materials and we wonder what will happen to those materials over time. We observed that some materials get crushed. Some of our questions about garbage materials were answered in a few investigations. We found out that even when we crush some materials, their matter is conserved and does not disappear.*

CLASS CHECK! Conservation of Matter Follow-up

Use student responses to connect to a new sub-question. *Last class, we answered the question on our DQ Board, What happens to materials when they are crushed in a landfill? We tested solid materials like paper, plastic, and soda cans. We collected data and argued that crushing and tearing does not change the type or the amount of material. We also completed a SEN entry in which we wrote our ideas about what happens to materials when we can't see them anymore. Many of you had different ideas. It seems like we have a new question, What happens to materials when we can't see them anymore?*

Carrying Out the Lesson

Investigating "Disappearing" Materials

Direct students to take out Investigation 2-3: Sugar and Water. Describe the investigation. *Our purpose is to investigate what happens to materials when we can't see them anymore. In our investigation, we will mix solid sugar with liquid water.*

- Review procedures for operating the electronic scale.
- Guide the class through the procedures in Investigation 2-3: Sugar and Water.
- Give students time to complete Investigation 2-3: Sugar and Water.

After groups have recorded observations, ask, *Did anything surprise you?* (Student responses will vary, but many students will be surprised that the volume stayed approximately the same.)

Direct groups to answer the questions in Investigation 2-3: Sugar and Water.

SMALL GROUP CHECK! Sugar and Water Particles

Guide groups in thinking about particles:

- *When you mixed the sugar into the water, where did the sugar go?* (The sugar dissolved or mixed in the water.)
- *Does that mean the sugar ceased to exist?* (No, just because I can't see the sugar doesn't mean it is not there. You cannot see the sugar, but maybe you can find out if the sugar parts that are too small to see are still in the water.)
- *What further evidence could you find that shows the sugar is still in the water?* (We can taste the water. If it's sweet, the sugar is still there. The weight of the water mixed with sugar is equal to that of the sugar and water separately. The weight tells us that all the sugar and all the water are still there in the final mixture.)

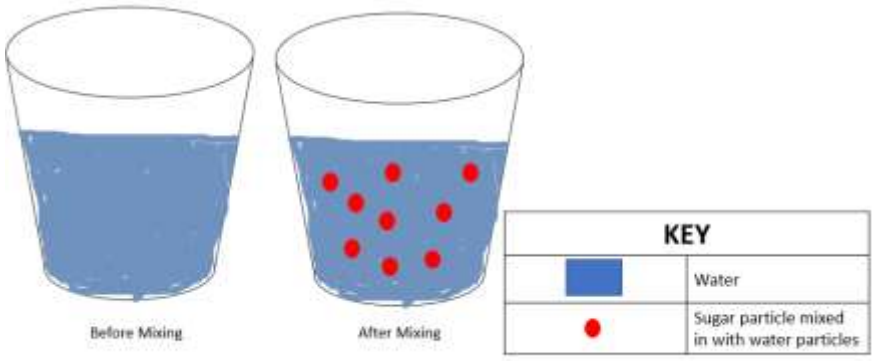
Review evidence from the investigation:

1. The weight of the mixture. The final weight of the mixture equals the initial weight of the sugar and water. The weight tells us that all the sugar and all the water are still there in the final mixture.
2. The taste of the mixture. Tell students that since we do not taste our experiments in science, you have prepared a separate sample of the mixture that someone can drink. Call on a volunteer to sample a cup of water and sugar you have prepared in advance to verify that the mixture is sweet.

SEN Entry: Modeling Solid and Liquid Matter

Students develop an individual model in their SEN to describe both solid and liquid matter as they mix together. Direct students to think about the model if they had a very powerful microscope that could show the details of the sugar and the water. Say, *Write down how your model describes what you observed in the investigation.*

Sample student model:



Teacher Introduction: Obtaining Information About Scientists' Model of Matter

Describe that scientists have also developed models of what happens to matter when it is divided into smaller and smaller pieces, or when different types of matter, such as solids and liquids, are mixed together. Elicit students' prior knowledge about solids and liquids. *What observations did you observe about the solid sugar we mixed with the liquid water? How are they similar and how are they different? Let's read more about scientists' model of solids and liquids.* Direct students to read Article: *What is Matter Made of?*

After students have read the Article: *What is Matter Made of?* call on students to share what information they obtained and their reactions to the article.

Guide students to think about matter as made up of particles that are too small to see. Say, *Scientists have studied matter for over a century and tested their ideas using very complicated technology. Scientists developed and tested the model that all matter is made of very, very tiny pieces or particles.*

These particles are too small to see with your eye, or even with a very powerful microscope. In fact, scientists have to use special tools and indirect measurements to show that matter is made of these very small pieces or particles. It took a lot of evidence to develop this idea that matter is made of very, very small particles, because when you look around, all matter appears to be made of a blob, or a whiff, or a splash, or a lump of material.

It's hard to believe that our world and everything in the universe itself is made of these little particles, everything from the sun to the paper we tore up.

Teacher Background: Building Progression for Particle Nature of Matter

From the K-2 grade band, students may be familiar with the ideas that solids and liquids are types of matter, and that many objects are made up of smaller pieces. This lesson builds on this idea, adding that all matter can be subdivided into smaller pieces call particles. The particles are too small to see. Even if we cannot see the particles of matter, the particles can be detected by weighing materials. That is, even though the sugar appears to disappear when mixed with water, we know the particles of matter are still present because of the weight.

The focus of this lesson is on solid and liquid matter. Gas matter, as made of particles too small to see, is emphasized in Lesson 3-2.

Using a Physical Model as an Analogy that Matter is Made of Particles

Continue the discussion with a demonstration.

Describe the investigation with a dramatic surprise of the volume data, *We observed that the sugar and water mixed together. We were surprised to find that the volume after mixing sugar and water was only slightly more than the initial volume of water before the sugar was added. How is that possible? We know that matter was conserved after mixing.*

If needed, review conservation of matter.

Let's model this mixing to show what is happening if we could see the particles. We are going to use a physical model for the particles of matter. The physical model describes how liquids and solids are made of particles too small to see.

In this physical model, each ping pong ball represents a particle of water that is too small to see. Each marble represents a particle of sugar that is too small to see. Remember that even though you can see the ping pong balls and marbles, you should think that in matter, the particles are too small to see.

Show Video Lesson 2-3: Particles. At the beginning of the video, remind students that we are imagining that we see the particles of water and the particles of sugar in this physical model demonstration. Tell students that you will be pausing the video to ask questions about what they are observing.

Pause the video when cued for students to answer the questions:

- When some marbles have been added, pause the video and ask, *What happened to the volume?*
- When more marbles have been added, pause the video. You can make this dramatic by acting surprised at how many marbles can be added. Students will observe that the total volume as indicated by the level of the liquid, i.e., marbles, does not change.

- Ask, *Where do the marbles go?* (The marbles fit into the spaces around the ping pong balls.)

Invite students to imagine that the ping pong balls are water particles and the marbles are sugar particles. *What does this model show us about particles?* (The particles can be in the same space together.) *Why?* (Because there are spaces between the particles).

Direct students to talk in groups, *How does the physical model using ping pong balls and marbles help you understand how the sugar particles could be added to the water particles without changing the volume of the liquid?* (The marbles can fit in between the ping pong balls. The marbles move past the ping pong balls and fill in the spaces. In our sugar and water investigation, the particles are too small to see, but the particles do the same thing as the physical model in the video demonstration.)

Call on a few volunteers to summarize their group's answer to the question.

Describe how the model helps us understand the sugar and water investigation results. *In our investigation, the sugar mixed with the water, but the volume did not change by very much. By modeling matter as made of particles too small to see, the physical model demonstrated how it is possible for the volume to remain the same after mixing solids and liquids.*

Break – end of class period 1

Resume during the next class period:

Modeling Solids and Liquids with Our Bodies

Tell students that they are going to use a model to describe the behavior of the solid sugar mixing with liquid water. This time, each student will represent a particle.

To prepare, make a square out of tape on the floor. Tell students, *The tape on the floor represents the cup from the physical model during last class.*

Describe the task for students in groups, *Your group will plan a demonstration to describe what the mixing of liquid water and solid sugar would look like if we could see the individual particles.*

- Some students are liquid particles already in the cup. *Think about how the liquid particles moved when we mixed sugar and water. Think about how the liquid particles interacted with each other and with the sides of the cup. How would you move to be like a liquid particle?*
- Some students are solid particles entering the cup. *Think about how the solid particles moved when we mixed sugar and water. Think about how the particles interacted with each other. How would you move to be like a solid particle?*

Be sure to answer these questions in your demonstration:

- How will the audience know which particle is which? (boys vs. girls, labels on the particles, liquids on tip toe vs solids squatting)
- How will the particles move? (liquid particles move freely while solid particles stick together, solid particles move between liquid particles)

Tell the class, *When your group is ready, you will demonstrate to the class.* Circulate between the groups, asking clarifying questions about the groups' plans. Guide groups to think in terms of solids and liquids made of particles too small to see.

Possible teacher prompts:

- *Can you demonstrate what the solid sugar particles look like in the cup before mixing? How do they move?*
- *Can you demonstrate what the liquid water particles look like in the cup before mixing? What do the particles look like if I swirl the cup?*
- *Can you demonstrate what the particles look like when we mix sugar and water? When we mixed sugar and water in the investigation, it looked like the sugar disappeared. In our model, I notice that all of the sugar particles are still here. What does that tell you about what happened to the sugar when we mixed it with water?*

Guide students to think about the limitations of the physical model. Ask, *How is the physical model similar to and different from scientists' model of particles?* (The model is similar because both solids and liquids are represented by particles. The model is different because matter is made up of a lot of particles, but the physical model only represents a few of them.)

Conclude the physical model by summarizing, *You made a physical model of an important scientific idea. Scientists developed and tested the scientific idea that all matter is made of very, very tiny pieces or particles.*

Developing and Sharing Group Model: Solid and Liquid

Describe, *We wondered what would happen if we kept tearing a piece of paper into smaller and smaller pieces. We investigated mixing a solid and a liquid to help us understand the scientific idea that solids and liquids are made of particles. Let's apply this new idea to a piece of paper or a liquid in a landfill. How would that look if we could see it really closely?*

Tell students that using the "pass the marker" strategy (add one thing to the model; if you have the marker you are not talking), they will work in groups to develop group models of liquids and solids based on the physical models from the previous class:

- Physical model features of ping pong balls and marbles representing particles of liquids and solids.
- Investigation of mixing solid sugar and liquid water with slight volume change.

Pass out paper. Direct the groups to develop a model that represents what we would see if we could look inside a liquid and a solid with special tools much more powerful than a typical microscope. Remind students that scientists have used such tools to figure out that the particles that make up matter are much smaller than anything we can see with a typical microscope.

SMALL GROUP CHECK! Modeling Solids and Liquids as Particles

As groups work, meet with each group and reinforce through your questions to the group:

1. Expectations for the features of a model, including key, symbols (e.g., lines, arrows), and writing (e.g., labels, sentences).
2. Expectations for group work (i.e., all students participate meaningfully and contribute to the group work).

3. Connections between observations of the physical model using ping pong balls and the group model.

Possible teacher prompts to guide student thinking:

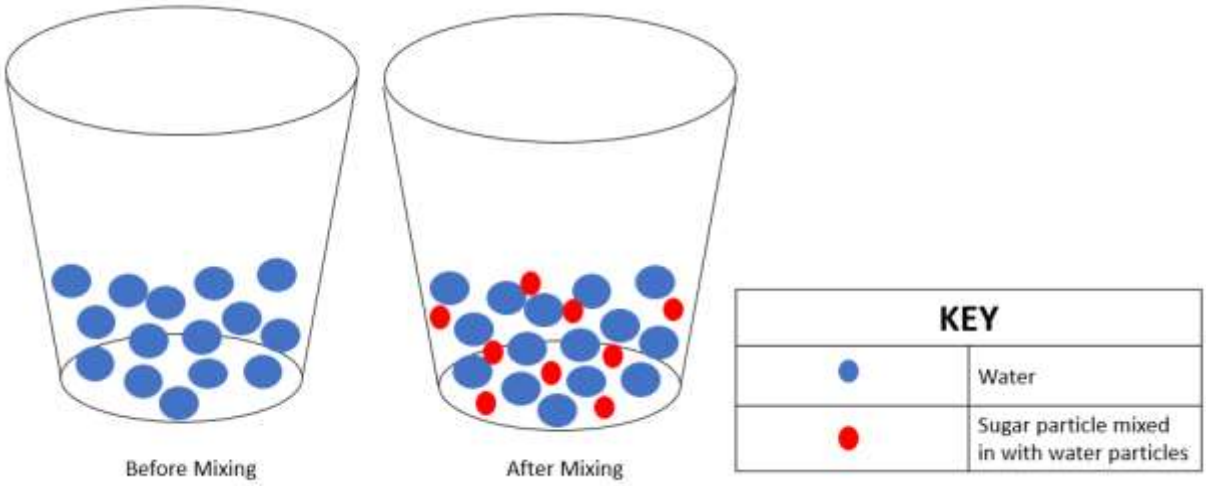
- *How does your model show that both solids and liquids are made of particles?*
- *How are the sugar and water particles interacting in your model?*
- *Why can't we see the sugar and water particles?*

Possible teacher prompts to EXTEND student thinking:

- *How would you model the zoomed-in version of your desk? Your book? Juice?*
- *Are there other things that are made of particles, in addition to solids and liquids?*

Call on groups to share their models with the class. Direct groups to use their models to share their thinking about liquids and solids as made of particles.

Possible group model: Solid and Liquid



SEN Entry: Revising Individual Model

CLASS CHECK! Modeling Solids and Liquids as Particles

Say, *Scientists revise their models as their thinking changes. You may revise your model with any new ideas you have after doing the investigations. What additions or changes will you make to your individual model? In your SEN, revise your individual model of solids and liquids from last class.*

Collect SENs and check the extent to which students' models represent the particle nature of matter (e.g., use dots instead of waves). You will use this information to review particle nature of solids and liquids when the particle nature of gas is introduced in Lesson 3-2.

Closing the Lesson

Connecting to the Next Question

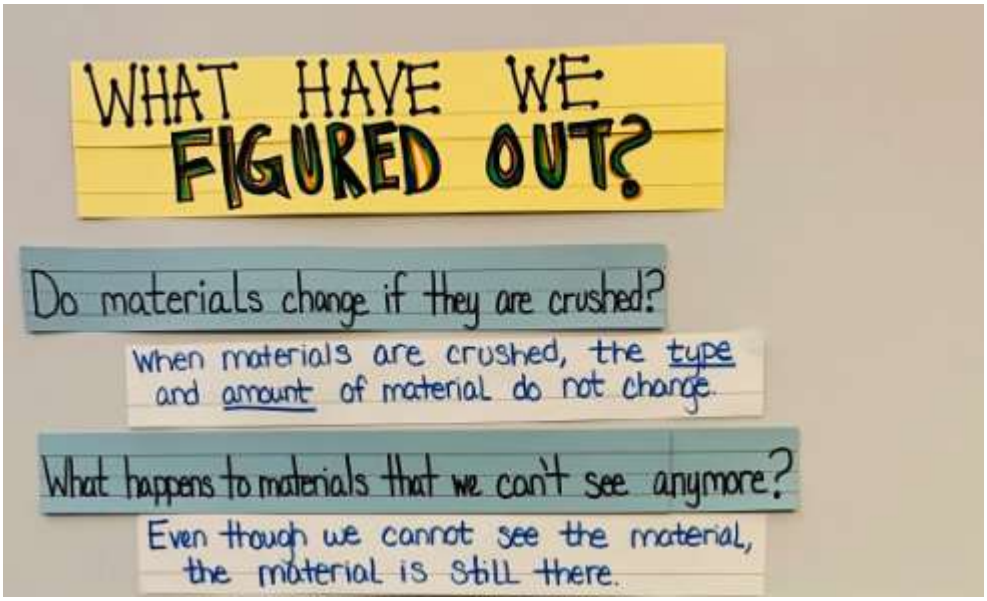
Ask, *Can we apply our new understanding that matter is made of particles too small to see? Are the materials in a landfill made of particles too small to see? Are the materials we placed in our landfill bottles made of particles too small to see?*

What happens when materials get torn up into really small pieces in a landfill? Do they disappear then? (No, materials are made of very tiny particles. Even when they seem to disappear, the tiny particles still exist).

Inform students that next class they will be observing and weighing the landfill bottles again.

Tracking What We Figured Out (optional)

Guide students to think about the sub-question of the lesson and what they have figured out so far. Create a class visual display using their responses. In addition to the class visual display, students may complete the individual graphic organizers (located in Lesson 2-2). Students can add to their graphic organizers after each lesson.



Evidence Statements 2-3

LP2-3 ES

- Students develop models of solid and liquid matter to describe that matter is made of particles too small to see.

LP2-3 ES

- Students use models of matter as made of particles too small to see in order to describe and explain observed similarities and differences between solids and liquids. Both solids and liquids are made of particles, but the particles of solids are held together while the particles of liquids have larger spaces between them.

Connections to Targeted 5th Grade NGSS Performance Expectations

5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-3 Make observations and measurements to identify materials based on their properties.

Building Progressions

SEP *Developing and using models:* *Develop and/or use models to describe and/or predict phenomena.*

K-2: Develop a simple model based on evidence to represent a proposed object or tool.

3-5: *Develop and/or use models to describe and/or predict phenomena.*

Middle School: Develop a model to describe unobservable mechanisms. Develop a model to describe phenomena.

DCI *PS1.A:* *Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. Measurements of a variety of properties can be used to identify materials.*

K-2: Different kinds of matter exist and many of them can be either solid or liquid, depending on the temperature. Matter can be described and classified by its observable properties. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces.

3-5: *Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. Measurements of a variety of properties can be used to identify materials.*

Middle School: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to

thousands of atoms. Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

CCC *Energy and matter – flows, cycles, and conservation:* *Matter is made of particles.*

K-2: Objects may break into smaller pieces and be put together into larger pieces, or change shape.

3-5: *Matter is made of particles.*

Middle School: Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. The transfer of energy can be tracked as energy flows through a designed or natural system.

Connections to CCSS for English Language Arts-Literacy

W.5.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

SL.5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher- led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.

SL.5.1.C: Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.

L.5.6: Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships (e.g., however, although, nevertheless, similarly, moreover, in addition).

Connection to CCSS for Mathematics

5.NBT.3.B: Compare two decimals to thousandths based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.

MP1: Make sense of problems and persevere in solving them.

MP2: Reason abstractly and quantitatively.

Name: _____ Date: _____

Investigation 2-3: Sugar and Water

Investigation plan		✓
1	Gather materials for the group: ☐ 1 Electronic scale ☐ 1 Graduated cylinder ☐ 2 Clear plastic cups (any size, approx. 10 oz) ○ 1 Water cup ○ 1 Sugar cup ☐ 1 Water supply ☐ 1 Spoon ☐ Sugar (1 Spoonful) ☐ 2 Permanent markers, different colors (Color 1 and Color 2)	
2	Prepare the water cup: ☐ Weigh the empty water cup on the electronic scale: ○ Place the scale on a flat surface. ○ Press the power button to turn on the scale.  ○ Make sure the scale unit is in grams (using the kg/lb button).  ○ Place the empty water cup on the scale. ○ Calibrate the scale by pressing the “0.0 TARE” button.  ☐ Carefully pour 50 mL of water from the water supply into the graduated cylinder. ☐ Pour the 50 mL of water from the graduated cylinder into the water cup. Weigh the cup with water, and record the weight in the investigation table. 	

	☐ Place the water cup on a flat surface. Look at the water cup at eye level, and draw a small line at the top of the water level with a permanent marker (Color 1). 	
3	Prepare the sugar cup: ☐ Weigh the empty sugar cup on the electronic scale: ○ Place the scale on a flat surface. ○ Press the power button to turn on the scale.  ○ Make sure the scale unit is in grams (using the kg/lb button).  ○ Place the empty sugar cup on the scale. ○ Calibrate the scale by pressing the “0.0 TARE” button.  ☐ Measure 1 spoonful of sugar, and carefully pour the spoonful of sugar into the sugar cup. ☐ Weigh the sugar cup, and record the weight in the investigation table.	
4	Carefully pour all the sugar from the sugar cup into the water cup. Use the spoon to help get all the sugar out. 	

5	Mix the sugar with the water: □ Carefully mix the water and sugar together with the spoon until the sugar is dissolved (can no longer see the sugar). □ Weigh the cup with water and sugar after the sugar is dissolved. Record the weight in the investigation table. □ Look at the cup of water and sugar at eye level, and mark the top of the liquid with a permanent marker (Color 2).	
6	Record your observations below.	

Investigation Table:

Material	Weight (grams)
Sugar	
Water	
Mixture of sugar and water	

Investigation Questions:

1. What did you observe about the solid sugar as you mixed it with the liquid water?

   _____

   _____

   _____

   _____

2. Compare the weight of the sugar and water (before mixing) to the weight of the mixture of sugar and water (after mixing).

   _____

   _____

   _____

   _____

3. Compare the volume of water before mixing to the volume after mixing sugar and water.

_____

_____

_____

_____

4. Did the sugar disappear when you mixed it with the water? How do you know?

_____

_____

_____

_____

Investigation 2-3 ANSWER KEY

Investigation Questions:

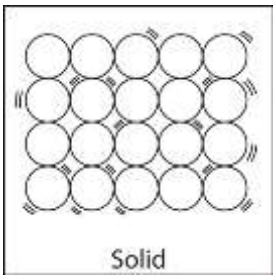
1. What did you observe about the solid sugar as you mixed it with the liquid water?
   When we mixed the sugar with the water, I couldn't see the sugar anymore.
2. Compare the weight of the sugar and water (before mixing) to the weight of the mixture of sugar and water (after mixing).
   The weight of the sugar and water before mixing is the same as the weight of the sugar and water after mixing.
3. Compare the volume of water before mixing to the volume after mixing sugar and water.
   The volume slightly increased after mixing the sugar and water, but the increase was smaller than I thought it would be.
4. Did the sugar disappear when you mixed it with the water? How do you know?
   No, the sugar did not disappear when I mixed it with the water. I know this because the weight stayed the same before and after mixing, and the sugar water tasted sweet. The volume also slightly increased after mixing.

Article: What is Matter Made of?

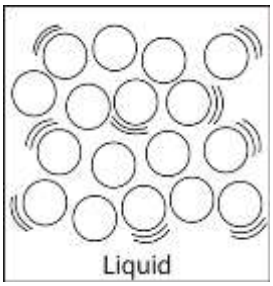
Scientists have studied matter for over 100 years! They tested their ideas using very complicated technology. Scientists developed and tested the model that all matter is made of very, very tiny pieces or particles.

These particles are too small to see with your eye, or even with a very powerful microscope. In fact, scientists have to use special tools to show that matter is made of these very small particles. It took a lot of evidence to develop this scientific idea that matter is made of particles, because when you look around, matter appears to be made of solids or liquids.

Take a look at your desk.[1] Looking just with your eyes, the desk looks like a solid that could not be broken down into smaller pieces. If you could use a very powerful microscope, you would see that the desk is made up of tiny particles.



A glass of water might look like a continuous blob, but it is also made of tiny particles. If you could use a very powerful microscope, you would see that liquids like water are made of particles that are too small to see.[2]



It's hard to believe that our world and everything in the universe are made of these little particles, everything from the sun to paper to orange juice.

[1] Desk image from https://www.globalindustrial.com/c/office/desks/school

[2] http://2.bp.blogspot.com/-S0vzGF356FM/Vn-n_1RxifI/AAAAAAAAAxQ/Hmy_zRv3nsc/s1600/liquid.jpg