**Lesson 2 – Modeling Matter on the Molecular Level**

**Storyline Summary:**

Through discussion around their initial Lava Lamp models, students have discovered that they need to know more about what is in the Lava Lamp in order to explain how it works. Help students realize that when they are trying to understand more about the blob in the Lava Lamp, at a very basic level, the question they are asking from the DQB, is: What is stuff made of, or “What is matter?”

To begin their investigation into the Lava Lamp, students explore the properties of solids, liquids, and gases. Based on their observations, students conclude that matter is made of particles that are too small to see and always in motion.

**Note:** This lesson covers an activity exploring the attraction and motion of water molecules, as well as modeling the arrangement and motion of particles in solids, liquids, and gases. Depending on the amount of time devoted to the activity, class discussion, and student work on the activity sheet, this lesson will probably take more than one class period.

**What Students Do**

Students experiment with drops of water on wax paper to develop a particle-level model of a liquid. Students then view and analyze particle-level models of solids and gases. Students use dots or circles with motion lines to model a liquid, a solid, and a gas and eventually apply this type of model to the blob-like substance in the Lava Lamp.

**What Students Learn**

* All matter is made of particles called atoms and molecules.
* Solids, liquids, and gases are all matter and are all made up of atoms and molecules that are in motion.
* Solids, liquids, and gases can be modeled on the molecular level.

**Materials & Preparation:**

* [DQB (Driving Question Board)](https://docs.google.com/document/d/194x-ZuWD8U4XH53Uzpk34zayY-MsPZtk/edit?usp=sharing&ouid=113322496769338911004&rtpof=true&sd=true) Organized into topics such as matter, mass, volume, density, floating and sinking, phase change, heat energy, and heat transfer.

**Materials for Each Group**

* Water in small cup
* Dropper
* 2 popsicle sticks
* Wax paper
* 2 large index cards (5 × 8”)
* Tape

**Materials for the Demonstration**

* Tall, clear plastic cup
* Water (room temperature)
* White sheet of paper
* Food coloring (red, blue, or green)

**1. Return to the DQB to review student questions about the substance that makes up the blobs in the Lava Lamp.**

Before class begins, group student questions into categories such as states of matter, heat transfer, phase change, mass, volume, density, rising and sinking, and the particle nature of matter (atoms and molecules in liquids, gases, and solids).

Start class with the Lava Lamp operating for students to refer to during class discussion. Show students the newly arranged DQB and explain that you have taken their questions and ideas and grouped them into “categories”. Point out that they have come up with a great list of questions and that the class will work together to decide which questions and what new questions will need to be explored as a piece of the larger question: “How does a lava lamp work?”

Ask students where they think they should begin - with questions about rising and sinking, the light, the “stuff”, why the “stuff” breaks apart and comes together? Allowing students to help guide the investigation will encourage them to share their ideas and questions.

As you lead the class discussion, refer to “Talk Moves” to deepen the discussion, responding to students with questions. For example, if a student shares that we should start by learning why the blobs rise and sink you might ask follow up questions like: “Who else thinks this is a good place to start?”, “Why/why not is this a best place to start our investigation?” or “What else do you think we might need to know about to understand the rising and sinking motion?”

**During the discussion, guide students to agree that understanding more about the blob material in the Lava Lamp is the most important question to begin with.**

Once in agreement that the stuff that makes up the blobs inside the Lava Lamp is key to solving how it works, ask: "what is “stuff” anyway? What is it made from? Accept all ideas and then explain that they are going to explore what “stuff” or matter is so they can begin to answer more questions on the DQB and ultimately explain how a Lava Lamp works.

**2. Ask students whether the blob material in the Lava Lamp looks more like a solid, liquid, or gas.**

Students will probably say that the material looks kind of like a solid, soft solid, semi-solid, or a cross between a solid and a liquid. Students may say that it might depend on whether the Lava Lamp is on or off. It looks more solid when off and more liquid when on.

Tell students that they will first investigate the properties of a liquid to better understand what liquids are made from and how they behave.

**3. During the lesson, check for understanding of modeling matter as little circles or dots with motion lines.**

As the lesson progresses, look at student drawings to be sure that representations of a solid, liquid, and gas show the relative distance between the particles and motion lines to indicate that the particles are in motion.

**4. Have students explore water and model the attraction and motion of water molecules.**

**Molecules Matter**

(From middle school chemistry, Chapter 1, Lesson 1)

***Key Concepts***

* Chemistry is the study of matter.
* Matter is made up of extremely tiny particles called atoms and molecules.
* Atoms and molecules make up the three common states of matter on Earth—solids, liquids, and gases.
* The particles of a liquid are attracted to one another, are in motion, and can move past one another.
* Being a solid, liquid, or gas is a property of a substance.

***Summary***

Students discuss the meaning of “chemistry” and “matter.” Students investigate a drop of water hanging from a dropper and drops of water beading up on wax paper. They also look at a molecular animation that models the motion of water molecules. Students are introduced to the idea that matter is made up of extremely tiny particles that are attracted to one another.

***Objective***

Students will describe their observations about water on the molecular level using the idea that water is composed of tiny molecules that are attracted to one another.

***Evaluation***

The activity sheet will serve as the “Evaluate” component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding.

***Safety***

Be sure you and the students wear properly fitting goggles.

***Materials for Each Group***

* Water in small cup
* Dropper
* 2 popsicle sticks
* Wax paper
* 2 large index cards (5 × 8”)
* Tape

***Materials for the Demonstration***

* Tall, clear plastic cup
* Water (room temperature)
* White sheet of paper
* Food coloring (red, blue, or green)

***Note****: Some solids, liquids, and gases are made of atoms, and some are made of molecules. Since the concepts covered in Chapter 1 apply to both atoms and molecules, the term “particle” is used as a generic term to include both. At this point, it is enough to give students simple working definitions of “atom” and “molecule.” You can tell students that an atom is the smallest building block of matter and that a molecule is two or more atoms connected together.*

# ENGAGE

# Have a discussion about matter.

Tell students that the blob material inside the Lava Lamp has to be some type of matter. Ask students for the three common types of matter on Earth (solid, liquid, and gas).

Ask students questions such as the following to guide their thinking:

## What are some examples of matter?

Tell students that matter is often defined as anything that has mass and takes up space. Continue the discussion by using water as an example.

## Does water have mass, and does it take up space?

A bucket of water is pretty heavy to lift. It definitely has mass. It also takes up space in the bucket. Since it has mass and takes up space, water is matter. But that’s just the very beginning. We want to look deeper and find out more about what matter is made of and how it acts. Eventually, this will help us explain how the Lava Lamp works.

## Give each student an activity sheet.

Students will record their observations and answer questions about the activity on the activity sheet. The *Explain It with Atoms & Molecules* and *Take It Further* sections of the activity sheet will either be completed as a class, in groups, or individually, depending on your instructions. Look at the teacher version of the activity sheet to find the questions and answers.

# EXPLORE

## 2. Do an activity to explore the attractions water molecules have for each other.

In this activity, students look closely at a drop of water and move drops of water on wax paper. They see that the water holds together well and is not so easy to separate. The goal is for students to begin thinking about water, or any substance, on the molecular level and to conclude that water molecules must be attracted to one another. The reason for these attractions will be dealt with in later chapters.

## Question to investigate

Does water hold together well or come apart easily?

## Materials for each group

* + Water in small cup
  + Dropper
  + 2 popsicle sticks
  + Wax paper
  + 2 large index cards (5 × 8")
  + Tape

## Teacher preparation

Cover a large index card with a piece of wax paper so that the wax paper completely covers the card. Tape the wax paper in place. Prepare two cards for each group.

**A person holding a dropper

Description automatically generatedProcedure**

1. Use the dropper to gently squeeze out a drop of water but try not to let the drop fall completely out of the dropper. See how far you can make the drop hang off the end of the dropper without the drop falling.
2. A cartoon of hands holding a piece of paper

   Description automatically generatedPlace 4 or 5 drops of water together on a piece of wax paper to make one medium size drop.
3. Gently tilt the wax paper in different directions so that the drop moves.
4. A hand holding a pen over a wooden surface

   Description automatically generatedUse a popsicle stick to slowly drag the drop around the wax paper a bit. Try using your popsicle stick to separate your drop into two.
5. A hand holding a stick

   Description automatically generatedUse your popsicle stick to move the drops near each other. Then move one drop so that the two drops touch.

## Record and discuss student observations.

Give students time after the activity to record their observations by answering the following questions on their activity sheet. Once they have answered the questions, discuss their observations as a whole group.

* + **When you squeezed the drop of water out of the dropper, did the water break apart or did it hold together?**
  + **When you tilted the wax paper, did the drop split apart or stay together?**
  + **When you were pulling the drop around the wax paper, did the water seem to hold together or come apart easily?**
  + **When you tried to split your drop, did the drop separate easily?**
  + **What happened when the two small drops touched?**

**Expected results**

The water beads up on the wax paper and stays together when the wax paper is tilted and when the drop is moved around with a straw. It is difficult to separate the drop into two drops. When the drops touch, they combine quickly and easily.

## Do a demonstration to show that water molecules are in motion.

**Materials**

* Tall, clear plastic cup
* Water (room temperature)
* White sheet of paper
* Food coloring (red, blue, or green)

## Procedure

1. Add water to the cup until it is about ¾ filled.
2. Ask students to watch closely as you add one or two drops of food coloring to the water. Do not stir. Instead, allow the color to slowly mix into the water on its own.
3. Hold the cup up with a sheet of white paper behind it so it is easier for students to see the color moving and mixing in the water.

## Expected results

The drops of food coloring will slowly move and mix into the water. Eventually all the water in the cup will be evenly colored.

Ask students:

## How do your observations support the idea that water molecules are moving?

Help students understand that the drop of coloring mixes into the water because the water molecules move and push the color in all directions. The molecules of the food coloring themselves are also in motion. Students will soon see an animation depicting this process.

# EXPLAIN

## Show an animation of the molecules in liquid water.

**Show the molecular model animation *Particles of a Liquid*.**

[www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html)

Explain that the little balls represent the particles of a liquid, in this case water molecules. Let students know that for now, they will use circles or spheres to represent atoms and molecules, but eventually they will use a more detailed model. For now, students should focus on the motion of the molecules, how they interact, and their distance from one another.

Point out that the molecules of a liquid are in motion, but they are attracted to each other. That’s why they move past each other but don’t get very far apart from one another.

**Show the molecular model animation *Food Coloring in Water***

[www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html)

Explain to students, or have students explain how the random motion of the water molecules moves the food coloring throughout the water.

## A group of circles with text Description automatically generatedHave students draw their own model of water on the molecular level and complete the activity sheet.

**Draw or project the illustration *Water Molecules*.**

[www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html)

Explain to students that this is a model of water molecules. Point out that the molecules are not in any exact order but are near each other. They have little curved “motion lines” to show that the molecules are moving.

Have students draw a model of water on the molecular level on their activity sheet. They should use the model you have shown them to guide their own drawing.

Students’ drawings should show that the molecules are:

* Randomly arranged
* Close together
* Moving

Be sure students realize that this model shows water molecules enormously bigger than they actually are. Not only are water molecules much smaller, but they are also much more numerous. A single drop of water is made up of more than a billion trillion extremely tiny water molecules.

To give students an idea of how small and numerous water molecules are, you could tell students the following: In about 1 tablespoon of water, there are about 600 billion trillion water molecules. If you could count 1 million water molecules every second, it would take about 200 million centuries (20 billion years) to count all the molecules in that tablespoon of water. Atoms and molecules are huge in number and incredibly small in size.

# EXTEND

## Show a video so that students can see an example that water molecules are attracted to one another.

**Show a video of a water balloon popping in slow motion.**

[www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html](http://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson1.html)

Ask students:

* **Why do you think the water keeps its shape the moment the balloon is popped?**

Students should realize that water holds together pretty well because the water molecules are attracted to each other.

## Imagine a drop of water hanging from your finger. How is this similar to the water staying together after the balloon is popped?

This can also be explained by the fact that water molecules are very attracted to each other.

Explain to students that the attraction between molecules of the same substance for each other, like what they observed in water, is called “cohesion”. Have a class discussion about how cohesion might apply to the stuff that makes up the blobs in the Lava Lamp.

Students will probably say that the blobs seem to be attracted to each other and stick together like water. They should notice that the pulling apart and coming together is a continuing pattern in the lamp.

**EXPLAIN**

1. **Discuss whether the blob material in the Lava Lamp, when turned off, seems more solid or more liquid, or something in between.**

Students may decide that, before the Lava Lamp is turned on and heated enough, the blob material seems kind of like a soft solid, like butter, wax, or soap.

**Show students an animation of the** [**particles of a solid**](https://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson4.html#simulation141)**.**

Have students make a drawing of the particles of a solid. Be sure students notice the differences between the particles of a solid and a liquid and show those differences in their drawings.

**5. Show students that there is a little gas inside the top of the Lava Lamp so the class will also look at the particles of a gas.**

Carefully remove the top of the lamp and show students the small amount of air space above the liquid at the top of the lamp.

Discuss with students whether they believe that gas is matter and whether it is also made up of particles like liquids and solids.

**Show the molecular model animation** [**Particles of a Gas**](https://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson5.html#simulation153)**.**

Explain to students that the molecules of a gas are very far apart compared to the molecules in liquids and solids.

The particles of a gas have very little attraction for one another and barely interact with each other. They just collide and bounce off. It may be hard for students to accept, but in the space between the gas molecules there is nothing.

**Note:** An inquisitive student might ask: If gas molecules aren’t attracted to each other and can just float around, why don’t they all just float away? That is a very good question. In fact, very light gases like hydrogen and helium have floated away and there are very little of these gases in our atmosphere. Different heavier gases, such as nitrogen, oxygen, water vapor, and carbon dioxide, surround the Earth. In the big picture, gravity holds these gases near the Earth as our atmosphere.

**After you have showed the animation of the particles of a gas, you can also show the animation** [**Comparing Solids, Liquids, and Gases**](https://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson5.html#simulation155)**.**

Have students make a drawing of the particles of a solid, liquid, and gas.

**Note:** Be sure students realize that the molecules shown are from three different substances all at room temperature. The solid is not melting to become a liquid and the liquid is not evaporating to become a gas. The model is not trying to show state changes but instead show three different substances (such as metal, water, and air), which are solid, liquid, and gas at room temperature.

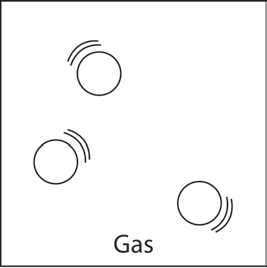
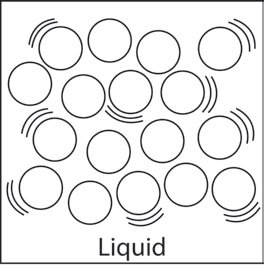
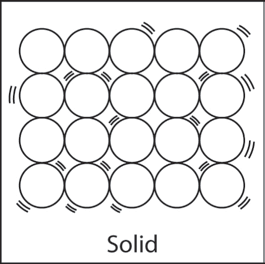
Explain the following differences to students:

* + **Solid**—Particles (atoms or molecules) are very attracted to one another. They vibrate but do not move past one another. The atoms or molecules stay in fixed positions because of their strong attractions for one another. A solid has a definite volume and a definite shape.
  + **Liquid**—Particles (atoms or molecules) are attracted to one another. They vibrate but are also able to move past one another. A liquid has a definite volume but does not have a definite shape.
  + **Gas**—Particles (atoms or molecules) are not attracted to each other much at all and move freely. A gas does not have a definite shape or volume. The atoms or molecules of a gas will spread out evenly to fill any container.

**6. Project the illustration *Solid, Liquid, and Gas.***

[www.acs.org/middleschoolchemistry/simulations/chapter1/lesson5.html](http://www.acs.org/middleschoolchemistry/simulations/chapter1/lesson5.html)

Have students use the projected illustration as a reference as they draw a model of solids, liquids, and gases on their activity sheet. Point out that the number of motion lines is the same for the solid, the liquid, and the gas. This indicates that the different substances are at the same temperature. Have students write captions like those listed below to describe the molecules in solids, liquids, and gases.



* Attractions strong enough to keep atoms in orderly arrangement
* Vibrate in fixed positions
* Definite volume and shape
* Attractions keep particles close together, but they can slide past each other

• Random arrangement

• Definite volume, not definite shape

* Attractions too weak to keep particles together

• Particles move independently

* No definite volume or shape

**EXTEND**

**7. Have a class discussion about whether the mass of the blobs might be important in how the Lava Lamp works.**

Since the blobs go up and down, students should agree that their mass or weight is important to know about.

Let students know that in the next lesson they will begin to explore the concept of mass and whether the mass of the blobs is important to the way the Lava Lamp works.