Demo: How Does Temperature Affect Water Molecules?

FOR THE TEACHER

Summary
In this demonstration, students will observe models to better understand that temperature affects molecular movements.

Grade Level
Elementary School

NGSS Alignment
This demonstration will help prepare your students to meet the performance expectations in the following standards:

- 5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.
- **Cross-Cutting Concept:** Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
- **Scientific and Engineering Practices:**
  - Analyzing and Interpreting Data
  - Engaging in Argument from Evidence

Objectives
By the end of this demonstration, students should be able to:

- explain how temperature is related to molecular movement
- provide evidence and explain what temperature measures

Chemistry Topics
This lesson supports students’ understanding of:

- Molecules
- Particle Motion
- Temperature

Time
**Teacher Preparation:** 10 minutes  
**Lesson:** 20 minutes

Materials

- three clear containers of equal size
- room temperature water
- ice water
- hot water
- food dye (yellow can be difficult to observe and won’t work well for this demonstration)
- alcohol-based thermometers, preferably in Celsius.

Safety

- Students should wear proper safety gear during chemistry demonstrations. Safety goggles are required.
- Use caution when handling hot water.
Teacher Notes

- This lab was modified from the original version, *What is Temperature?* for use specifically in the elementary school classroom. It was developed as part of the AACT Strategic Plan and the work of the AACT Grade-Level Ambassadors.
- The lesson shows the students that water is made of molecules and that those molecules move differently under different temperature conditions. This lesson fits well when introducing the concepts of heat/temperature, measurement using thermometers, and molecular movement. It reveals students’ preconceptions about temperature and heat, and challenges the idea that temperature is the measure of how hot or cold something is.
- This lesson should be split into two class periods if your class is not familiar with either how to use a thermometer and/or the concept of atoms and molecules.
- This lesson should guide students in learning that temperature is a measure of molecular movement and is not a measure of heat.
- This experiment works best when the ice water is very cold. If the water is not cold enough for a significant amount of condensation to form on the jar, then it can be hard to distinguish between the room temperature water and the cold water.
- A good way to get very cold water is to fill a large container completely full with ice and then add water. After letting the ice and water sit for several minutes, pour the water into the beaker or jar that you will use for the lab.
- For better viewing, you may want to gently wipe the condensation off the ice water beaker. Make sure not to disturb the water and dye in the beakers.

Procedure

Part 1

1. Prepare each container by putting cold water in one, room temperature water in the second, and hot water in the third.
2. Have students sketch the three containers. When sketches are complete, ask the students if there are any observable differences between the three containers. Students might mention steam coming off the hot water container. (Some students may talk about smoke. Be sure to clarify that it is water vapor and not smoke.) Students might mention the condensation on the outside of the cold container. Younger students may believe the container is leaking. Depending on students’ prior learning, you may or may not want to have a discussion about water vapor in the air.
3. Review how to use thermometers. Drawing a large thermometer on the board may be useful. If possible, pass out thermometers, allow the students to practice reading thermometers at room temperature and allow them to watch the readings rise as they hold the thermometers in their fists.
4. Place thermometers in the three containers. Record the results.
5. Ask students what the difference between each of the containers is. Ask them to define “hot”, “cold”, “room temperature”, or any other words they use such as “warm”. Ask the students what the thermometers are measuring. Accept answers and use them to guide your teaching in the second part of the lesson.

Part 2

1. Ask the students what happens when you mix water and food coloring. Discuss.
2. Have them review from their worksheets what they think will happen when you add the food dye to each of the three beakers. Will the temperature affect how the food dye mixes? If so, describe how.
3. Place 1 drop of food dye in each of the beakers. **NOTE:** Depending on the length of time the prior steps took, you may want to reheat the water and add more cold water from the ice bucket to the cold water.
4. Have students record their observations every second minute for 5 minutes (at zero minutes, 1 minute, 3 minutes, 5 minutes and 7 minutes). Do not disturb the containers!
5. Have students discuss their understanding of the different results for the different containers. Probe until they begin discussing what water is made of. Depending on the level of students, you may get more sophisticated answers such as H₂O, hydrogen and oxygen, or less sophisticated answers such as atoms and molecules. For the youngest students, you can introduce the idea that everything is made of tiny particles (pieces) that can’t be seen.
6. Continue discussion until students reach the idea that the molecules move at different speeds at different temperatures. Students should recognize that there is a direct correlation between temperature and molecular movement.
7. [Optional] Have the students record their observations again at the 20 or 30 minute point.

Expected Results
- The dye in the hot water, where particles had the quickest molecular motion, rapidly dispersed to create a uniform distribution throughout the beaker (the color was the same from top to bottom). The time this took might vary depending on how hot your water was, but should be within the first minute or two.
- The dye in the ice water, where particles had the slowest motion, started out by sinking to the bottom. The dye slowly mixed with some water, but the distribution was still very uneven at the 7-minute mark.
- In the room temperature water, some of the dye started out by sinking to the bottom. However, by 3 minutes, the dye was mixing with the water. By the 5 minute point, much of the dye was mixed, although the solution was not as uniform as the hot water solution.
- If you chose to have the students observe the reaction at the 20 or 30 minute point, all three beakers should be fully mixed and have a uniform concentration.

For the Student

Lesson

How Does Temperature Affect Water Molecules?

Part 1
Observe and sketch the three containers. Be prepared to discuss how they are similar and how they are different.

<table>
<thead>
<tr>
<th>Cold Water</th>
<th>Room Temperature Water</th>
<th>Hot Water</th>
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<tbody>
<tr>
<td>____ °C</td>
<td>____ °C</td>
<td>____ °C</td>
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Part 2
Background
Temperature is a measure of how hot or cold something is but the words hot and cold are not very scientific terms. Hot and cold are really just opinion words and, in science, we stick with facts we can measure or observe, like the numbers on a thermometer. All matter is made of particles - atoms or molecules - that are in constant motion. Because the particles are in constant motion, they have energy. The faster the particles are moving, the more energy they have. What does temperature have to do with energy? The
more energy the particles of an object have, the higher the temperature of the object. The higher the temperature, the faster the molecules of the substance move. Confusing? Let’s do this experiment to see if we can help it make sense.

**Question**
What will happen when we add food coloring to each of the three containers? Will it mix right away, or will the temperature change how it mixes? Why or why not?

**Hypothesis**
Write your hypothesis below:

**Directions**
1. Complete the data table for “0 seconds” before any food coloring is added to each beaker. Record the temperature for each beaker at the start of the experiment.
2. Record observations at the 1 minute mark, 3 minute mark, 5 minute mark, and 7 minute mark for each beaker. You may sketch, write, or do a combination for your answers.

**Observations**

<table>
<thead>
<tr>
<th>Time</th>
<th>Room Temp Water</th>
<th>Ice Water</th>
<th>Hot water</th>
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<tbody>
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<td>_____ °C</td>
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**Conclusions**
Answer the following questions:
1. What happened to the food dye in the three containers? Describe what you observed. You may include a sketch to help show what happened.
2. Why do you think the food dye mixed differently in each of the three containers?