Activity 6.1
Matter on the move

Do heating and cooling have an effect on matter?

In this two-part demonstration and activity, students will be introduced to the idea that heating and cooling have an effect on matter. They will see that food coloring mixes significantly faster in hot water than in cold water and begin to develop the idea that adding heat energy increases the movement of water molecules. Students will extend this idea to realize that adding heat energy increases the movement of gas molecules, too. Students will also do an activity where they heat and cool the air inside a bottle that is covered with a film of bubble solution. These demonstrations and activities will help students develop a foundation for why substances change from one state to another.

Materials needed for the demonstrations

Hot tap water
Cold water
Blue food coloring
Yellow food coloring
2 Tall clear plastic cups
1 Wide clear plastic cup
Plastic bottle with lid, ½ pint or ½ liter

Materials needed for each group

Hot water
Cold Water
3 Wide clear plastic cups
Bubble solution (made with dishwashing liquid, sugar, and water)
Plastic bottle, ½ pint or ½ liter

Notes about the materials

- **Be sure you and the students wear properly fitting goggles.**
- **Hot tap water is sufficiently hot for the activity. Students should use care when handling hot tap water.**
- You will need two little squeeze bottles each of blue food coloring and yellow food coloring for the demonstration. This is so that you and a student volunteer can place one drop each of yellow and blue food coloring into containers of hot and cold water at the same time.

Preparing Materials

- Make a bubble solution for the entire class by adding 4 teaspoons of dishwashing liquid and 4 teaspoons of sugar to ½ cup of water.
- Gently stir until the sugar and detergent are dissolved.
- Then place about 1 tablespoon of this bubble solution in a wide clear plastic cup for each group.

Activity sheet

Copy *Activity sheet 6.1—Matter on the move*, pp. 338–342, and distribute one per student when specified in the activity.

Assessment

An assessment rubric for evaluating student progress during this activity is on pp. 372–373. For this formative assessment, check a box beside each aspect of the activity to indicate the level of student progress. Evaluate overall progress for the activity by circling either "Good", "Satisfactory", or "Needs Improvement".

Activity 6.1
Matter on the move

Question to investigate

Do heating and cooling have an effect on matter?

Take a closer look

1. Have students read the introductory story on *Activity sheet 6.1* and ask them to predict how food coloring will move in hot and cold water.

Distribute *Activity sheet 6.1—Matter on the move* and have students read the introductory story. Ask students if they have had similar experiences mixing colored substances in hot or cold liquids. Then explain that as a demonstration, you will place one drop each of yellow and blue food coloring in hot water while a student places one drop of each color in cold water. Ask students what they expect will happen to the drops of color in each cup.

2. Do a demonstration comparing the movement of food coloring in cold water and hot water.

Procedure

1. Add hot tap water and cold water to two separate clear plastic cups until they are about ¾ full.
2. With the help of a student volunteer, add 1 drop of blue and 1 drop of yellow food coloring to each cup at the same time.
3. Do not stir, but watch the colors as they move and mix on their own.

Expected results: **The food coloring in the hot water moves and mixes faster than the coloring in the cold water.**

3. Discuss with students what makes food coloring move faster in hot water than in cold.

Help students begin to think about molecular motion by asking them questions such as the following:

- Are these observations similar to anything you have experienced before?
- Do you think the water is moving in each cup?
- What evidence do you have that suggests something about the water is moving?

Explain that water is made up of tiny particles, called *molecules*, which are too small to see. These particles are always moving, even in very cold water. Since water molecules move, the molecules help mix the food coloring.

However, the color mixed faster in the hot water than it did in the cold. Ask students what this might say about the movement of water molecules in hot and cold water: Do molecules in hot water move faster than they do in cold water? Students should agree that they probably do. The observation of the color moving and mixing faster in the hot water is evidence of this.

Watch this!

4. Do another demonstration to show that heating also affects a gas.

Procedure

1. Add hot tap water to a wide cup until it is about ⅓ full. Make sure students realize you are using hot water.
2. Use your finger and a little water to moisten the rim of the bottle and the top surface of the lid. Then, place the lid upside down on the bottle so that there are no leaks.
3. Carefully push the bottle down into the hot water.

***Expected results*: The lid rises and falls making a tapping sound.**

Note: If you would like to show the demonstration again, you can uncover the opening and let some more air in. Then repeat Steps 2 and 3. If the lid does not tap, check to see that the lid is positioned directly over the opening of the bottle forming a seal.

5. Discuss with students what may be causing the lid to move.

Ask students if there is anything in the bottle that might be causing the lid to go up and down. After all, the bottle appears to be empty. Students should recognize that the bottle is filled with air. Explain that air, like water, is made of tiny particles that are too small to see. In fact air is made up of a mixture of different molecules—nitrogen, oxygen, water vapor, and carbon dioxide, just to name a few.

Ask students questions such as the following:

- Do you think pushing the bottle into hot water warmed the air in the bottle?
- How might heating the molecules inside the bottle change their motion?
- Is it possible that this faster motion could push the lid up?

When the bottle is heated, the particles in the bottle will move faster and push harder against every part of the inside of the bottle. Since the lid is on so loosely, these faster-moving particles can push the lid up.

Explain that students will do a similar activity with a film of bubble solution over the opening of the bottle. Ask students what they think might happen to the film of bubble solution when this bottle is placed in hot water.

Try this!

6. Have students conduct a similar activity with a film of bubble solution over the opening of the bottle.

Procedure

Heating a gas

1. Add hot water to a wide cup until it is about ⅓ full.
2. Lower the open mouth of the bottle into the cup with detergent solution as shown. Carefully tilt and lift the bottle out so that a film of detergent solution covers the opening of the bottle.
3. Slowly push the bottom of the bottle down into the hot water.

Cooling a gas

4. Add cold water to a wide cup until it is about ⅓ full.
5. Re-dip the opening of the bottle in the detergent solution and place it in hot water again to form a bubble.
6. Then slowly push the bottom of the bottle into the cold water. Alternate placing the bottle in hot and cold water. Record your observations on the activity sheet.

***Expected results*: The bubble film grows into a bubble when the bottle is placed in hot water. When the bottle is placed in cold water, the bubble shrinks. It may even go down into the bottle and possibly pop.**

7. Discuss student observations and explain them in terms of the movement of molecules.

Ask students questions such as the following:

- What happened to the bubble film when you placed the bottle in hot water?
- What happened to the bubble film when you placed the bottle in cold water?
- What can you say about the movement of molecules inside the bottle when the bottle was placed in hot water and the air inside the bottle was warmed?
- What effect did this increased motion have on the bubble film?
- What can you say about the movement of molecules inside the bottle when the bottle was placed in cold water and the air inside the bottle was cooled?
- What effect did this decreased motion have on the bubble film?

Students should apply the explanation for the colors mixing faster in hot water and the cause of the tapping lid to their observations of the bubble film. Students should recognize that the motion of the molecules inside the bottle increased when it was placed in hot water and decreased when the bottle was placed in cold water.

When the air was warmed, the molecules inside the bottle moved faster and pushed harder against the inside of the container. This pushing occurred in all directions. Because a bubble film is very flexible and easy to push, the faster-moving molecules caused the bubble film to stretch.

When the air is cooled, the molecules inside the bottle move more slowly and push with less force against the inside of the container. The molecules in the air around the bottle move faster than the molecules of the cooler air inside the bottle. These molecules in the air outside the bottle push harder against the flexible bubble film than the molecules inside the bottle do. This causes the bubbles to shrink down and sometimes even get pushed inside the bottle.

What's next?

8. Introduce the idea that heating and cooling matter can cause it to change state.

In the demonstrations and activity, students have seen that heating and cooling affects liquids and gases. Ask students if heating and cooling can affect solids, too. Heating and cooling affects all states of matter—sometimes causing them to change state. For example, cooling water enough can cause it to become ice and heating water enough can cause it to become a gas. Ask students for more examples of heating or cooling that cause matter to change state. Explain that they will do a series of activities to explore the process of water changing back and forth between water vapor (the gaseous form of water), liquid water, and ice.