Pre-festival Lesson 1.2 Molecules in Motion Lesson Plan

Investigative Question:

- What are the relationships between heat and the movement of water in the water cycle?

Summary: This activity brings water molecules up to size (student size!) by physically involving students in simulating molecular movement of water's physical states (solid, liquid, gas). It also uses experiments with food coloring to help students see how heat affects water molecules.

Reference: adapted from **"**Molecules in Motion", *Project WET Curriculum and Activity Guide 2.0*, 2011, pg. 33-36.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- systems and system models
- stability and change
- energy and matter*

Science and Engineering Practices Integrated:

- develop and use models
- engage in argument from evidence
- construct explanations and design solutions

Materials Needed:

- 2 one-quart size glass jars
- Clear cups approximately 5 inches in height (enough for 2 for each table group)
- Rubber bands
- Popsicle sticks or wooden skewers (enough for 2 for each table group)
- Small clear vials (enough for 2 for each table group)
- Blue Food color
- Ice
- Large container of boiling water (an electric kettle or hotplate can be used)
- Large container of room temperature water
- Large container of ice-cold water
- Sticky Notes
- Lesson 1 Molecules in Motion Simulation Worksheet

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Warm Up: (If you cannot do this in person, please watch the video and stop it to let your students make observations and ask questions). Use the slides provided above to introduce this lesson.

Demonstration -

Students will observe the motion of water molecules in ice cold water and boiling water using food coloring so that those motions are visible and will brainstorm driving questions to explore what is happening.

1) Have students create a **See-Think-Wonder Chart** in their science notebook.

I see…. (observations)	I think…(initial ideas/prior thinking)	I wonder…(how or why questions)

2) Place 2 one-quart size glass jars on a table, one jar filled with very cold water (remove any ice) and one jar with boiling water. Ask students to closely observe what they see happening in the demonstration. Do not share the difference in temperature in each jar with students at this time.

3) Add 4-6 drops of food coloring to the jar with cold water in it and observe what happens.

4) Add 4-6 drops of food coloring to the jar with hot water in it and observe what happens.

5) Have students take a few minutes to think about what they saw and to fill out their "See-Think" sections of their Chart: **What did you see/observe in the left jar and the right jar? What ideas do you have about why the dye may have behaved the way it did in each jar?** Have students share their observations in their table groups or as a class.

6) Next have students fill in their "I wonder" section of their chart with 2 or 3 how/why questions that they have about the demonstration. Once they have filled that section out have them pick one of their questions to put on a sticky note and share with their table group/the class.

7) Tell students the temperature of the water in each jar that they observed. Knowing there was a temperature difference, have them discuss why they think the dye in each jar behaved the way it did. Did this help answer any of their "I wonder" questions? If there are unanswered questions remaining, those questions can be put on display to return to in the wrap up.

8) Discuss: **Why does this happen?** Heat is a form of energy, so heat energizes the water molecules. Water molecules will move faster when they are hotter and have more heat energy. Water molecules will move slower when they are colder and have less heat energy.

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Lesson Sequence:

Investigation:

In table groups, students will slowly and carefully insert a vial of hot water (colored blue so that we can see it -and more food coloring to make it darker) into a cup of room temperature water. They will draw a picture looking at the side of the cup showing what happened. Students will then observe what happens when very cold water (colored blue) is added to a different cup of room temperature water. They will draw a picture looking at the side of the cup showing what happened.

1) Give each table group 2 clear cups filled ¾ full of room temperature water, 2 popsicle sticks or wooden skewers, 2 rubber bands and 2 clear vials. Have them securely attached a vial to each stick with a rubber band.
2) While students are setting up, add blue food coloring to the container of hot water. Fill one of each table group's vials with hot water.
3) Ask students: **What do you think will happen when we lower the vial with the hot water in it slowly and carefully down the side of the cup to the bottom?** Have students reflect on the earlier demonstration and make a prediction.
4) Have students carefully lower the hot water vial into one of the cups of room temperature water while observing what is happening to the blue water in the vial.
5) Ask students: **What do you see happening in the cup?** The hot water in the vial is rising to the top. Have students draw a picture of what they see happening in their science notebooks.
6) Add blue food coloring to the container of ice-cold water and fill one of each table group's vials with ice cold water.
7) **What do you think will happen when we lower the vial with the cold water in it slowly and carefully down the side of the cup to the bottom?** Have students reflect on the earlier demonstration and make a prediction.
8) Have students carefully lower the cold-water vial into the other cup of room temperature water while observing what is happening to the blue water in the vial.
9) Ask students: **What do you see happening in the cup?** The water is staying in the vial. Have students draw a picture of what they see happening in their science notebooks.
10) Ask students: **Why do you think the hot water rose while the cold water stayed in the vial? What does this experiment tell you about how hot water behaves versus cold water?** Hot water rises because the water molecules are moving faster and are more spread apart than room temperature water. This causes hotter water to rise above the cooler water. Cold water stays below in the vial because the water molecules are moving slower and stay closer together.

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Simulation: Developing and Using a Model

Students will simulate the cause-and-effect relationships between water molecules and energy. Heat is a form of energy. Through the Anchor Phenomena Demonstration and the above investigations, students should have some prior knowledge about the relationships between water molecules and heat energy.

1) Ask students: **Let's think about what form water is in, when it's affected by a lot of heat. First, what is heat again?** Heat is energy. **So, when water molecules have the most energy, what do you think they look like?** They are moving fast! **What form are they in?** Gas.
2) Ask students: **Where is water in gas form? Can you see it?** It is right here in the room in front of us, but you can't see it.
3) Tell the class they are going to become water molecules. They will begin as water in its gas form. Ask students: **How do you think you should behave as molecules in gas form?** In its gaseous state, water molecules move freely. Students should move quickly around the room waving hands and wiggling fingers.
4) Ask students: **Over time, some heat energy is lost. What will happen to all of you water molecules?** Water molecules will not move as fast. They will not have as much energy. Students should slow down a little.
5) Tell students they are now liquid. As a liquid, they begin bonding with other molecules and letting go (they do this by putting a hand on a neighbor's shoulder and letting go and then moving on to another). They are still moving fairly quickly as warm water.
6) As more heat it lost, water becomes room temperature, and students' movements should slow some more. Tell them they are lethargically bonding and letting go.
7) As even more heat is lost, the liquid water becomes cold. Ask students**: What do you think happens?** They slow even more and should get very close together like they observed the cold water behave in the vial.
8) Ask students**: What happens when water molecules get very, very cold?** They turn to ice. **How should we demonstrate that?** They may think that they should get very close together. But at 4 degrees C, water does an amazing thing. It begins to expand in to ice. Have students in groups of 6 put a hand on their neighbors' shoulder and stiffen their arms to make a hexagonal (6-sided) shape representing the structure of water molecules in a frozen state. As a liquid, water molecules will continually bond and let go. As ice, water molecules stay bonded making a structure.
9) Ask students: **Now that you are ice are you closer together or farther apart than when you were a very cold liquid?** Farther apart. **What happened to the cold water in the vial when we put it in room temperature water?** It stayed in the vial. **What do you think would happen if we put ice in room temperature water?** Let them predict but do not give the answer.

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10) Have students gather around a table with a cup of room temperature water and add an ice cube. Have students observe what happens. **What is the ice doing? Floating!** Water molecules turn solid in ice form and spread out creating more space in between making them float on liquid water. Therefore, ice water floats while the cold water stays on the bottom.

 Students will use an online simulation to visualize the cause-and-effect relationships between water molecules and heat energy.

1) Have students go to: https://phet.colorado.edu/sims/html/states-of-matter- basics/ latest/states-of-matter-basics_en.html
2) Students should complete the Lesson 1 Molecules in Motion Simulation Worksheet while moving through the instructions.

Wrap-Up:

Have students go back to their questions from the warm up. Have them write answers to questions they can answer. Ask students: **What are the cause and effect relationships between heat and water molecules?** Use sentence starters: **1) When heat is added to liquid water…** water molecules get lots of energy and can drift off and become a gas. **2) When heat is added to solid water…** water molecules get more energy and move out of a 6-sided structure to become a liquid. **What is the heat source or energy in the water cycle?** The sun which is a source of heat energy. Make sure they have the sun labeled on their water cycle diagram.

*Students should complete the Lesson 1 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of energy and matter – Energy is something that causes matter to move or change. Matter is the stuff things are made of.

Other resources:

https://www.usgs.gov/special-topics/water-science-school/science/adhesion-and-cohesion-water

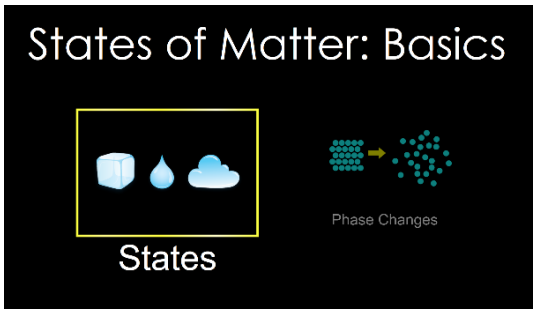
https://www.usgs.gov/special-topics/water-science-school/science/water-cycle

Molecules in Motion Exploration

Instructions:

1) Go to: https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

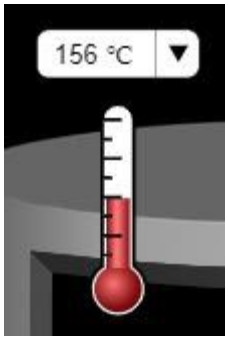
2) Select **"States"**



3) Select **"Water"** as your molecule type and **"Gas"** as your state of matter found on the right side of the screen.

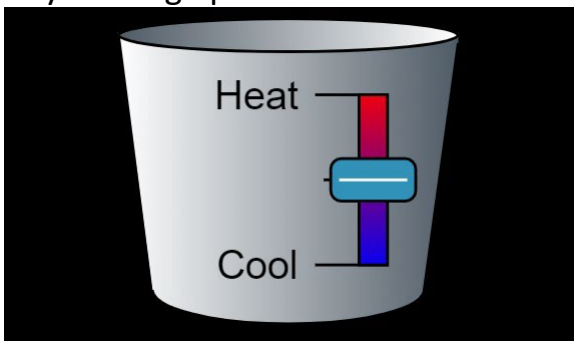
Molecules in Motion Exploration

4) Make sure to change the temperature to Celsius (°C) by opening the drop-down menu above the thermometer.



5) Each of the red and white structures is a water molecule. Water can change into gas form at 100°C and above so at 156°C the molecules you are seeing are in gas form. Observe how the water molecules are behaving.

6) Increase the temperature by heating up the molecules. Move the "Heat/Cool" scale up.



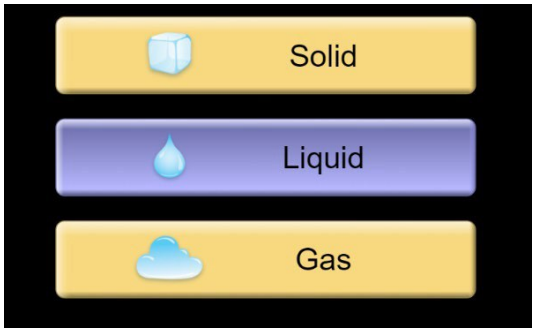
How does adding more heat make the water molecules behave?	

7) Decrease the temperature by cooling off the molecules. Move the "Heat/Cool" scale down. Notice the thermometer begins to go down.

Molecules in Motion Exploration

What do you observe happening to the molecules as heat is removed?	
Are the molecules moving closer together farther apart?	
Are the molecules moving faster or slower? Why?	

8) Select liquid as your state of matter. Below 100°C the water molecule begin to change from a gas to a liquid.



What do you notice about the structure of the liquid water molecules?	

9) Try decreasing the temperature by using the “Heat/Cool” scale.

Molecules in Motion Exploration

Do the molecules move closer together or farther apart as heat is removed?	
Are the molecules moving faster or slower? Why?	

10) Select solid as your state of matter. At 4°C liquid water molecules begin to change into solid water molecules. The more common name is ice!

What do you notice about the structure of the solid water molecules?	

11) Try decreasing the temperature by using the “Heat/Cool” scale.

In their ice form are the molecules closer together or farther apart than they were in liquid form?	

Molecules in Motion Exploration

Thinking about what you've observed, do you think an ice cube will float or sink in a cup of water?	
Which state of matter has the fastest moving molecules; gas, liquid, or solid?	
Which state of matter has the slowest moving molecules; gas, liquid, or solid?	
What causes water to change from solid to liquid to gas?	
Thinking about what you observed, how does this affect water moving through the water cycle?	