

# Convection

Grade 6

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**Science Content Standards:** Grade 6, 3a — *Students know* that energy can be carried from one place to another by heat flow or by waves, including water, light and sound waves, or by moving objects; and 3c — *Students know* that heat flows in solids by conduction (which involves no flow of matter) and in fluids by conduction and by convection (which involves flow of matter).

**Lesson Concept:** Convection is a type of heat transfer that occurs in fluids.

## Conceptual Flow:

- ▶ Heat energy flows (transferring from areas with more heat to areas with less heat).
- ▶ Radiation transfers thermal energy by electromagnetic waves through matter and space.
  - Heat is transferred through space (from one object to another object not in contact with each other).
  - Heating by sunlight is an example of radiant energy transfer.
- ▶ Conduction transfers thermal energy only through matter.
  - Particles with more thermal energy collide with nearby particles that have less thermal energy.
  - Thermal energy moves by conduction more quickly in some materials than in others.
- ▶ Convection is heat transfer through movement of particles.
  - Part of a fluid that is at a higher temperature moves to where the fluid is cooler.
  - A convection current is the circular motion that results in a fluid heated from below.
    - When a fluid is heated, the warmer parts of the fluid are less dense than the surrounding fluid.
    - Warmer fluid floats upward.
    - Cooler fluid is more dense and sinks.

Concepts to pre-teach before this lesson

- Density (most important)
- Radiation
- Conduction

## Teacher Background:

Convection is the transfer of thermal energy by the movement of matter from one place to another. For convection to take place, the particles of the materials must be able to move easily from place to place. In a solid, particles cannot move from one place to another. However, a fluid is a material made of particles that can easily change their locations. Liquids and gases are fluids, so convection occurs only in liquids and gases.

During convection, parts of a fluid that have a higher temperature move to a region where the temperature of the fluid is lower. Warm fluid is less dense than cool fluid. Warmer parts of a fluid that are less dense float upward in the surrounding cooler fluid which is more dense. Convection occurs because of differences in density in a fluid.

A convection current is the circular motion that results in a fluid heated from below. As the warm water/air rises, it cools and its density increases. As it cools, it sinks and pushes the warm water/air (which is less dense) upward.

(Adapted and excerpted from Glencoe Science, 6<sup>th</sup> Grade, *Focus on Earth Science*)

Convection occurs because most fluids become less dense when heated; the hot fluid will rise through the cold fluid because of the hot fluid's greater buoyancy. As hot fluid rises from a heat source, it may cool, become denser, and sink back to the source to be warmed again. The resulting circulation is called a "convection current".

(Adapted and excerpted from the *Science Framework for California Public Schools: Kindergarten Through Grade Twelve*.)

## Explanation for the Teacher Concerning this Investigation:

When the soup is heating on the stove, changes in density cause convection in the soup. As the soup at the bottom of the pot gets hot, it expands and becomes less dense. The cooler soup at the top is now denser than the hot soup next to the hot plate, and so the denser cool soup sinks down, pushing the hot soup out of the way. The hot soup goes upward and flows over the cold soup. Then the soup at the bottom becomes heated, becoming hotter than the soup at the top which has been cooling down since it's no longer next to the hot plate of the stove. And the whole thing happens again; the cooled water at the top becomes denser than the heated water at bottom, the cooler water sinks and causes the hot water to rise. This cycle keeps on going as long as the stove stays on. We call the movements of cooler and warmer pockets of fluid, caused by convection, "convection currents". The particles in the soup are used to show the water's movement.

Note: In the "Explain" section of the lesson, the students (not the teacher) should be explaining what they have learned about convection. After the lesson, students should be able to explain the following: **The food coloring helps us to see the movement of water. In the water container with the ice and hot water, the ice is cold and the water in the small bottle of red food coloring was hot. The cold water from the ice sank and stayed at the bottom because it is more dense than the warmer red**

food coloring. The cold water pushed the warm water to the top of the tank. The cold water did not spread throughout the tank.

## Materials Needed for the Lesson:

### Teacher Materials

- Hot plate, large glass beaker (or heat resistant glass measuring cup or pot); package of Miso soup; pot holder
- Small bottles of red and blue (or green) food coloring; one small bottle of red food coloring for each table group. The blue or green food coloring is used for making ice cubes.
- Colored ice cubes (green or blue; must be very dark) – at least 3 for each group
- Identify pages in textbooks or other reference books that explain convection currents (or obtain a DVD that shows and describes these)
- Clear plastic tub filled with room temperature water to place in front of the room

### Student Hands-on Material

- Clear plastic tub filled with room temperature water (one for each group)
- Small bottles of warmed red food coloring (one for each group)
- A clip-board or 8.5" x 11" piece of rigid cardboard to write on (students can also use their textbooks)
- 8 small cups (one for each group) to hold the ice cubes
- Colored pencils (red and blue or green)

### Student Handout

- “Student Data Sheet: Movement of Warm and Cold Water”

### Advanced preparation

- Make dark blue or dark green ice cubes – 2 trays of 12 ice cubes each (use enough food coloring in the water to make the water as dark as possible)
- Heat hot water for warming up red food coloring
- Obtain a bowl into which to place the hot water and food coloring bottles
- Heat soup mixture in large beaker or other clear container to boiling.
- Put 3 green or blue ice cubes into each of 8 small cups. Keep them clustered in a small cardboard box or cooler to minimize melting before they are handed out.

### Preparation activities in the classroom

- Set up the DVD so it is ready to go (if one is available on convection)
- Put hotplate with beaker of soup at the front of the room. Keep the soup boiling.
- Place food coloring bottles into a bowl of hot water.
- Place a plastic tub with water and ice cubes in containers in front of the room.

- Divide students into groups of four. Assign students numbers: “1, 2, 3, 4.”
- Write on the board at the front of the room the rule: “Avoid bumping the tub of water on your desk.”
- Place one tub of room-temperature water on each group’s desk cluster/table.
- Make sure students have their textbooks handy, so that they can turn to the proper page for the “Explain” section of the lesson.
- Give each student a clip-board or 8.5" x 11" piece of rigid cardboard, and one student handout data sheet, “Movement of Warm and Cold Water”

### 5E Lesson: Convection

Teacher Does	Student Does	Concept
<p><b>ENGAGE:</b> Tell students:</p> <ul style="list-style-type: none"> <li>▶ <i>Each group has a tub of water. It is important that the tub of water on the desks is not disturbed. The water must be as still as possible. Student #1 in each group is in charge of making sure that the water stays as calm as possible.</i></li> </ul> <p>Point to container of soup on hotplate. Ask students to observe the soup. Ask:</p> <ul style="list-style-type: none"> <li>▶ <i>What do you notice?</i></li> <li>▶ <i>What do you think causes the up and down motion of the stuff in the container? Discuss with a partner or in a threesome an explanation for what is causing the motion in the soup. You have two minutes for your discussion.</i></li> </ul> <p>Chart responses on the board. (Save to review at the end of the lesson.)</p> <ul style="list-style-type: none"> <li>▶ <i>Those are interesting ideas. Today we will do an investigation that will further help explain the movement of the materials in the soup. At the end of the investigation, we will check and see how close the original ideas are to the scientific phenomena that explains why the soup moves the way it does.</i></li> </ul>	<p><b>Expected Student Response (ESR):</b> The particles in the broth are going up, around and then down; then back up, around and down again.</p> <p>Discuss with a partner or threesome.</p> <p><b>ESR:</b> Boiling water is pushing particles around; heat makes them move; air in the water makes them move; heat pushes up the particles; heat is conducting in the soup.</p>	<p>With a heat source, a fluid is set in motion through convection currents.</p>

<p><b><u>EXPLORE:</u></b></p> <p>Have students focus on the tub of water on the desk/table. Remind them not to move or bump the table or desk; it is important that the tub of water remains very still.</p> <p>Explain:</p> <ul style="list-style-type: none"> <li>▶ <i>Very cold water in the form of colored ice-cubes will be put into one end of the tub of water (on top of the water); very warm water from the small bottles (colored with food coloring) will be put into the water (at the bottom of the tub) at the opposite end of the tub. Note that we are using the food coloring only to allow us to see what is happening with the water.</i></li> </ul> <p>Have students discuss what they predict will happen.</p> <ul style="list-style-type: none"> <li>▶ <i>From your group, choose the prediction that you think is the best one.</i></li> </ul> <p>Distribute student data sheet, "Movement of Warm and Cold Water."</p> <ul style="list-style-type: none"> <li>▶ <i>Based on the group discussion, choose a prediction to record under number "1" on the student data sheet.</i></li> </ul> <p>Remind students to write on the clipboard/ cardboard (or even their textbooks) placed on their laps to avoid bumping or shaking the table to keep the water from moving.</p> <p>Demonstrate the procedure for putting the ice cubes and the warmed colored water into the tub (3 ice cubes on one side, at the top; 3 drops of warmed dye water on the other side.</p> <ul style="list-style-type: none"> <li>▶ <i>Student #3, will be in charge of gently placing the ice cubes into the tub; Student #4, you will be in charge of adding the warm water with the food coloring.</i></li> </ul> <p>Distribute cups with ice cubes and a warmed bottle with food coloring from the hot water bowl to each group.</p> <p>Say to students:</p> <ul style="list-style-type: none"> <li>▶ <i>Do the investigation and observe for a few minutes. You may share with others what</i></li> </ul>	<p>Students groups discuss their predictions.</p> <p><b>ESR:</b> Color with go to the bottom; ice cubes will melt; water color will mix to make purple.</p> <p>Record prediction on lap to avoid shaking the table.</p> <p>Place ice cubes and warmed water with food coloring into the</p>	<p>Two different levels of heat (temperatures of water) are going to result in motion (convection currents).</p>
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<p><i>you are seeing. Once the food cooling settled into a final pattern, record your observations. Using colored pencils or crayons, draw precisely what you observed happening in the tub. (#2 on data sheet)</i></p> <p>Have individual groups discuss what was observed:</p> <ul style="list-style-type: none"> <li>▶ <i>What does the ice cube colored water represent? What did the ice cube water do? What did the warm water do? Complete #3 on your data sheet.</i></li> <li>▶ <i>Complete #4 on your data sheet.</i></li> <li>▶ <i>Discuss in each group whether the original prediction agrees with what was observed.</i></li> </ul> <p>Have groups share observations and comparisons to original predictions.</p> <p>Have students read an explanation of convection currents in their textbook.</p> <p><b>Optional:</b> Show DVD on convection currents.</p> <ul style="list-style-type: none"> <li>▶ <i>Discuss in your groups the connections between what was observed in the tub of water and what you read in the textbook (or saw on the DVD).</i></li> </ul> <p>Review original student explanations of particle movement in the soup. Refer to each explanation and have students give responses (based on investigation and reading from the text or on the DVD) to each of the explanations; analyze each original explanation and compare to scientific investigation and reading to distinguish if the original explanation makes “scientific sense.”</p>	<p>tub.</p> <p>Looking at the tub at desk level, observe and complete #2 on data sheet (using colored pencils or crayons).</p> <p><b>ESR:</b> Cold water.</p> <p>Group share to discuss observations. Complete #3 on data sheet.</p> <p>Complete #4 on data sheet.</p> <p>Class shares observations and whether their original prediction agrees.</p> <p>Read textbook pages (or watch DVD and take notes).</p> <p>Discuss connections to what was observed in the tub of water.</p> <p><b>ESR:</b> Dependent on original explanations; but need to be based and related to observations in the investigation and the reading in the text or watching the DVD.</p>	
<p><b>EXPLAIN:</b></p> <ul style="list-style-type: none"> <li>▶ <i>Using the investigation of cold and warm water in the tub and the information learned from the textbook reading or the DVD, explain why the cold and warm water moved the way they did (#5 on the student data sheet).</i></li> <li>▶ <i>Share with the class.</i></li> </ul>	<p><b>ESR:</b> The cold water from the ice falls to the bottom of the tank because it is more dense than the water in the tub. The dense cold water pushes the warm red water up; the warm red water is less dense than the surrounding water and is pushed up by the more dense cold water.</p>	<p>When a fluid is heated, the warmer parts of the fluid are less dense than the surrounding fluid. Warmer fluid is less dense and floats upward.</p> <p>Cooler fluid is more dense and sinks. Cooler more dense fluid pushes warmer less dense fluid upward.</p>

<p><b><u>EXTEND:</u></b></p> <p>Have students experiment with more or fewer colored ice cubes and number of warm water drops to see what combination shows the best results.</p> <p>Have students do research on how convection currents affect weather patterns.</p> <p>For more information on convection see:</p> <p><a href="http://academickids.com/encyclopedia/c/co/convection.html">http://academickids.com/encyclopedia/c/co/convection.html</a></p> <p><a href="http://encyclopedia.kids.net.au/page/co/Convection#Atmospheric_convection">http://encyclopedia.kids.net.au/page/co/Convection#Atmospheric_convection</a></p>		
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**Input Question:** What do you notice? (Engage); What did the ice cube water do? What did the warm water do? (Explore)

**Process Question:** Analyze each original explanation and compare to scientific investigation and reading to distinguish if the original explanation makes “scientific sense”. (Explore); Explain why the cold water and warm water moved the way they did. (Explain)

**Output Question:** None in this lesson; this lesson is an introductory lesson so an output question is not necessarily appropriate at this time.

**STUDENT HANDOUT****Movement of Warm and Cold Water**

1. Predict what will happen when you add colored ice cubes on one side and warm food coloring on the side of the tub.
2. Draw the set-up of the tub of water and what you observed happening in the water. Use arrows and labels to show what happened to the cold colored water from the ice cubes and what happened to the warm red dye.
3. Put your observations in words — describe what the cold water with the food coloring from the ice cubes does; and what the warm water (with the red food coloring) from the dropper does?
4. Does your prediction agree with your observations? How is it similar or different?
5. Explain why the cold and warm water moved they way they did. Use the back of this sheet if needed.