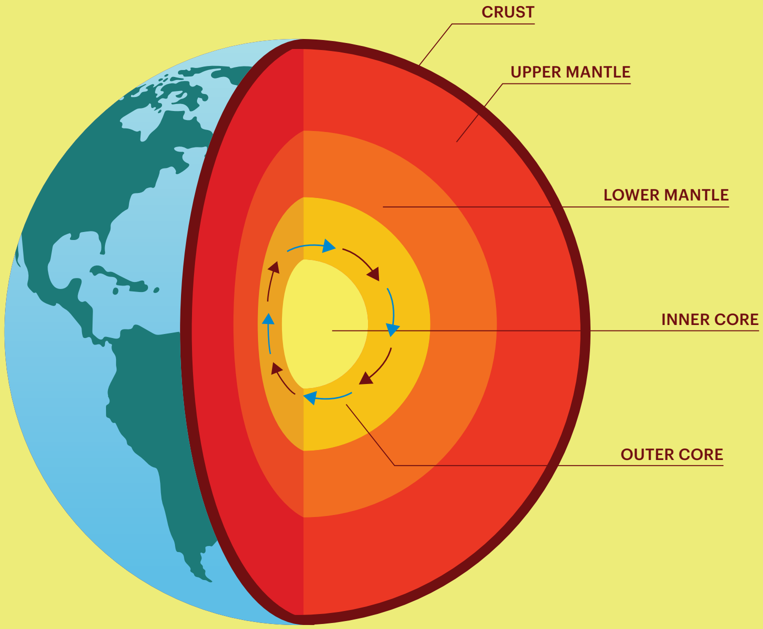
LESSON
Convection Currents

Grade Levels: 4-8
Duration: 60 min

Students work in teams to explore how differences in density can create motion in liquids. Then they reflect on a demonstration of convection currents in action.



Outline

Session 1	30 min
Students conduct an experiment to explore the connection between temperature and density.	
Session 2	**30 min**
Students observe and reflect on a demonstration of convection currents.	

Lab Connection:
Engineering for Earthquakes

Grade Levels: 4-8

Duration: 60 min

Concepts/Skills
Temperature, density, convection currents

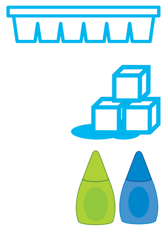
Objectives
Students will:
- Observe and analyze how temperature and density are related.
- Apply their understanding of density to the phenomenon of convection currents.

Materials and Preparation

Materials

Session 1

For the classroom:



- ☐ Ice cube trays (1-2)
  - At least 2 ice cubes per group
  - Reserve at least 5 ice cubes for the **Session 2** demonstration
- ☐ Food coloring, 1 color, 2 tbsp
  - Darker colors like red, blue, or green work better
- ☐ Available sink or bucket to dispose of colored water between trials in **Session 1**

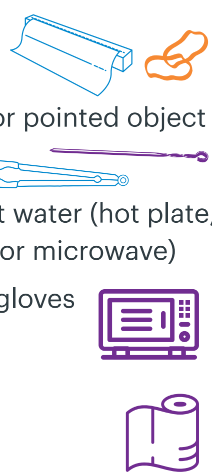
Each group will need:

- ☐ 1 colored ice cube per trial
  - Two trials recommended
- ☐ Clear cup or beaker at least 16 oz filled with room temperature water
- ☐ Paper towels
- ☐ **Observation Sheet** (1 per student) Used in both Sessions

Session 2

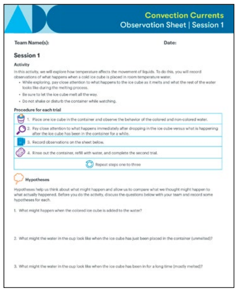
For the classroom:

- ☐ Large container to hold water
  - E.g., 5 gallon tank or 16 quart tub
- ☐ Small glass beaker or other container *(Approximately 100 ml or 3-4 oz.)*
- ☐ Food coloring, 1 color, 2 tbsp.
  - Darker colors like red, blue, or green work better
  - Choose a color different from the ice cubes used by the groups
- ☐ Aluminum foil
- ☐ Rubber bands
- ☐ Sharp skewer or pointed object
- ☐ Tongs
- ☐ Method to heat water (hot plate, electric kettle, or microwave)
- ☐ Heat resistant gloves
- ☐ Towels



Each group will need:

- ☐ **Observation Sheet** (1 per student) Used in both sessions



Session 1 Preparation: Before Activity

1. To prepare ice trays, add 1 tbsp of food coloring to a 1 gallon pitcher filled with water.
   - Stir, then fill the ice cube trays.
   - Alternatively, fill each tray with water and add 2-3 drops of food coloring to each cube.
2. Freeze the ice cube trays overnight.

Session 1 Preparation: Day Of

1. Plan to have students complete the activity in groups of 3-5.
2. Pre-fill cups or beakers two-thirds full with room temperature water.
   - Have a sink available or bucket prefilled with water nearby for students to reset their activity.

Session 2 Preparation: Day Of

1. Fill the large container three-quarters full with water 30-40 minutes before beginning the demonstration to allow the water to reach room temperature (around 70 degrees). • ***Note***: Plan to have the container in an area where all students will be able to see either by standing or sitting near it or using technology such as a document camera to broadcast the demonstration.	
2. Tape white paper to the back of the same large container so students will be able to see the colored water clearly.	
3. Just before **demonstration time**, begin heating the water. • ***Note***: If using a microwave, add a chopstick or skewer to the container to prevent overheating.	
4. Once heated, fill the small container to the top with hot water and add 6-10 drops of food coloring. • ***Note***: Select a color that is dissimilar to the color of the ice cubes	
5. Quickly cover the small container with aluminum foil and add a rubber band to hold the foil in place.	
6. Remove the colored ice cubes from the freezer and place into a cup.	

Tip: Complete preparation steps 4-6 while students record their hypotheses on their **Observation Sheets** The larger the temperature difference between the hot and cold water, the better the demonstration will appear.

Lab Connection

Convection Currents builds on the discussion of earthquake causes in the **Engineering for Earthquakes** lab at The Tech Interactive. In this activity, students will focus on how temperature and density are related to each other and how they are part of the convection current process.

Session One
Convection Currents
1

Frame the Activity

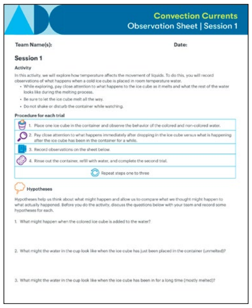
Session 1	30 min total
Activate Prior Knowledge	5 min
Introduce the Activity	10 min
Exploring Density Activity	10 min
Debrief	5 min

Activate Prior Knowledge *(5 min)*

1. Ask students to share what they know about **temperature** and **density**. Use some of these questions to guide the discussion:
   - *When might the temperature of a liquid be important?*
   - *Does the temperature of a liquid change how it can move?*
   - *What do you already know about density?*
2. Students may comment that:
   - Temperature is important in cooking or when they play or bathe in water.
   - Liquids become solid when frozen and a gas when heated very high.
   - Density has to do with how things float or sink.
3. Have students get into their teams of 3-5.

Introduce the Activity *(10 min)*

1. Hand out the **Observation Sheet** and review the procedure steps for the activity.
2. Have students discuss and record their hypotheses on the **Observation Sheet** (on page 1).
3. Distribute and introduce the materials the students will be working with. Let student teams know how they will clean their container after the first trial.
   - Point out that they should allow the ice cube to melt almost fully then discuss and record observations before moving on to the next trial.

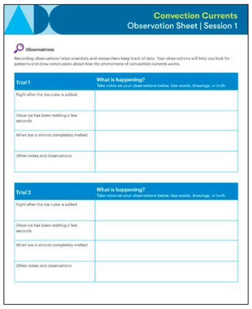

Convection Currents
Observation Sheet | Session 1

Observation Sheet Page 1

Tip: Leave the colored ice cubes in a freezer or refrigerator as long as possible to prevent them from melting.

Exploring Density Activity (10 min)

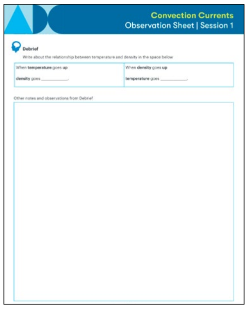
1. Have students begin the activity and work through both trials at their own pace.
2. As students are working, walk around and check in.
   - *What changes are happening as the ice melts?*
   - *What is happening to the dyed water as soon as you put the ice cube in?*
   - *What is happening to the dyed water after the ice cube has been melting for a while?*
   - Encourage teams to look for small details in the next trial.
     - *Did you notice anything new?*
     - *What patterns are you seeing?*
     - *What kinds of shapes are you noticing in the movement of the dye?*
3. Students should take notes in their **Observation Sheet** (on page 2).


Convection Currents
Observation Sheet | Session 1

Observation Sheet Page 2

Observation Tip: The key observation time is right after adding the ice cube. Encourage students to focus on what happens in different areas of the cup right after they add the ice cube. Optionally, have additional ice cubes available for any teams that need another trial to make observations.

Debrief *(5 min)*


Convection Currents
Observation Sheet | Session 1

Observation Sheet Page 3

1. Bring the class back together and have teams take turns sharing their observations.
   - Students should record any new information they learn during the share-out on their **Observations Sheet** (on page 3).
2. Support students in making connections between temperature and density. Lead a discussion around student observations using the following questions to guide the conversation.
   - *What did you observe about the movement of the colored water?*
   - *How did the water temperature impact its motion?*
   - *How can we see temperature and density working in this demonstration?*
   - *How do you think temperature and density might be related?*
3. Conclude by confirming the scientific concepts students have just explored.
   - ***Example**: "Temperature and density are related. When something is at a colder temperature it has a higher density which is why the colder water sinks to the bottom of the container. Hotter objects have a lower density which causes them to rise above something more dense."*

Preparation Reminder
Refer back to the **Materials and Preparation section** at the beginning of this guide for the details on supplies and set up.

Plugged Design Challenge	30 min total
Review the Concepts	5 min
Record Hypotheses	10 min
Convection Currents and Density Demonstration	5 min
Debrief	10 min

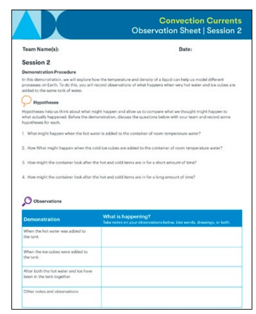
Frame the Activity

Review the Concepts *(5 min)*

1. Ask students to share what they know about convection currents. Use some of these questions to guide the discussion:
   - *What do you already know about convection currents?*
   - *How might temperature and density be able to create constant motion?*
   - *Where or when might convection currents occur?*
     - If students are brand new to convection currents, have them make hypotheses about what it could be based on the words convection and current and knowing that it is related to temperature and density.
2. Students may comment that:
   - Convection currents cause earthquakes and volcanoes.
   - Temperature and density are related and have to do with liquids moving up or down.
   - Weather involves convection currents.
3. Have students get back into their teams from Session 1.

Record Hypotheses *(10 min)*

1. Let students know that they will be seeing a demonstration similar to the previous activity using more extreme temperatures.
2. Have students discuss and record their hypotheses on the **Observation Sheet** (on page 4).


Convection Currents
Observation Sheet | Session 2

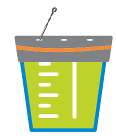
Observation Sheet Page 4

Tip: Complete **preparation steps 4-6** yourself while students write down their hypotheses.

Convection Currents and Density Demonstration *(5 min)*

1. Invite students up to the demonstration area. While completing the demo, ask students open-ended questions to guide their thinking.
   - See the next page for the demonstration procedure.

Demonstration Procedure

1. Use the tongs to pick up the aluminum foil covered beaker of hot water and gently place it *at one end* of the room temperature water container. Do not place it in the center.	
2. Use the skewer to poke three small holes so water can escape.	
3. Have students share observations of what happens to the hot water for about 30 seconds.	• *"What do you notice about where the hot water is moving?"* • *"What do you notice about how quickly or slowly the water is moving?"* • *"What else do you notice?"*
4. After about 30 seconds, place about five ice cubes on the side of the container opposite the hot water. • ***Note:*** Opposite side is important as it will prevent the color from mixing immediately.	
5. Have students share observations of what happens in the tank over the next minute.	• *"What happened when we first put the ice cubes in the tank?"* • *"What did the cold water do?"* • *"What did the hot water do?"* • *"What else did you notice?"*

1 Alternative Demonstration

There are many ways to demonstrate convection currents in action. An alternative option is to use a plastic bag and a hair dryer. Secure the plastic bag so it has an opening only large enough to fit the hair dryer. Hold the bag over the running hair dryer for about 30 seconds to inflate and evenly heat the air inside. Turn off the hair dryer and release the bag. As it rises, have students make observations and suggestions for why this is happening.

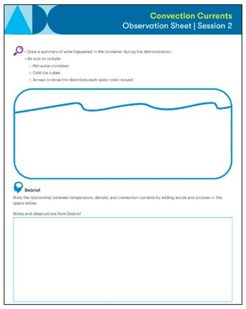
Students might observe:

- The inflated bag rises very quickly at first.
- The bag stalls after it has been up for a while.
- The bag will begin to fall.

Support students making connections between temperature, density, and convection currents. Use the following questions to guide the conversation.

- *How would this be different if the bag could re-inflate with hot air every time it got near the ground?*
- *How can we see temperature and density working in this demonstration?*
- *How might this be similar to what happens in layers of the Earth?*

Debrief *(10 min)*



Observation Sheet Page 5

1. Have the students get back into their groups to share and record their observations from the demonstration. Walk around and check in as teams discuss and record on their **Observation Sheet** (on page 5).
2. Bring the class back together and have them share-out from their discussions. Students may point out that:
   - The hot water rose to the top very quickly.
   - The cold water sank to the bottom in a straight line, quickly.
   - The hot and cold water did not mix at first.
   - The water started mixing and the color blended together after some time.
3. Support students making connections between temperature, density, and convection currents. Use the following questions to guide the conversation.
   - *How can we see temperature and density working in this demonstration?*
   - *How might this be different if the hot and cold water never ran out?*
   - *What parts of this might this be similar to what happens in layers of the Earth?*
4. Conclude by confirming the scientific concepts students have just explored and other places they can be found.
   - ***Example***: *"Temperature and density drive convection currents. The core of the Earth heats up the layer above it, the* ***mantle****. When some of the mantle magma gets hotter, the density goes down and the magma will rise up towards the crust. Once it is away from the core it starts to cool down, the density increases, and the magma falls back down towards the core. This process can then repeat."*
   - *Where else might convection currents happen?*
     - The atmosphere (weather)
     - The ocean (ocean current)

Career Connection: Geological Oceanographer

Many types of scientists and engineers need to understand the phenomena of convection currents. Oceanographers can specialize in many different areas but Geological Oceanographers study the ocean floor and the processes that form it. They examine samples to study sea-floor spreading, volcanic processes, mantle circulation, and more. This involves collecting and analyzing data from all over the planet, collaborating with other scientists, and communicating by presenting information or writing papers. Oceanographers are crucial to helping understand the impacts of climate change and what the future of the planet may be.

To learn more about geological oceanographer skills and career path options check out the resources below:

- **Meet an Expert:** One company studying the oceans on our planet is **Woods Hole Oceanographic Institution.** They work on everything from studying the effects of microplastics to piloting robots on the bottom floor of the ocean. Check out videos of their ocean robots and even footage of some of the things they find at the bottom of the ocean on their **Video Page.**
- **Try it:** There are lots of different topics that geological oceanographers study. Try out some of these activities to learn more about the science and mystery solving involved in the role. To see more convection currents in action try making a **DIY Solar Balloon**. Learn more about how climate change is impacting the ocean in the **Ocean Impossible** game from Woods Hole Oceanographic Institution.
- **Research**: Many other career fields require an understanding of convection currents and their impacts. Check out some of the below career fields to see if any of them spark interest for you!
  - Meteorologists use math and science to predict the weather. Check out this SciShow Kids video ***"How Do We Know When it Will Rain?"*** (YouTube, 4:21) to learn about the science of predicting weather.
  - Airline pilots have to not only fly airplanes but understand the conditions in the air to make safe choices. Check out this SciShow Kids video ***"How Airplanes Fly!"*** (YouTube, 4:30) to learn about the science of flight.

Standards Connections

Next Generation Science Standards

Grade	Performance Expectation	Description
4	4-PS3-4	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
6-8	MS-PS3-5	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
	MS-ES1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
Related Standards		MS-ESS2-2
Science and Engineering Practices		Developing and Using Models Constructing Explanations and Designing Solutions
Cross Cutting Concepts		Cause and Effect Stability and Change

Vocabulary

- **Convection current:** The cycling of opposing density materials. This can occur in water, air, or rock. The movement of the mantle. It brings the hot mantle toward the surface, where it moves laterally and then falls when cool. Hot mantle rises to replace it. This cycle moves the crust over time.
- **Core:** The central portion of the earth, having a radius of about 2100 miles (3379 km) and believed to be composed mainly of iron and nickel in a molten state.
- **Density:** The amount of matter in a given volume, higher density objects will sink when placed in a lower density liquid.
- **Mantle:** The portion of the earth, about 1800 miles (2900 km) thick, between the crust and the core.
- **Temperature:** The measure of the average kinetic energy of all the particles in a substance. The faster the particles move, the higher the temperature and warmer it feels.

Convection Currents
Observation Sheet | Session 1

Team Name(s): **Date:**

Session 1

Activity

In this activity, we will explore how temperature affects the movement of liquids. To do this, you will record observations of what happens when a cold ice cube is placed in room temperature water.

- While exploring, pay close attention to what happens to the ice cube as it melts and what the rest of the water looks like during the melting process.
- Be sure to let the ice cube melt all the way.
- Do not shake or disturb the container while watching.

Procedure for each trial

1. Place one ice cube in the container and observe the behavior of the colored and non-colored water.
2. Pay close attention to what happens immediately after dropping in the ice cube versus what is happening after the ice cube has been in the container for a while.
3. Record observations on the sheet below.
4. Rinse out the container, refill with water, and complete the second trial.
Repeat steps one to three

Hypotheses

Hypotheses help us think about what might happen and allow us to compare what we thought might happen to what actually happened. Before you do the activity, discuss the questions below with your team and record some hypotheses for each.

1. What might happen when the colored ice cube is added to the water?

2. What might the water in the cup look like when the ice cube has just been placed in the container (unmelted)?

3. What might the water in the cup look like when the ice cube has been in for a long time (mostly melted)?

Observations

Recording observations helps scientists and researchers keep track of data. Your observations will help you look for patterns and draw conclusions about how the phenomena of convection currents works.

Trial 1	**What is happening?** Take notes on your observations below. Use words, drawings, or both.
Right after the ice cube is added	
Once ice has been melting a few seconds	
When ice is almost completely melted	
Other notes and observations	

Trial 2	**What is happening?** Take notes on your observations below. Use words, drawings, or both.
Right after the ice cube is added	
Once ice has been melting a few seconds	
When ice is almost completely melted	
Other notes and observations	

Debrief

Write about the relationship between temperature and density in the space below

When **temperature** goes **up** **density** goes _____________.	When **density** goes **up** **temperature** goes _____________.

Other notes and observations from Debrief

Team Name(s): **Date:**

Session 2

Demonstration Procedure

In this demonstration, we will explore how the temperature and density of a liquid can help us model different processes on Earth. To do this, you will record observations of what happens when very hot water and ice cubes are added to the same tank of water.

Hypotheses

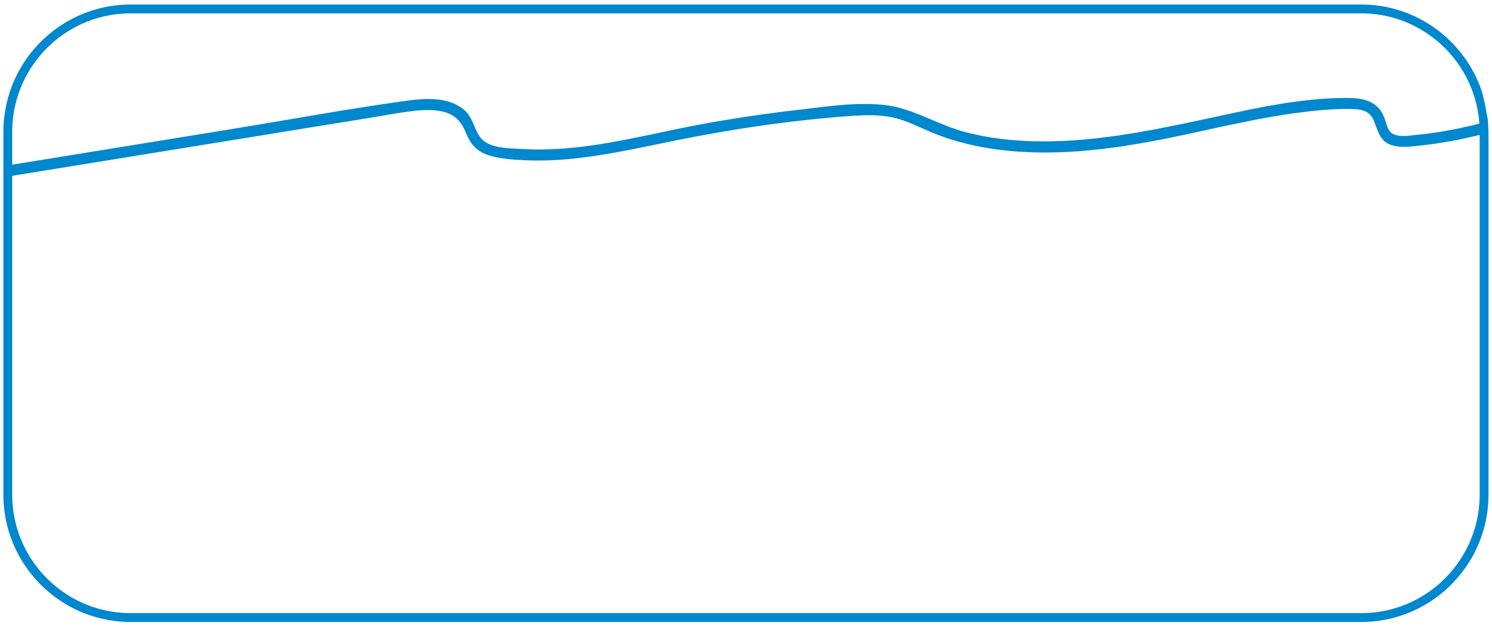
Hypotheses help us think about what might happen and allow us to compare what we thought might happen to what actually happened. Before the demonstration, discuss the questions below with your team and record some hypotheses for each.

1. What might happen when the hot water is added to the container of room temperature water?
2. How What might happen when the cold ice cubes are added to the container of room temperature water?
3. How might the container look after the hot and cold items are in for a short amount of time?
4. How might the container look after the hot and cold items are in for a long amount of time?

Observations

Demonstration	What is happening? Take notes on your observations below. Use words, drawings, or both.
When the hot water was added to the tank	
When the ice cubes were added to the tank	
After both the hot water and ice have been in the tank together	
Other notes and observations	

- Draw a summary of what happened in the container during the demonstration.
- Be sure to include:
  - □ Hot water container
  - □ Cold ice cubes
  - □ Arrows to show the directions each water color moved



Debrief

Note the relationship between temperature, density, and convection currents by adding words and pictures in the space below.

Notes and observations from Debrief