

## ACTIVITY FOUR: CURRENTS AND HEAT TRANSFER

### Getting Your Bearings

In February 1779, John Adams spent the winter in France and wrote to his wife Abigail Adams:

My Dear,  
The Climate here is charming. The weather is every day, pleasant as the month of May—soft, mild air—some foggy days, and about 10 or twelve days in January were cold and icy. But we have had scarce 3 inches of snow the whole Winter. The Climate is more favourable to my Constitution than ours.

Why did Europe and the US experience such differences in temperature? In Activities Two and Three, you learned about density and wind-driven ocean circulation. Now you will investigate how the ocean stores heat energy and how some currents, like the Gulf Stream, warm the air. You will also learn how a slowdown of the Gulf Stream could affect the climate of Northern Europe.

In Activity Four, you will explore the differences that still exist between temperatures in Europe and in North America. These differences are due, in large part, to the ability of water to hold onto heat energy and then transfer it to the air above it. In particular, the Gulf Stream is able to hold onto heat energy, transferring it to Europe as it travels east. In Exploring and Discovering, you will compare how well water and sand "hold onto" heat energy. This ability is called specific heat capacity. In Looking Closer, you will look at images of surface temperature in North America and Europe, and explore the temperature differences of cities at the same latitude on both sides of the Atlantic. You will use your knowledge of specific heat capacity to explain any differences that you observe. In Looking Ahead, you will read about how changes in Earth's overall temperature affect thermohaline circulation and how those changes, in turn, affect climate.

### Goals

- You will observe which takes longer to heat up and cool down, water or sand.
- You will observe what happens to the heat energy from water and sand as they cool.
- You will learn what happens to the heat energy from the Gulf Stream as it travels north.
- You will learn what might happen to the climate in Northern Europe if the Gulf Stream weakens.
- You will learn that ocean currents and climate are related in complex ways.

## Exploring and Discovering Which Stores Heat Energy Better, Water or Sand?

When sunlight enters the Earth's atmosphere, everything heats up. But some materials hold heat energy better than others. Some warm up gradually and hold onto heat energy for a long time, giving it off slowly to the surrounding environment. Other materials warm up quickly and give off heat energy quickly. Scientists describe the ability of a material to take up and store heat as *specific heat capacity*.

In this investigation, you will compare how well water and sand store heat energy. You will also investigate how water and sand transfer this heat energy to the air above them. Half the class will investigate water; the other half will investigate sand. Your teacher will tell you which group you are in.

### Water group:

#### Materials

- Hot plate
- 1, 250-ml beaker
- 1, 500- or 600- ml beaker
- Tap water
- 100g water at room temperature
- 2 thermometers
- Lab apron
- Safety goggles
- Oven mitts
- Stopwatch
- [Which Stores Heat Better, Sand or Water? Record sheet](#)



### Procedure

First you will heat your material over a warm water bath, as if it were summer. Then you will let it cool down, as if winter were approaching. Follow the instructions for your group. Your teacher will pair you with a sand group. You will share your data with this group when you are finished.

### Making a prediction

Think about sand and water. If they were heated to the same temperature, which do you think would cool down more quickly? Write your prediction on the record sheet and explain your reasoning.

**Warming the water**

1. Put on your goggles and lab apron.
2. Fill your large beaker about 1/4 full with tap water. This is your warm water bath. Put it on your hot plate and turn the hot plate to the highest setting. Put a thermometer in the beaker. When the temperature reaches 75°C, turn the hot plate to its lowest setting. You need to keep the temperature of the warm water bath between 74°C and 76°C. You will need to adjust the setting of the hot plate to maintain the correct temperature.



3. You will need 100 grams of room-temperature water for this lab. One ml of water equals one gram of water. Therefore, instead of finding the mass of the water, you can just fill your smaller beaker with 100 ml of water. This is equal to 100 grams of water.
4. Find the temperature of the water in the smaller beaker. Check with your sand group to make sure that it is the same temperature as the sand. If not, add hot or cold water to your beaker until it is the same temperature. You may need to adjust the amount to keep the mixture at 100 ml.
5. Start your stopwatch.
6. Place the smaller beaker in the warm water bath. Keep a thermometer in both beakers.
7. Check the temperature of the water in the smaller beaker every 30 seconds until the temperature reaches 55°C. Every time you check the temperature, stir the water with your thermometer to redistribute the heat.
8. Once the temperature reaches 55°C, turn off the hot plate. Record how long it took for the water to reach 55°C in Table 1. Remove the thermometer from the warm water bath and set it aside. Keep it at room temperature.
9. Take the beaker out of the warm water bath and set it aside. You can use the oven mitts when removing the beaker. Set your timer for 1 minute.

**Cooling the water**

10. After 1 minute, check the temperature of the cooling water. Record the data in Table 2. Check the temperature of the cooling water every minute for 10 minutes. After recording the temperature, stir the water thoroughly to redistribute the heat.

11. After the 10 minutes are up, find the temperature of the air above the small beaker. Use the thermometer that has been sitting out at room temperature. First record the temperature that the thermometer shows for room temperature in Table 3. Then hold the thermometer about 0.5 cm above the water for one minute. Record the temperature of the air above the water in Table 3.

Sharing data

12. Plot your data from Table 2. Your x-axis is time and your y-axis is temperature. Be sure to title your graph and to label the axes.

13. Get together with your sand partners. Copy their data from into your data table and make a copy of their graph.

14. Answer the questions on your record sheet and be prepared to discuss them with the class.

## **Exploring and Discovering** **Which Stores Heat Energy Better, Water or Sand?**

**Sand group:**

### **Materials**

- Hot plate
- 1, 250-ml beaker
- 1, 500- or 600- ml beaker
- Tap water
- 100g sand at room temperature
- Beam balance
- Paper
- 2 thermometers
- Lab apron
- Safety goggles
- Oven mitts
- Stopwatch
- [Which Stores Heat Better, Sand or Water? Record sheet](#)

### **Procedure**

First you will heat your material over a warm water bath, as if it were summer. Then you will let it cool down, as if winter were approaching. Follow the instructions for your group.

Your teacher will pair you with a water group. You will share your data with this group when you are finished.

## Making a prediction

Think about sand and water. If they were heated to the same temperature, which do you think would cool down more quickly? Write your prediction on the record sheet and explain your reasoning.

## Warming the sand

1. Put on your goggles and lab apron.
2. Fill your large beaker about 1/4 full with tap water. This is your warm water bath. Put it on your hot plate and turn the hot plate to the highest setting. Put a thermometer in the beaker. When the temperature reaches 75°C, turn the hot plate to its lowest setting. You need to keep the temperature of the water in this large beaker between 74°C and 76°C. You will need to adjust the setting of the hot plate to maintain the correct temperature.
3. You will need to measure out 100g of sand. To do this, put a piece of paper on your beam balance. Zero the beam balance. Put sand on the paper and keep adding or subtracting sand until you have 100g.
4. Put the sand in your smaller beaker.
5. Find the temperature of the sand. Check with your water group to make sure that their water is starting at the same temperature.
6. Start your stopwatch.
7. Place the beaker of sand in the warm water bath. Keep a thermometer in both beakers.
8. Check the temperature of the sand every 30 seconds until the temperature reaches 55°C. Every time you check the temperature, stir the sand with your thermometer to redistribute the heat.
9. Once the temperature reaches 55°C, turn off the hot plate. Record how long it took for the water to reach 55°C in Table 1. Remove the thermometer from the warm water bath and set it aside. Keep it at room temperature.
10. Take the beaker out of the warm water bath and set it aside. You can use the oven mitts when removing the beaker. Set your timer for 1 minute.



### Cooling the sand

11. After 1 minute, check the temperature of the cooling sand. Record the data in Table 2. Check the temperature of the cooling sand every minute for 10 minutes. After recording the temperature, stir the sand thoroughly to redistribute the heat.
12. After the 10 minutes are up, find the temperature of the air above the sand. Use the thermometer that has been sitting out at room temperature. Record the temperature that the thermometer shows for room temperature in Table 3. Then hold the thermometer about 0.5 cm above the sand for one minute. Record the temperature of the air above the sand in Table 3.



### Sharing data

13. Plot your data from Table 2. Your x-axis is time and your y-axis is temperature. Make sure to title your graph and to label the x and y-axes.
14. Get together with your water partners. Copy their data into your data table and make a copy of their graph.
15. Answer the discussion questions on your record sheet and be prepared to share them with the class.

## Looking Closer

### How Does the Gulf Stream Affect Air Temperature?

In the last investigation, you learned that water is a huge heat reservoir. It holds onto heat energy better than sand and gives off its heat energy to the air relatively slowly. Therefore, in general, air over water can stay warm longer than air over land. What does this mean for climate? In this investigation, you will examine the effect of a warm body of water, the Gulf Stream, on the climate in Northern Europe.

You already know that the Gulf Stream carries warm water from the Straits of Florida and the Gulf of Mexico to Northern Europe. Now you will find out what effect warm water has on air temperature, examining a process known as heat transfer. You will also learn about what could happen to Northern Europe's climate if the Gulf Stream were to stop or slow down.

#### Materials

- [Looking Closer Record Sheet](#)

#### Procedure

1. Look at the satellite images on your record sheet. Image A shows the east coast of North America. Image B shows the west coast of Europe. In both images, different colors represent different temperatures. From coldest to warmest, the colors are: purple, blue, green, yellow, and red. These images show temperatures during the month of January 2002.
2. Notice that the satellite images have numbers on them. Each number in North America has a corresponding number in Europe. Locations with the same numbers are cities at the same latitude, so they receive the same amount of solar energy. Find the city pairs and then note their temperatures. Enter the data in the table on your record sheet.
3. Look at your findings and discuss them in your group. Your teacher will ask for your observations. Then answer the questions on your record sheet.

#### Check for Understanding

Answer the questions on your [Letter to Benjamin Franklin](#) record sheet.

**Looking Ahead****The Role of the Ocean in Our Global Climate**

You will think about the important role that the oceans play as a heat sink in the global climate change story. Read *The Role of the Ocean in Our Global Climate* and answer the "as you read, think about..." questions.