



# Lesson 8: What causes wind?

## Background Information

Air immediately above the Earth's surface is heated by conduction. (Air that is higher up in the atmosphere is heated by the infrared radiation produced by the Earth & Sun.) Therefore, the air above warm surfaces heats up more than the air above cool surfaces. The differential heating of the Earth's surface creates areas of colder, denser air, and areas of warmer, less dense air. The regions of dense and less-dense air interact by convection, in which the colder, denser air displaces the warmer, less dense air, forcing the warmer air upward. This air movement is wind.

## Summary & Rationale

The purpose of this lesson is for students to learn how temperature differences create convection currents in the atmosphere that result in wind. In the Motivator, students will be asked to think back to the previous lesson and predict whether the air is warmer over land or over water. Students will then create convection cells in water to model how heat creates movement. Once they have seen convection in action in the water, they will then observe convection in the air. (This is an optional demonstration, depending on availability of equipment.) Finally, the class will discuss how convection cells cause air to flow from cooler areas with higher air density to warmer areas with lower air density. This flow, or movement of air, is wind.

## Goals

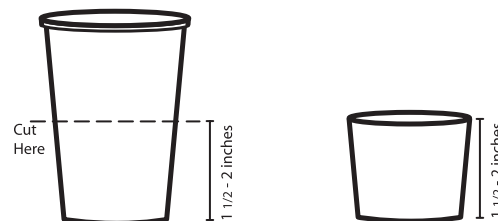
- Students will explain how convection creates cells in which the colder material sinks and the warmer material rises. They will use a model of this movement as evidence.
- Students will explain how the differential heating of the Earth's surface results in convection cells that produce wind. They will create visual representations of this process.

## Materials

- overhead of the Motivator image of land and water (p.49)
- overhead of John F. Kennedy International Airport (p.50)

### For the activity

- student worksheet (optional: pictures can be drawn in notebooks)
- clear plastic pan or other container (one per group)
- supports for plastic pan (five per group)



(The supports should be about one inch high. Styrofoam cups that have been shortened or empty, single-serving applesauce containers work well.)

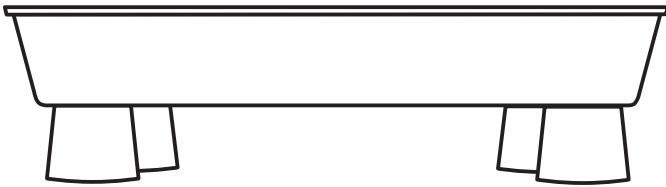




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### Materials (continued)

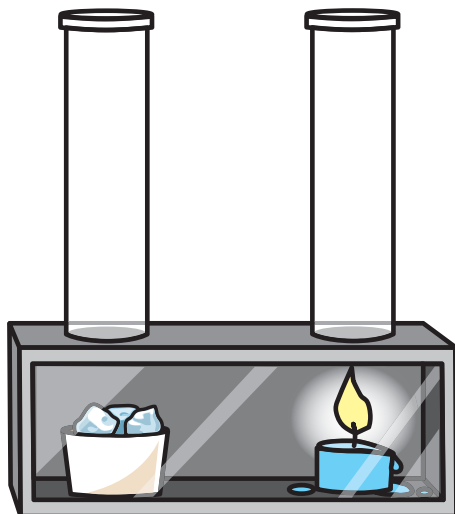
Four of the supports will be turned upside down and used to hold up the plastic pan. Make sure all the supports for one pan are the same height. The fifth support will be used right side up to hold the hot water.)



- water
- hot water (as a heat source)
- napkins or paper towels
- food coloring (preferably in a screw-top rather than a squeeze bottle)
- eyedropper

### For the demonstration (optional)

- gas convection apparatus [A]
- ice
- candle
- matches
- incense stick, splint, or other smoke source



[A]

### Preparation & Safety

#### Activity A (How do Earth's surfaces heat up?)

- It will be easier to keep the food coloring from dispersing through the water if it is denser than the water. Therefore, it is helpful (but not necessary) to chill the food coloring in a refrigerator before class.
- Practice placing drops of food coloring at the bottom of a pan of water.
  - Fill the eyedropper with food coloring.
  - Use a paper towel to wipe the food coloring off the outside of the eyedropper. This will keep excess food coloring from dispersing through the water.
  - Lower the eyedropper so the opening is at the bottom of the pan of water.
  - Slowly squeeze the eyedropper so that a distinct drop of food coloring forms on the bottom of the pan.
  - Slowly remove the eyedropper from the water so that the food coloring drop is not disturbed.
- Each group should have a plastic pan held up on four supports and a fifth support for holding hot water.
- Fill each pan with about two inches of water.
- Heat water with a hot plate, microwave, or water heater. For safety reasons don't let the water boil.
- The rest of the setup (placing food coloring in the water and adding the heat source) should be done right before students conduct the activity.
- **Caution:** Whenever using water, be careful not to spill. Wet floors can be dangerous.
- **Caution:** Heated water and hot plates can burn. Be careful whenever dealing with hot materials.

### Assumed Prior Knowledge

Land heats up and cools down faster than water does (previous day's activity).





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# Lesson Steps

## Motivator

Put up the overhead with the picture of thermometers on land and water. Have students answer the question independently.

**Think back to the last class. Which thermometer will show the highest temperature, and why?**

### Assessment:

Walk around the class as students are working on the Motivator. Check to see that they are answering that the air above the land should be warmer because land heats up more than water does.

Ask students to share their responses to the Motivator. Make sure the conversation includes that the Sun is out, so it is daytime. During the day the person on the sand thermometer would read the highest temperature. This is because land heats up faster than water. The hot land will heat the air immediately above it (by conduction) more than the cooler water will. [This content will be revisited in Lesson 1.]

Ask the students if the same thing would be true at night. Make sure they refer to evidence from the previous day's experiment. Because land cools faster than water, the person on the sand will record a lower temperature at night than the person on the water.

## Introduction

Now tell the class that they will be investigating the results of temperature differences like these. They will be using water instead of air because food coloring can easily be used as a tracker. After looking at convection in water, they will relate what they have learned to convection in air.

## Activity

In this activity students observe a convection cell in water and draw the results. A student worksheet is provided on p.51.

- Each group needs a pan with two inches of water in it. The pan should be raised off the ground with four supports. This can be done before class, or by the students.
- Have students make a prediction of how heat will spread through the water by drawing directly on a diagram of the setup.



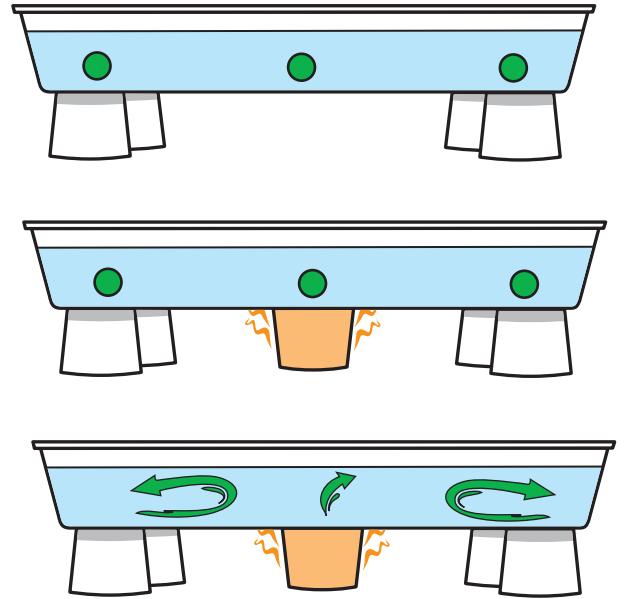


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- While students are making their predictions, place three drops of food coloring in each pan of water.
- Once the students have made their predictions and the food coloring is in place, pour hot water into the fifth cup and slide it under the pan in the center.
- The food coloring will start to move. Students should record its movement by drawing on the diagram.

### Assessment:

As students are working, walk around the room and check to see what they are drawing.



- Convection cells should form in less than five minutes. Some groups may get better/more distinct cells than other groups. If this is the case, have students look at other groups' results to be sure that everyone sees at least one good cell (one that looks similar to the 3rd picture above).
- After students have observed and drawn the convection cells, they should answer the follow-up questions on the worksheet.

### Optional: Convection in Air Demonstration

This is a wonderful demonstration of convection in air. It is optional because it takes a special piece of equipment. However, all efforts should be made to get the gas convection apparatus so that the demonstration can be done.

Use the gas convection apparatus to demonstrate that convection also occurs in air. Place a candle under one tube and a cup of ice under the other. Light an incense stick as a source of smoke. Hold the smoke over the tube with the candle. It will rise faster. Hold the smoke over the tube with the ice. It will be pulled into the tube. Discuss with students why this happened. This discussion should get at the following idea:

Convection in air happens for the same reasons as convection in water. Warm air is less dense than cold air. Therefore, cold air is pulled down by gravity and forces the warm air upward. When the warm air rises, it is no longer close to its heat source. Therefore, it cools, becomes denser, and sinks back down.

If the optional demonstration is not done, it is still necessary to discuss convection in air. After discussing how the convection in water activity was a model, talk about how that model can be applied to convection in air. Have students describe how convection in air would happen.





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### Wrap-up

Apply the concept of convection to the Motivator. Have students draw the picture from the Motivator and then have them draw in the direction of the wind for both day and night. Discuss students' new drawings to get at the following idea:

During the day, the land is warmer than the water and hence the air above the land is warmer than the air above the land. This warm, less dense air has a lower pressure than air that is cooler and denser. The wind will blow from the ocean to the land as the cooler air displaces the warmer air. At night, the opposite will occur. The water is warmer than the land, so the air above the water is warmer and has a lower pressure than the air above the land. The wind will blow from the land to the ocean as the cooler air displaces the warmer air. Draw the direction of the wind on the overhead.

Have students answer: What is wind? What causes wind? Students can answer the question independently in their notebooks or as a turn-and-talk. Students should be addressing the following concept:

Wind is simply the movement of air. It is caused by differences in air pressure. Air flows from areas of high pressure to areas of low pressure, thus creating wind. The denser the air is, the higher the pressure it will have. The less dense the air is, the lower pressure it will have. Therefore, wind blows from areas of high air density to areas of low air density.

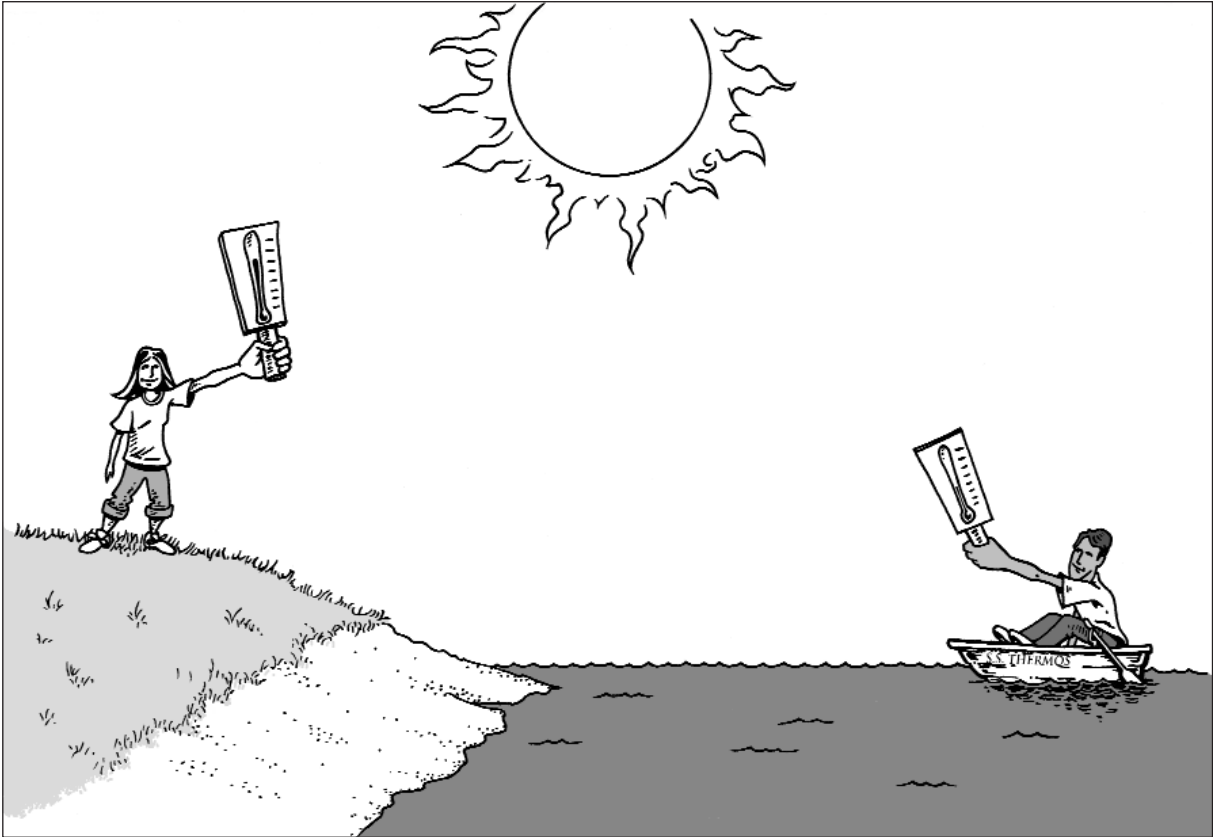
Show students the overhead of John F. Kennedy International Airport (p.50). Tell students that airplanes take off and land into the wind. Ask students which runways would be best for the airplanes to use, and which direction they should take during the day compared to at night. Students should explain the following:

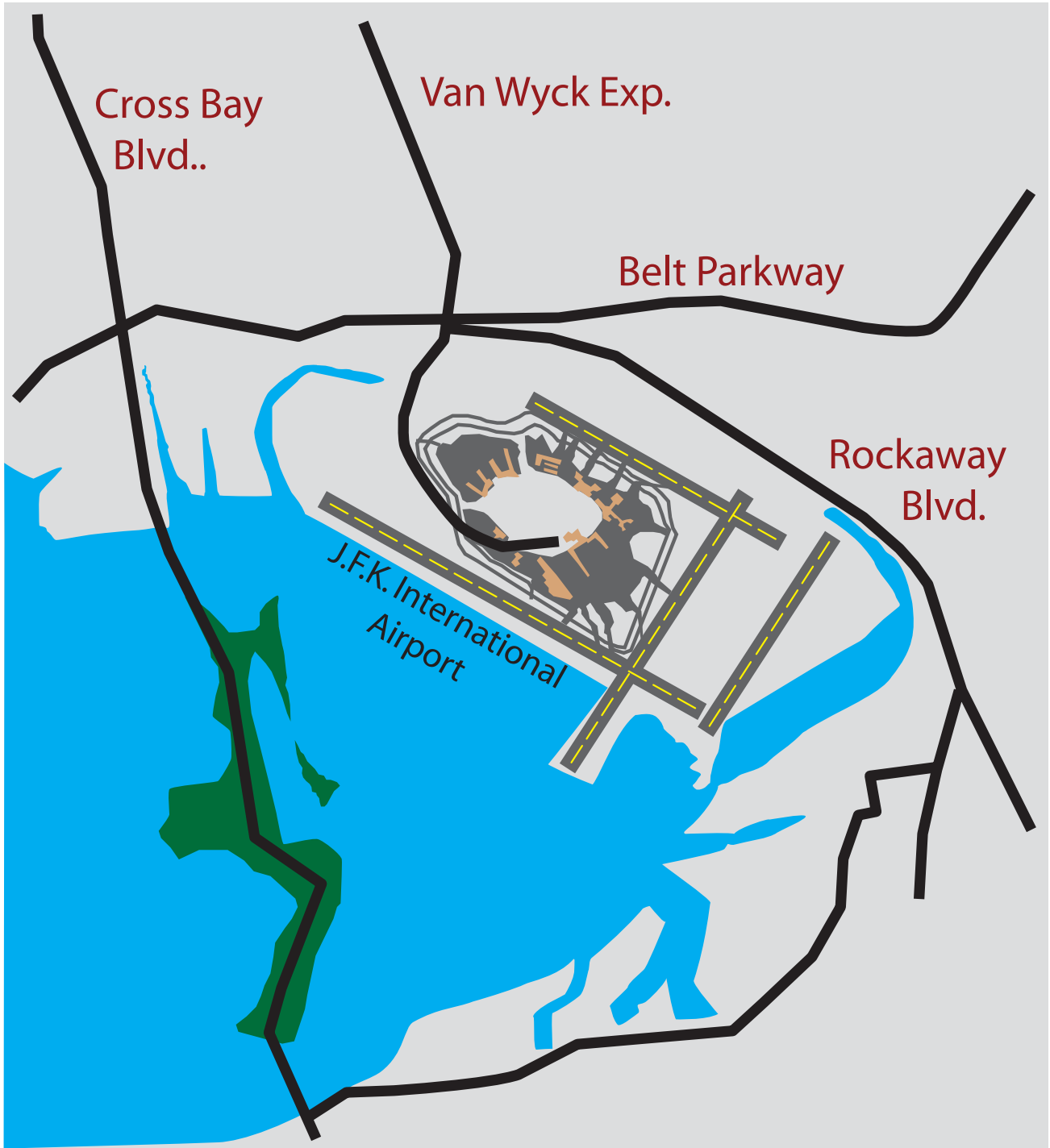
Under normal wind patterns, planes will ideally take off and land on runways perpendicular to the water. Planes at J.F.K. take off toward the water during the day and away from the water at night.

However, because of air traffic congestion, planes also use runways that are parallel to the water. These runways usually have crosswinds, but during some weather conditions (for example, during systems influenced by hurricanes or nor'easters), these runways are with the wind.



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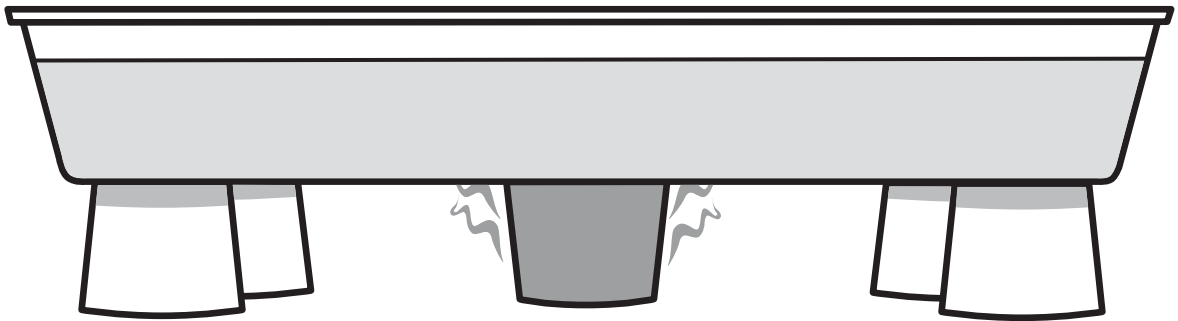


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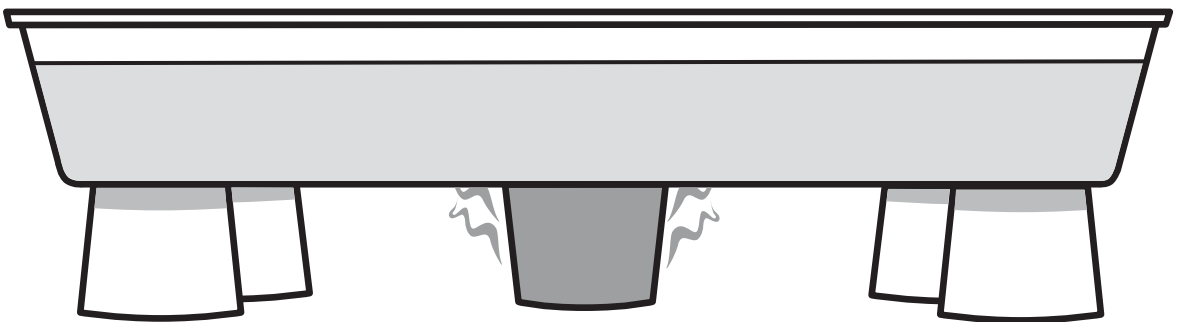
Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

# How is heat transferred through water?

Before conducting the experiment, predict how heat will spread from the heat source (the red cup) through the water. Draw your prediction directly on the diagram below.



To find out how heat travels through water, you will be using a small cup of hot water placed under a pan of room-temperature water. Food coloring will be used to trace how the water moves during the experiment. Your teacher will place several drops of food coloring at the bottom of your pan. Place a dot on the diagram below to show where the food coloring started. Then slide the cup of hot water under the center of the pan. Watch the food coloring and draw its path on the diagram below.



**Follow-up questions:**

1. In your own words, describe how the warmer water moved through the container.
2. Why do you think the warmer water moved in the way it did?

