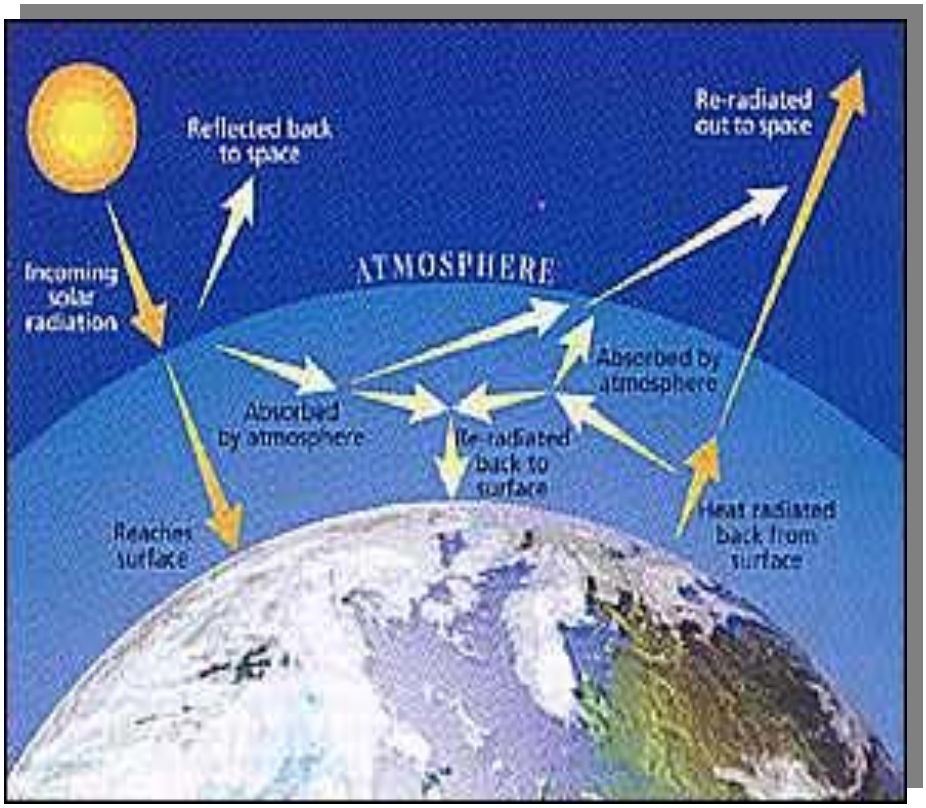
# Heat: An Agent of Change

# Three Methods of Heat Transfer

## TEACHER GUIDE

### BACKGROUND INFORMATION

The three methods of heat transfer are conduction, convection, and radiation. This investigation allows the student to experience these three methods; to determine what type is occurring in specific contexts; and then to apply this understanding to an everyday situation. There are several safety concerns in using these activities. Be sure to address them with the students.




The greenhouse effect is a good example of the three types of heat transfer, but a common misconception is that light from outside the greenhouse passes through the window, turning into heat. Correct understanding of this concept requires the knowledge that different materials may be relatively more transparent or more opaque to different types of radiant energy. Air and glass, for example, are considered transparent to visible light. Air is also transparent to heat, but glass is relatively opaque to heat. So light passes through the window, but heat does not (at least not very well). Heat is actually created inside the greenhouse like this:

Light travels through the atmosphere, through the greenhouse windows, through the air inside the greenhouse, and finally hits some solid material, like a flowerpot or a bench, where it is absorbed. The light interacts with the material and changes into heat. This raises the temperature of the flowerpot or bench, which, in contact with air around it, heats up the air by conduction. The air inside the greenhouse convects and carries the heat up to the windows, where it is unable to leak out into the outside air. This warms up the internal air, and we notice the increased temperature when we enter the greenhouse.

### STANDARDS ADDRESSED

#### Grades 5-8

Abilities Necessary to Do Scientific Inquiry
Physical Science: Transfer of Energy

#### Grades 9-12

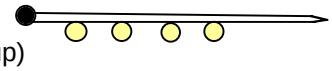
Physical Science: Conservation of Energy and the Increase in Disorder

## MATERIALS NEEDED

Safety glasses for each student
Copies of student text “Heat and Thermodynamics”
Safety instructions for each station
Chart paper and markers

### Station 1: Wax Dot Demonstration

- Heat source: Bunsen burner, candle, or alcohol lamp
- Metal rods (knitting needle works well) with equidistant, equal-sized dots of wax from a candle melted onto it (one per group)



- Pliers, or ring stand with clamp, to hold the end of the metal rod while it is being heated
- Aluminum foil

### Station 2: Hot Air Rises

- Heat source: light bulb. (Other heat sources, such as a candle or alcohol lamp can be used but present a higher danger of fire.)
- Paper spiral on a string through the middle (see diagram—page 5)

### Station 3: Measuring Infrared’s Temperature

- Large, glass prism to separate the wavelengths of sunlight (small or plastic prisms do not work well for this activity)
- Three accurate, sensitive thermometers (can be done with a sensitive thermistor device) (see diagram of setup in student activity)
- Window with sunlight

## PROCEDURE

**Before the Investigation:**

Set up stations around your room with the materials listed above. (Station 4 doesn’t have any materials.) You may want to set up duplicate stations of each activity so students can work through them more quickly. Two stations of each type should be sufficient for a class of 30 students.

[If you have completed the activity “What We Know About Heat” with your class, you may omit the following introductory discussion and start the Investigation.]

Ask: What does the word "hot" mean? If I say that the stove is hot, what does that mean? What is happening when a substance gets really hot? (Accept all explanations at this point. Record these responses on a classroom chart or chalkboard.)

Ask: What are some substances that you know of that are hot? (List a few on the chalkboard or a chart.) What is the source of the heat for each of these? (Some substances, like the Sun for example, may be their own source of heat; others, like a blacktop playground, may be heated by an outside source.

**The Investigation:**

Say:

Today you will investigate heat at four different activity stations. This heat comes from a source and interacts with other matter. It will be your challenge to discover the source of the heat, how it gets to the material, and how it interacts with it. Stations contain some equipment that can be harmful or dangerous. Please pay attention to the safety instructions at each station. (Go over these instructions if they are new to your students.)

Wear your safety glasses at all times.

Divide the class into groups of three to four students. Let them rotate through the stations and collect their data. Limit groups to a maximum of four students. This may require more time to rotate through the stations, but is critical for student interaction and safety.

**After the Investigation:**

Bring the students back into a whole class. Give them this scenario:

You are at the beach or at the pool. The sun is shining on you and you feel your skin get a little tender. You fear that you are getting sunburned. So, you jump into the water and get out into the breeze and feel cooler on your body, but now the bottoms of your feet are beginning to burn. Which of these stations gives us information about why you are getting sunburned? (Station 3) Which addresses the issue of feeling cooler in the water? (Station 1 and/or 4) Which tells why you feel cooler in the breeze? (Station 2) Which station addresses why your feet feel hot on the beach? (Station 1)

As each of these situations is discussed, have students report on the results of their investigations at each station. Encourage lab groups to question other groups if their results are different. Discuss these differences. Continue until all stations have been discussed and all groups have had a chance to contribute in some way.

Go back to the classroom chart created during the introduction or from the activity “What We Know About Heat.”

Ask:

Are there any similarities between this list of what happens when a substance gets hot, and what was found in the investigations? Allow students to adjust their list to include what they discovered or add to the list if necessary.

Assign the student text “Heat and Thermodynamics.” In a class discussion, introduce the terms: *conduction*, *convection*, and *radiation*. Then direct student groups to determine which type of heat transfer they experienced in each station. (Station 1: conduction, Station 2: convection, Station 3: radiation, Station 4: conduction)

**Homework Assignment:**
Students should observe their world as they return home and find examples of each type of heat transfer in their home, school, or neighborhood. They should be prepared to share these with the class during the next class period.

**The Next Class Period:**
Create a chart that lists the three types of heat transfer and includes spaces for students to record examples as they enter the room. Confirm the examples recorded by other students with the class. If there are examples that are placed incorrectly, take time to discuss each. Allow students to challenge other students on the placement of their example. If a conclusion cannot be reached, write *disputed* in the appropriate space as determined by the students.

**Extended Activities or Homework Assessments:**
Students can choose one of the activities from the Additional Learning Opportunities to complete individually or in small groups. Students should prepare a procedure, get it cleared by the teacher, and then conduct the chosen activity. They may write it up, include it in a portfolio, and/or present the results to the class on a specified day.

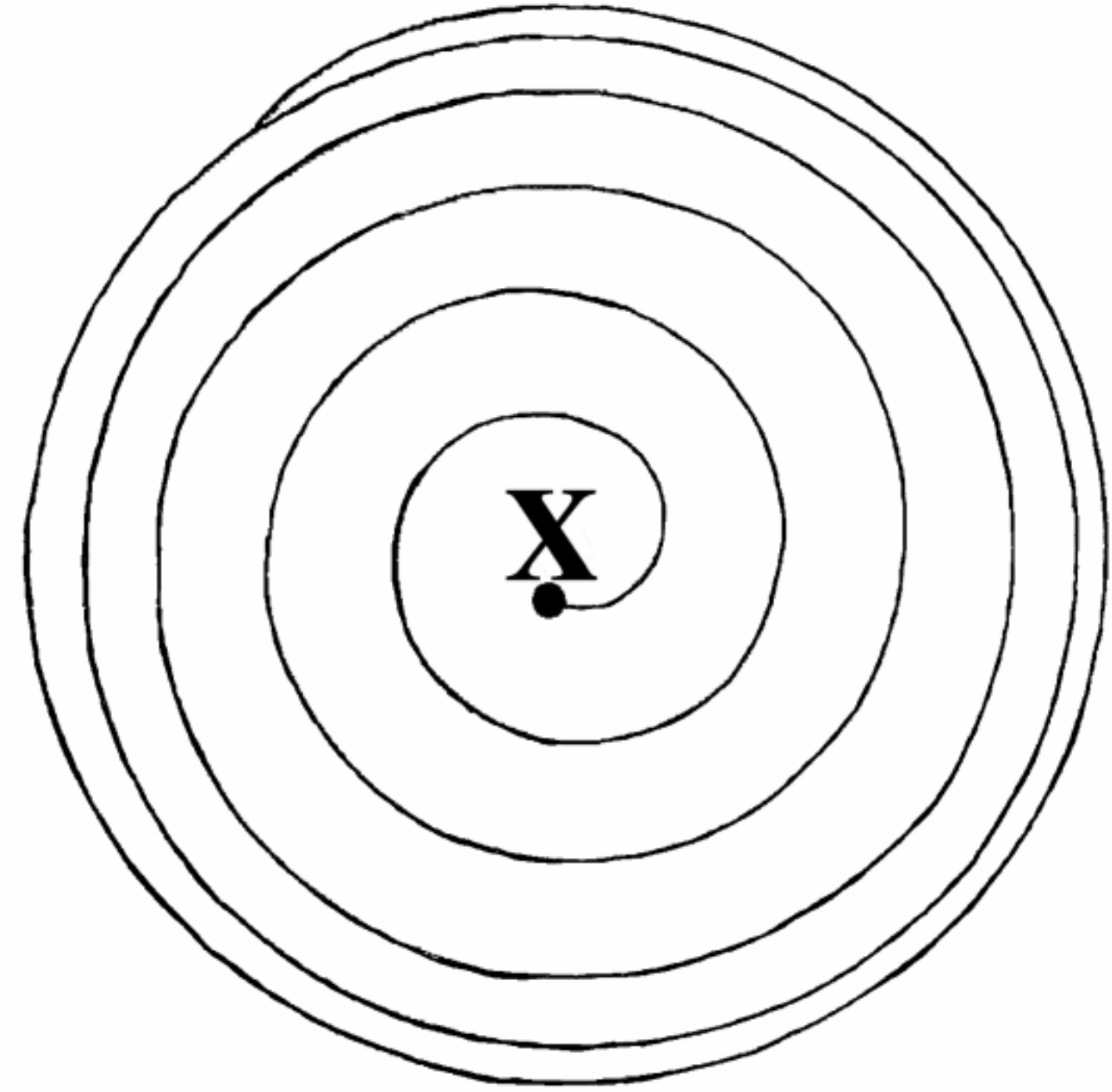
## ADDITIONAL LEARNING OPPORTUNITIES

1. Students can determine the ventilation and heating paths in your classroom or their home. If several students do this, they can look for common patterns. For instance, many heat vents are low in the wall or in the floor, while many air return vents are near the ceiling.
2. Students can report on weather, the water cycle, ocean currents, El Niño, etc., in terms of the circular movement of liquids or gases and the uneven heating of the Earth's surface.
3. Students may design an experiment to gather data on the transfer of light/heat energy through glass into an enclosed area, such as a car or greenhouse model. The common misconception is that sunlight interacts with the window to cause heat. Actually, radiation passes through transparent objects. It is when the light hits the car seats that it changes to heat energy.
4. Students may design an experiment to test the hypothesis that color affects the absorption of heat.
5. Students may design and test the operation of various types of solar cookers or solar water heaters.

## RESOURCES

http://sprott.physics.wisc.edu/demobook/intro.htm
This is a collection of demonstration activities in physical science. Several of the activities in section "2. HEAT" deal with methods of heat transfer.

http://www.cocc.edu/~bemerson/classes/212labs/212lab3d.html
This site from Central Oregon Community College is the discussion around lab activities (not included here). Lab #3 is on Thermal Conductivity. Students might enjoy the writing style.




Cut out spiral for “Hot Air Rises” as noted on page 2. Insert threaded needle through center of X and hang over heat source.