

# Post-Show

# THE SCIENTIFIC METHOD

## *AFTER THE SHOW*

We recently presented a show at your school, and thought you and your students might like to try out the scientific method on your own. The following activities are designed to review and extend the ideas covered in the show.

Please remember to use appropriate safety measures for all activities. An adult instructor should always supervise students during experiments.

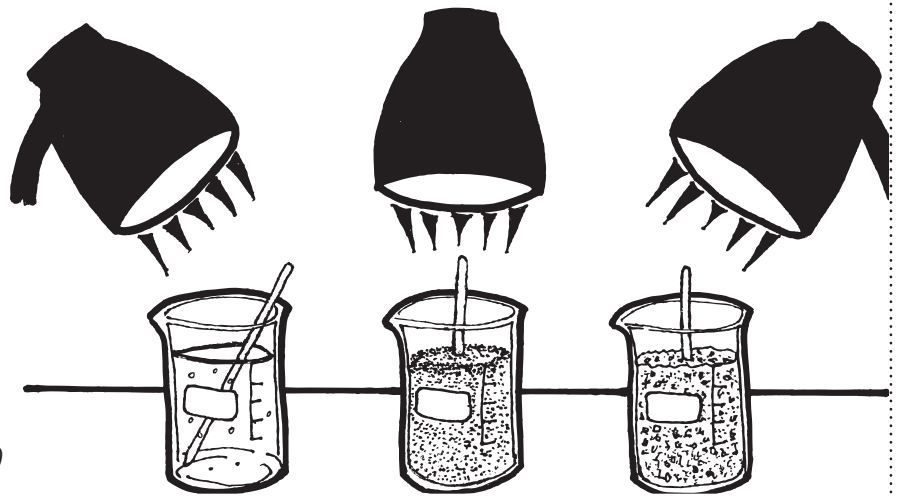
Visit us online at [www.fi.edu/TSS](http://www.fi.edu/TSS) or contact us at [tss@fi.edu](mailto:tss@fi.edu).



# SCIENCE AT THE BEACH

FOR GRADES 1-4

In the show, we learned that we can use tools to measure how a material's temperature changes when we add heat energy. In this activity, students will collaboratively design and conduct an experiment to determine how the addition of heat changes the temperature of different materials.



## EQUIPMENT

*Water, sand, & other land materials (such as soil)*

*Glass beakers*

*Thermometers*

*Hot lamps*

## PROCEDURE

1. Think back to your last visit to the beach – recall the feel of hot sand and cool water. Since the sand and water receive the same heat energy from the sun, why is one so much hotter?
2. Observe samples of sand and water. Ask students how they could measure the temperature of the water as heat energy was added.
3. Lead students towards a procedure. For instance, students could put samples of sand and water in separate beakers under a hot lamp, and measure the temperature every 3 minutes for 30 minutes. (Students may wish to test other materials as well, such as soil, mud, or clay.) What is the independent variable in this experiment? What is the dependent variable?
4. Brainstorm all the variables that should be controlled, or held constant, to make it a fair test. For instance, students should use the same type of lamp over each material and the same amount of material in each beaker. Make sure these are held constant in your procedure.
5. As students carry out the procedure, encourage them to record their data in a table.
6. Graph the change in each material's temperature over time. Which material heated up the fastest? Consider how these results help explain why the sand at the beach gets hotter than the water. When solar heat energy reaches the surface of the Earth, do you think land or water experiences more temperature change?

## WHY?

In this experiment, students vary the type of sample material (the independent variable) and measure its temperature (the dependent variable). All other variables are held constant, so that students know that a difference in temperature must be the result of different materials. We discover that water heats up (and cools down) more slowly than land materials, even when they receive the same amount of heat. This helps explain our observations about the beach, as well as other phenomena. For instance, how do you think this might affect weather in coastal areas?

# EXPLORING PENDULUMS

FOR GRADES 3-6

A pendulum is a simple device, but what determines its swing? Students typically suggest three variables that might influence a pendulum's swing: the weight of the pendulum, the angle at which it is released, and the length of the string. As we discovered during the show, the scientific method offers one strategy for answering questions like these. In this activity, students design and conduct experiments to test which variables influence the swing rate of a pendulum.

## EQUIPMENT

*Strong string (such as kite string or fishing line)*

*Small weights (such as fishing weights)*

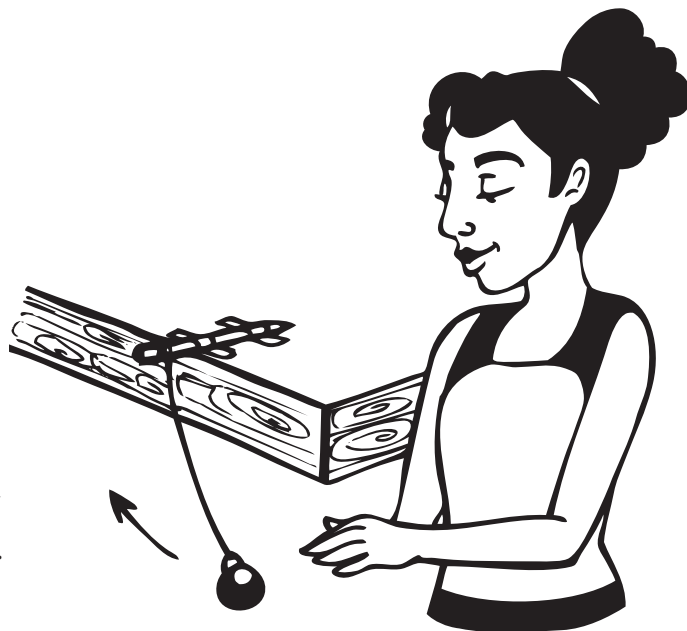
*Pencils*

*Tape*

*Rulers, protractors, and stopwatches (optional)*

## PROCEDURE

1. Look at a grandfather clock (or a picture of one). The swinging weight is called a pendulum. Can you think of other examples of pendulums?
2. To make a pendulum, tie or tape a weight to one end of the string. Tie the other end of the string around the pencil. Tape the end of the pencil to the edge of a table, so that the string hangs off the table and swings freely.
3. To start the pendulum, pick up the weight and pull it up at an angle. Release and observe how it moves. How can you measure how fast it swings? Lead students to calculate the swing rate as the number of swings in ten seconds. (Note: A swing is a complete back-and-forth cycle.)
4. Discuss ways you could change how fast it moves. In other words, what variables might affect the pendulum's swing rate?
5. Help students design controlled experiments to test the effects of each variable. Make sure it's a fair test – change only one variable at a time, keeping everything else the same!
6. Monitor students as they conduct their experiments in pairs or small groups. Encourage students to record their data in a table.
7. Share results as a class. Which variables did influence the swing rate? Based on your results, how could you make the pendulum swing more slowly? Why did you have to change only one variable at a time, keeping others constant?



## WHY?

To determine which factors do affect the swing rate, students must conduct controlled investigations in which they change only one variable at a time. If we changed both the length and the weight, we wouldn't know which variable was really affecting the swing time. After experimenting, we find that only the length affects the swing rate! This is surprising to many students, which is exactly why we do science: careful observation and experimentation allows us to uncover unexpected truths that we may not have guessed otherwise.

# DESIGN A WINDOW

FOR GRADES 5-8

During the show, we conducted experiments to learn about different methods of heat transfer. In this activity, students will design and conduct an experiment on heat transfer through windows, then apply the results to make a recommendation in a real-world situation.

## EQUIPMENT

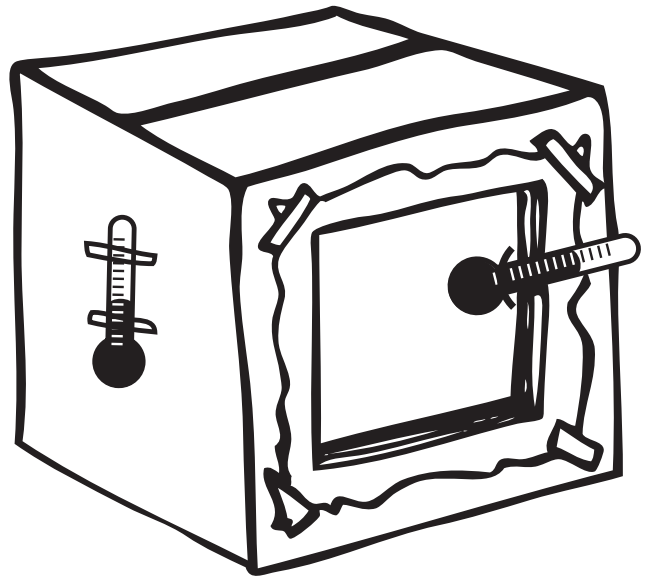
*Corrugated cardboard boxes*

*Scissors*

*Clear plastic sheeting (available at most hardware stores)*

*Tape*

*Thermometers*



## PROCEDURE

1. Discuss heat transfer through windows. Compare and contrast the windows in your building. How might different features affect heat transfer – and how can we test that?
2. Show students how to use a cardboard box to simulate a building. Cut a hole on the side of the box. Adhere plastic sheeting over the hole to represent glass panes. Make another small hole in the top of the box. Carefully insert a thermometer into the hole, so that you can read the temperature from above the box, and tape in place. Tape another thermometer to the outside of the box. Place the box outside or in a sunny window, then record the temperatures inside and outside the box at regular intervals.
3. Help students to brainstorm variables that could affect the heat transfer. For instance, you could add a second pane, window tinting, curtains, or even an awning over the window.
4. Have each student select one variable and write a hypothesis about how that variable relates to heat transfer. Ask students to design and complete an experiment to test that hypothesis.
5. Encourage students to share their results. Which windows would be best in the summer? In the winter? Which features could you combine to make an even more effective window?
6. Have students write a recommendation to the principal or facilities manager about which types of windows and window dressings are the best for your region. Make sure that they use evidence from the experiments to support their conclusions!

## WHY?

A simulation or model is one way scientists answer questions. It's a lot easier to test a model of a building, as you did above, than to actually construct multiple buildings for an experiment! Of course, the model is not exactly the same as the real thing, so the results may not be perfectly applicable; but when combined with other observations, a model gives us a pretty good estimate of the situation. What are some possible sources of error when using a model like this, as opposed to testing windows in an actual building?

# MORE INFORMATION...

*We've provided the following information to help refresh your memory about the topics we covered during the show, and to deepen your understanding about the scientific method.*

**Science:** A process for studying the natural world and the information gathered from this process. The process of science involves evidence-based testing and experimentation to explain phenomena. Scientific knowledge is open to constant review and revision as new information and evidence becomes available.

**Observation:** The collection of data or information, either directly or indirectly, through the use of one's senses or tools. Qualitative observations are descriptive (such as "dark blue" or "tastes sour"), and quantitative observations are numerical (such as "10 meters tall" or "100 degrees Celsius"). Observation is often the first step towards asking a scientific question, as when we notice something surprising and wonder how it works; but it is also used throughout the scientific method to gather information that helps answer the question.

**Question:** A scientific question tries to explain the natural world, is testable, and relies on evidence. "What do iguanas eat?" or "How hot is the sun?" are both scientific questions. "Who is the best singer ever?" is a matter of opinion, not a testable scientific question.

**Hypothesis:** A proposed explanation for a phenomenon. It is based on current understanding, observations, and logical reasoning. The hypothesis leads us to develop predictions about what will happen during specific experiments.

**Experiment:** A method of testing that relies on the controlled manipulation of variables in a system or event, and careful observation of the results. Experiments are one way, but by no means the only way, to test a hypothesis.

**Variable:** An element or factor that can change or be changed. In an experiment, the scientist manipulates the independent variable to study its effect on a system. The dependent variable is the one that responds to changes in the independent variable. For instance, a scientist might change the weight of an object (independent variable) and see if that affects how long it takes to fall 10 meters (dependent variable).

**Controls:** All the variables that are held constant in an experiment. Let's say a scientist wants to find out if a plant will grow faster under a blue light or a red light. In this case, the color of the light is changed; but the type of plant, temperature, and amount of water and soil will be the same for all the plants. This ensures it is a "fair test," so the scientist can compare the plants under the red light to the plants under the blue light.

**Control Group:** A group in an experiment that is not exposed to the experimental treatment. In medical trials, for instance, some patients receive the experimental medication. Patients in the control group receive a placebo like a sugar pill. Then scientists compare the results of the patients in the experimental group to patients in the control group to figure out the effect of the medication.

**Data:** Information gathered by observation. Data is usually gathered in a controlled manner, often by standardized measurement of the dependent variable. Scientists carefully record their data so that it can be peer reviewed.

**Graph:** A visual representation of data and data trends. Some graphs (such as bar graphs) show us the differences

between groups, while other graphs (such as line graphs) show the relationship between variables.

**Conclusions:** The final analysis of an experiment or scientific investigation. A conclusion uses evidence from the investigation to either support or refute the hypothesis. The conclusion also typically includes discussion of possible sources of error in the experiment and suggests questions for future investigations. Conclusions are often published in scientific journals to facilitate peer review.

**Peer Review:** The process of allowing scientific colleagues to read and evaluate published scientific articles. Other scientists are encouraged to review not only their peers' conclusions but also the methodology of the investigations, sometimes even repeating a published experiment in order to validate the objectivity and accuracy of the study.

**Scientific Theory:** A general, evidence-based explanation that encompasses a wide variety of phenomena. Theories often combine many hypotheses into one concise explanation. Although in everyday usage theory means "just a hunch," a scientific theory has strong, extensive support. Yet theories are still subject to modification as a result of new evidence.

## MORE RESOURCES...

**The Franklin Institute:** On your next field trip, look for examples of the scientific method throughout our exhibits. Then conduct your own experiments about the heart, electricity, trains, and more! Check out <http://www.fi.edu/teacherresources/> for exhibit guides.

**Variables Curriculum:** Visit <http://www.fi.edu/msp/variables/index.html> for a collection of inquiry-based activities. These fun, hands-on lessons develop students' abilities to design controlled experiments.

**The Franklin Awards:** Each year, the Franklin Institute honors outstanding achievement in science, engineering, and technology. At <http://www.fi.edu/franklinawards/>, you can read about how the award winners use the scientific method in their work.