Heat: An Agent of Change

Activities with Insulators and Conductors

TEACHER GUIDE

BACKGROUND INFORMATION

It is fascinating to examine common household objects closely. For example, a thermos bottle is a real "heat cage." It is a double walled glass container with a silver coating on the inside. How does it insulate the liquids it contains? First, glass is a poor conductor of heat. Second, it may be called a vacuum bottle because most of the air has been removed from between the double walls and that leaves very few air molecules to remove heat through convection currents. Third, the silver reflects heat back so very little is lost to radiation.

Remember, gases in general are not good conductors of heat. However, moving gases can transmit heat through convection. This is the principle behind “trapped air” insulators, such as double pane windows and fluffy sweaters.

The human body is like an oven set at 98.6° F (37° C). The digestion process changes chemical energy to heat energy. When the weather is cold and you put on a coat, the coat does not warm you. You warm the coat! An unlined nylon jacket cannot insulate very well; thus, the body loses heat rapidly. But a nylon jacket lined with material that is an effective insulator will contain the heat. A metallic-looking thermal survival blanket reflects heat radiation, so a warm body under the blanket retains its heat.

STANDARDS ADDRESSED

Grades 5–8

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Physical Science: Properties and changes of properties in matter; Transfer of energy
Abilities of technological design
Understandings about science and technology

Grades 9–12

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Physical Science: Interactions of energy and matter
Abilities of technological design
Understandings about science and technology

MATERIALS NEEDED

A collection of household items that are either insulators or conductors. (Some may be opened to show how they work.)

A collection of materials that may be used for insulating the pizza packages: newspaper, polystyrene foam in any form, waxed paper, quilt stuffing, feathers, aluminum foil, wool, cotton, acrylic, nylon, fur, masking tape, cotton balls, copper, brass, wood, plastic, marshmallows, and so on.
Equipment for experiments, including heat sources (light bulbs work well) and thermometers
Shoeboxes are useful in labs of this type, both as containers and as lab equipment

PROCEDURE

At least a week before this activity takes place you will need to begin collecting real world examples of conductors and insulators. These can be natural or engineered objects. Remind students to add to the growing collection. They should look especially for food and beverage containers such as foam coolers, bun warmers, and beverage immersion heaters, and for "people containers" such as mesh T-shirts, puffy coats, and sleeping bags.

On the day before this activity, arrange the samples in two groups, one of insulators and one of conductors. If possible, take some apart. Show the stuffing inside a sleeping bag or down coat. Saw a thermos bottle in half (or provide an ad or diagram showing the same thing).

Students will need an opportunity during the first lab period to examine the samples carefully. Circulate among lab groups while checking that they are recording their observations. Encourage students to consider the three methods of heat transfer. Remind them that not all insulators and conductors rely solely on a single method.

Remember to use the vocabulary "heat as the energy of moving molecules."

Say:

1. Sometimes we want the more active molecules in the warm area to hurry up and bump and jostle the slower moving molecules in the cooler area. Then all the molecules will be moving at the same speed. But sometimes we want the more active molecules in the warmer area to leave the slower moving molecules in the cooler area alone as much as they possibly can. We do not want the faster ones to lose any of their heat energy.

Students need to be reminded that heat is energy, not matter, that can be added or taken away from an object.

Connect the need to control the movement of heat with a problem from their real world . . . cold pizza delivery. This may be more significant to teenagers than the difficulties faced by the Genesis engineers.

Rename student lab groups as Research and Development (R&D) teams hired to do the preliminary studies to find materials that might be suitable for a fictional company's new insulated pizza packaging.

Students should design experiments to determine which materials are good conductors and which are good insulators. Use appropriate questions to guide them in their thinking and to encourage them to keep experimenting; a lab group that can order a list of six or seven materials with respect to thermal conductivity has definitely achieved concept mastery.

This activity sets the stage for the final activity in this module, in which student groups cooperate and share information to complete a construction project related to the Genesis mission. Because Product Design Teams will have different members than the R&D groups, it is critical that each student participating in this activity keep accurate records of results of the experiments. Each student will carry the research and development information from his or her R&D group to his or her Product Design Team for a final project.

Students should then consider other basic properties of the substances they are testing, for example, “substance X has a low conductive coefficient, but it stinks when it gets hot.” This activity can end with a class discussion to share some results. Students may want to start thinking about trade-offs. Is it worth using a good insulator if it will cause objectionable odors when it is heated?

ADDITIONAL LEARNING OPPORTUNITIES

Examine ads for objects that claim to transmit or insulate better than other materials. Determine the validity of these claims.
A commercial currently running on TV (Fall, 1998) doesn't compare the taste of the restaurant's pizza or the abundance of toppings with any of its competitors. Instead, it promises better pizza because of a better insulated packaging to keep the pizza hot until it is delivered. Poll potential pizza purchasers to determine whether the temperature of their delivered pizza is less, as, or more important than its taste.

RESOURCES

SEPUP Module: Plastics In Our Lives, Activity 5: Products and Properties, (1992) The Regents of the University of California, pp. 65–76.
The activity encourages students to compare the properties and insulating ability of synthetic and natural polymers.

Hackett, J. "Inquiry: Both Means and Ends," (September, 1998) Journal - The Science Teacher, pp. 34–37.
This article uses the Standards to define inquiry methods and outcome.