Be a Materials Scientist

Physics Question: ***How well does heat energy transfer through different materials?***

MATERIALS:

- Handwarmers (1–2 per 3–4 students)
- Liquid crystal thermometer strip (1–2 per 3–4 students)
- Material samples, approx. 6-inch squares of each of the following (1 set per 3–4 students):
  - Knit fabric (cotton)
  - Woven fabric (cheesecloth)
  - Spandex fabric
  - Microfiber cloth
  - Plastic sheeting (table cover)
  - Bubble wrap
- Pencils
- Lab notebooks
- Materials Scientist Career Card
- Optional materials:
  - Pieces of additional materials to test, such as aluminum foil, plastic wrap, paper, etc.
  - Large plastic zipper bags or containers (1 per pair of students)
  - Images or video of people skiing
  - Extra handwarmers

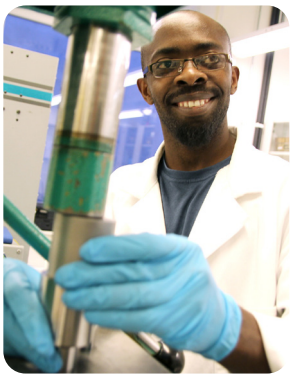
Prepare

1. Cut the fabrics and other materials into pieces as needed to have one piece for every three to four students. Pieces should be large enough to fully cover the handwarmer (approximately six inches square), but the exact size isn't important. Once the pieces are cut, they can be reused with multiple groups of students.
2. Familiarize yourself with the instructions for the handwarmers you are using so you know how to activate them.
3. If you are using reusable handwarmers, reset them between uses by immersing them in boiling water for 5–10 minutes, until they are fully liquid again. You may want to have extra handwarmers to exchange for cooled ones if you are including extension activities or leading multiple sessions in a row.
4. (Optional) Assemble student kits by placing one handwarmer, one thermometer strip, and one piece of each material type in a large zipper bag or other sealable container.
5. Before beginning the activity, hang the Research Lab sign in a visible location.

For younger students, you can simplify the activity by limiting the material choices to three: knit fabric, microfiber cloth, and plastic table cover.

For older students, consider adding additional materials like the optional materials listed above, or allowing them to suggest their own materials.

Engage



1. Introduce the materials scientist career by showing the group the career card and asking questions to encourage students to think about what a materials scientist might do:
   - *What do you notice about this picture? What do you think this person is doing?*
   - *What do you think a materials scientist might do or study?*
2. Explain that materials scientists study what different kinds of material are like—how strong or flexible they are, or how they react to water, light, or heat. They might create new kinds of materials or choose the right materials for a specific job.
3. Introduce the storyline of the activity like this:
   - Imagine that we are a team of materials scientists and this is our lab. What does our lab look like?
   - We work for a company that makes sports equipment for athletes—things like tennis rackets, skis, balls, or uniforms.
   - Our job is to choose the best materials for each piece of equipment, to help the athlete hit harder, ski faster, and so on.
   - We've been asked to develop the material to make suits for a ski team.
4. Ask students what they have seen or heard about skiing. You may want to refer to the pictures in their lab notebooks, or show some additional pictures or video of skiing, if students aren't familiar with the sport.
   - *Where does skiing happen? What do skiers do?*
   - *What kind of clothing do people wear to ski?*
   - *What do you think is important for a good ski suit? What does it need to help the skier do?*
5. Point out that one important feature of the suit is to keep the skier warm. That means thinking about **heat—which is a kind of energy**! The suit needs to keep the skier's body heat inside, close to their body, to keep them warm. As materials scientists, you'll need to think about how different materials can trap heat or let it pass through.
   - *What kinds of clothes do you wear to keep warm in cold weather?*
6. **Make connections** to students' experiences by asking them to think about everyday examples of materials getting hot (or not). Highlight how the materials transfer heat or block it. For example:
   - *When you put a pan in the oven or on the stove, what happens to it? (It gets hot because it soaks up heat energy from the oven or stove.)*
   - *What happens if you touch the hot pan? (It passes that heat energy into your hand. Ouch!)*
   - *What do we do instead if we want to pick up a hot pan? (Use an oven mitt to block the heat.)*
   - *What kinds of materials are oven mitts made from?*
   - *Can you think of other things you've seen that soak up heat energy (get hot)?*
   - *What about things that block heat energy—they don't get as hot, even when they're near hot things?*

For older students, introduce the word "insulate." Ask if they have heard it before, and what objects or materials they've heard about that are insulated. Insulating materials are materials that don't easily absorb heat energy, so they keep it from passing through.

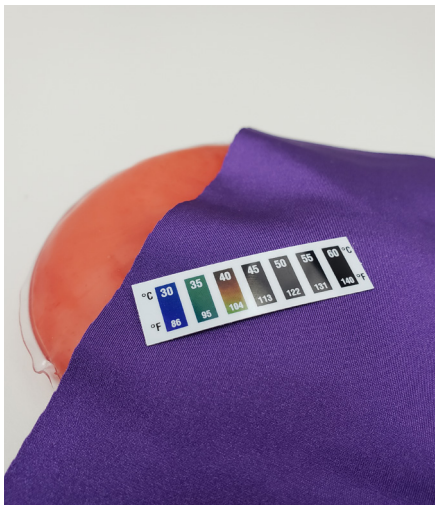
7. Summarize the big idea: some materials soak up heat energy and pass it on; other materials block heat energy and stop it from passing through. For the skiers' uniforms, **your team needs to find materials that stop heat energy**, so the skier's body heat stays close to them and doesn't escape into the cold air.
   - *What kinds of materials can you think of that might be good at blocking heat?*
   - *Scientists test their ideas, so let's go into our research lab and find out more!*

Explore

1. Divide the group into research groups of 3–4 students. Explain that they will be testing different types of material to see which ones block heat the best. Then, they can decide which material (or combination of materials) would work best for the ski suit.
   - *How could we test materials for our ski suit to see which ones block heat the best?*
2. Point out that they don't have the actual skiers (or snow!) to study, so instead they will use a **model**—a smaller, simpler version they can use to test ideas on. Introduce the parts of the model—the handwarmer and material samples—and **ask questions** to help students connect the parts to the real-life situation:
   - *What do you think the handwarmer stands for in real life?*
   - *How could we use these parts to test which materials keep a person warm?*
3. Introduce the liquid crystal thermometer strips. These are the measuring tools they will use to find out how much heat gets through the different materials. Remind the group that an important part of science is handling tools carefully:
   - *These tools are small and breakable. What tool rules could we make so they don't get lost, bent, or broken?*
4. Distribute materials and demonstrate how to activate the handwarmers. Invite students to try out the thermometers by measuring the temperature of the handwarmer and recording their observations on p. 13 of their lab notebook. Suggest the following tips:
   - Hold the thermometer strip flat against the handwarmer by holding down both ends.
   - The handwarmers take time to warm fully. Wait a minute or two (or until the thermometer reading stops changing) to record the final temperature.

Note: There are multiple ways to interpret the thermometer readings. Some students may use the marked temperature scales (Celsius or Fahrenheit) to record a numerical temperature. Others may count the number of blocks that change color or notice which block changes to a particular color. Each pair may determine their own method, as long as they use the same method throughout their tests.

5. Invite students to test the different material samples by placing a material over the handwarmer and measuring the temperature on top of the material:
    - Check the temperature of the handwarmer alone before each test, to see if it has changed.
    - Heat may move through the material slowly, so wait for the thermometer to stop changing.
    - Record the results on p. 14 of your lab notebook.
    - Notice the difference between the handwarmer's temperature alone and the temperature above the material. How much of the heat was blocked?



6. As students work, **encourage scientific thinking** by inviting them to make predictions, test ideas, and explain their thinking:
    - *Which material do you think will be the best at trapping heat? Why?*
    - *How much of the handwarmer's heat got through that material? All of it? Part of it? How can you tell?*
    - *What have you found out so far? Was there anything that surprised you? Why?*

For younger students, or those having trouble comparing or recording temperature data: Give research pairs two thermometer strips. Encourage them to cover half of the handwarmer with the material sample; then place one thermometer on the uncovered half and one on the covered half. This allows them to directly compare the two temperatures.

7. As groups finish testing individual materials, encourage them to apply their findings to designing a ski suit and test their ideas:
    - *How could you improve on these materials? Could you combine different materials? Or use multiple layers of one material?*
    - *What other features might be important for the ski suit's material? Flexibility? Comfort? Weight? Strength?*

Reflect

1. Gather the whole group together. Ask students to indicate by show of hands which fabric was best at stopping heat, based on their research. **Cultivate rich dialogue** by inviting them to discuss their findings:
    - *Which ones were the worst? Which were in the middle?*
    - *Were there any results that surprised you? Why?*
    - *Do the best materials have anything in common? Can you think of any other materials that might be good at blocking heat?*
2. Invite groups to share their best solutions for the ski suit material:
    - *What material(s) did you choose? How did you decide on your design?*
    - *What other features or changes would you make to improve the material even more?*
    - *What recommendations should we give about the best material for the ski team's suits?*

3. Encourage the group to reflect on how they were like materials scientists during the activity. You may want to show the materials science career card again, or refer to the science skills stickers in their notebooks:
    - *What are some of the things we did today as materials scientists?*
    - *How did we think like scientists? What science skills did we use?*
    - *What did you do today that made you feel like a scientist?*
4. Allow time for students to draw or write their reflections in their lab notebooks. Invite them to choose a science skills sticker that reflects a skill they used and add it to their notebooks.

Extend

- Encourage students to suggest other materials they think will be good at blocking heat and find or bring them in to test.
- Invite students to draw designs for their ski suits, showing what materials they would use for different parts of the suit, and what other features it would have.
- Imagine that your sports equipment company also needs to make jerseys for soccer players who play outdoors when it is very warm instead of very cold. Ask students to design and test a material for these hot-weather jerseys. What kind of materials would they want for keeping an athlete cool instead of warm? What other features might the material need to have?

Background

- **Materials scientists** study solid materials—what they are made of, how they are put together, and how that affects the way the materials behave. They might test materials to choose the right one for a specific purpose or design a new material to do the job even better. For example, they might design strong, lightweight building materials for skyscrapers or aircraft, choose the best plastic for a bike helmet to absorb impact, design waterproof coatings for backpacks and jackets, or create the touch screens and sensors on mobile phones that respond to pressure or light. Materials scientists need to understand **physics** to study how a material interacts with different forces and types of energy, like electricity, heat, light, pressure, or gravity.
- **Heat is a kind of energy** that represents how much the atoms or molecules of a substance are vibrating. (So, in fact, heat is just another type of motion energy!) Heat energy can flow from one object or material to another, or from one part of a material to another part. Cold is *not* a separate kind of energy; rather, it is just a lack of heat energy. When you feel a cold wind, it's because the air rushing past you has less heat energy than the air that was there before. When your finger feels cold after touching an ice cube, it's because heat energy has flowed out of your finger and into the ice cube.
- **Materials interact with heat differently**, depending on the substances they are made from, and how they are arranged. Some materials, like many metals, absorb and release heat quickly and easily. Other materials, like many plastics, do not absorb heat energy as easily as metal. A good example of this is the seat belt in a hot car: the metal buckle gets much hotter than the plastic holder or the fabric strap.
- **Insulating materials**—materials that do not easily absorb or transmit heat—are used as barriers to stop heat energy from flowing from one place to another, either to hold heat in (to keep something warm) or to keep it out (to keep something cool). Many insulating objects, like insulated mugs, coolers, or the insulation used in building houses, combine an insulating material with trapped pockets of air. In this activity, students may find that the best heat-blocking materials are bubble wrap and microfiber cloth. Both of these materials incorporate trapped air: in the bubbles of the bubble wrap, and between the tiny fibers of the microfiber cloth.

Materials Scientist Quick Guide

ACTIVITY SECTION	DO	ASK
Engage	Use career card to discuss career Introduce story: • Work for a sports equipment company • Choose best material for a ski suit Discuss examples of materials absorbing/ blocking heat	*What do you think this person is doing?* *What do you think a materials scientist does or studies?* *What do you think is important for a good ski suit to have or do?* *When you put a pan in the oven, what happens to it?* *What materials can oven mitts be made from?*
Explore	Introduce model Measure temperature of handwarmer Test material samples for heat-blocking ability Adapt or combine materials to design ski suit material	*Which material do you think will be the best at blocking heat?* *What have you found out so far?* *What could you do to improve these materials?* *What other features might be important for the ski suit material?*
Reflect	Share group results & designs for ski suit material Report conclusions to sports equipment company Reflect on career connections Use stickers & notebook to draw/write reflections	*Which materials were best at blocking heat?* *How did you decide on your ski suit design?* *What recommendations should we give about the best material for the ski suits?* *How were we like materials scientists today?* *What science skills did you use?*