FACILITATOR GUIDE
Temperature Mapping

Learning objectives

Learners engaged in this activity will explore these main ideas:

- Earth is a constantly changing and dynamic system.
- Different types of land cover on Earth absorb or reflect energy from the Sun in different ways.
- NASA scientists study land cover to understand and predict how Earth's climate is changing.

Materials

- Liquid crystal sheet
- Heat lamp setup (65+ W bulb, lamp with guard, and steel stand and clamp)
- Electrical outlet (not provided)
- Infrared thermometer
- White tile
- Black tile
- Clay paving stone
- Sphagnum moss (peat moss)
- Sign, sign stand, information sheets, and activity and facilitator guides
- "Tips for Leading Hands-on Activities" sheet

The Explore Science toolkit comes complete with all necessary materials for this activity. Materials are also readily available to create or restock activity kits. All graphic files can be downloaded from www.nisenet.org.

Safety

The light bulb can become very hot and should never be touched. Remind visitors to keep their hands away from the bulb.

Do not point the IR thermometer directly into anyone's eyes. The thermometer's laser can cause serious injury or even blindness. Assist younger participants with using the IR thermometer to ensure it is not pointed directly into someone's eyes.

Advance preparation

About 15-20 minutes before you plan to engage participants in the activity:

- Assemble the lamp and stand.
    - First, screw the metal rod into the black base.
    - Attach the steel ring about two inches from the top of the steel rod. Turn the finger fastener until the ring is firmly attached to the rod.
    - Thread the black vinyl grips of the clamp lamp through the steel ring.
    - Squeeze the clamp and attach the black vinyl grips to the steel rod so that the lamp is resting on the ring. Adjust the angle of the lamp so that it points down onto the table.
- Turn on the lamp and place the tiles, the container of peat moss, and the paving stone under the lamp for about 10 minutes. Allow the objects to sit under the lamp so they can begin to warm up.

Notes to the presenter

Landsat satellites use a thermal infrared sensor to measure land surface temperatures. IR technology, like the IR thermometer in this activity, uses the infrared light emitted by an object to measure its temperature remotely (without having to touch it!) By taking a series of measurements over an area, a scientist can create a visual representation of the surface temperatures (like a weather map for surface temperatures rather than air temperatures.)

The liquid crystal sheet is a visual representation of temperature. The science behind how the liquid crystal sheet works is very different from that of infrared imaging but the sheet provides a good entry point into conversations about thermal imaging because of the visual representation it provides. After the participant has experimented with testing the surface temperatures of the provided materials, refer to the thermal image map of the United States. You can point out where big cities are located and even where the highways measure higher temperatures compared with surrounding areas.

Young children are often fascinated by the liquid crystal sheets, so allow them to spend plenty of time experimenting with them and delighting in the experience. Try taking out a bowl of ice cubes and allow children to compare how the sheets react to contact with cold ice versus a warm hand.

You may want to just use the liquid crystal sheers with young children, but if you decide to also use the thermometer, keep in mind that temperature is an abstract concept that young children may not yet fully understand, so temperature values likely won't have significant meaning to them. Explain that the thermometer is a tool that allows us to measure how hot or cold an object is without touching it, and the higher the number, the warmer the object. Children could try touching the tiles under the lamp to feel for a

temperature difference, and compare their observations to what they observed with the thermometer reading.

Conversational prompts
You can introduce the activity by discussing how Earth is always changing but that humans contribute in significant ways to some changes. We now have the technology to track these human-made and natural changes. The Landsat Satellite Program offers the longest continuous global record of the Earth's surface; the first satellite was launched in 1972 and the Landsat 8 satellite is now in orbit.

For very young participants, you can focus just on the liquid crystal part of the activity and allow them to experiment with placing objects of different temperatures on the sheet.

Optional extensions
Provide participants with simple materials to create roofs for a small cardboard box (e.g., white felt and black felt) and challenge them to choose a roof that reflects the most light and therefore keeps the roof cool.

Difficult concepts

While this activity does not specifically address the causes of global climate change, you may find that you engage with some visitors on this important topic. Some participants might dispute climate change. You can respectfully respond, "Yes, not everyone is in complete agreement about climate change. The great majority of scientists agree it is occurring, and we have a lot of supporting evidence. We are presenting the scientific perspective on the importance of studying Earth from above in this activity." Landsat satellites provide impartial, unbiased data that show changes in Earth's land cover. This activity is designed to focus on tools that scientists use to study Earth and how the data are used to make decisions.

Temperature and heat are different concepts. Temperature is a measurement of the average random motion of molecules or atoms in an object (or system). Heat is energy transferred from one object to another as a result of "thermal interactions." To clarify, heat is the energy transferred when the random motions of atoms or molecules in an object bump into the atoms or molecules in another object, causing that second object's atoms or molecules to move more in a random way.

When the random movement of particles in an object is slower, the object will provide a measurement of a colder temperature. There is no way to "add cold," but you can take away energy to make something colder. Even very, very cold objects have some heat, or movement, of their components atoms or molecules.

If you add the same amount of thermal heat to a liter of water and to a milliliter of water, the temperature (measurement) of the milliliter of water will be much higher than that of the liter of water.

Participants may believe Earth receives heat from the Sun. Earth does not receive heat from the Sun. Earth receives light (including visible and invisible light like electromagnetic radiation which includes infrared light) from the Sun, which is absorbed and causes temperature increases. These temperature increases are felt by people as warmth. Light from the Sun interacts with the atoms and molecules in objects in different ways. Sometimes the sunlight is absorbed, increasing the random motion of the atoms or molecules, thus increasing the temperature. Sometimes sunlight is reflected, bouncing off the atoms or molecules at the object's surface and not affecting the random motion of the atoms and molecules, thus not affecting the temperature.

If you touch something that transfers energy quickly (something that **has high heat**), it may feel hotter to you than something that transfers energy more slowly, even if the one that feels hotter has a lower temperature. An example of this is comparing hot air in an oven to boiling water. The air in a hot oven at 400 degrees Fahrenheit has less heat than boiling water at 212 degrees Fahrenheit because the air in the oven transfers energy more slowly than the lower-temperature boiling water. Putting your hand in the 400-degree air in your oven won't hurt you at all, but putting your hand in boiling water may send you to the hospital. This is one way to remember heat versus temperature!

Two objects that are the same temperature might "feel" very different. A cake that is baked in a metal pan will be the same temperature as the pan itself right when it comes out of the oven. You could confirm this fact using an infrared thermometer. However, if you touch the pan, the metal will transfer energy to your hand much more quickly than the cake itself and will result in a much more severe burn. This situation results from the heat-transfer property of the pan rather than its temperature. To help visitors better understand this concept, facilitators might wish to try the Exploring Properties: Heat Transfer activity from the NISE Network: http://nisenet.org/catalog/exploring-properties-heat-transfer.

Staff training resources

Refer to the "Tips for Leading Hands-on Activities" sheet in your activity materials.

- An activity training video is available at vimeo.com/304241378
- A content training video is available at vimeo.com/304241270
- Additional training videos on misconceptions and facilitation can be found at vimeo.com/album/4249834
- The NISE Network has a curated list of programs, media, and professional development resources that directly relate to the toolkit. These resources can be viewed and downloaded from www.nisenet.org/earthspacekitextensions.

Credits and rights

This activity was adapted from a variety of educational resources by Arizona State University. And was developed for the NISE Network by the Arizona State University and the Sciencenter.

Image of urban heat islands courtesy NASA/ Earth Observatory
Image of volunteers painting a roof white, Community Environmental Center, and used under a public domain license. Retrieved from:http://www.flickr.com/photos/communityenvironmentalcenter/4017632858/, some rights reserved.

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