Overview

An incandescent lightbulb works like this: Electrical current makes the filament inside the bulb get hot. Hot objects emit electromagnetic radiation, and so the bulb glows. All objects that are warmer than absolute zero give off electromagnetic radiation. The primary wavelength of electromagnetic radiation that an object gives off depends on the object’s temperature. Really hot objects emit visible light. Cooler objects emit far infrared light; we call this “thermal radiation” because it is an important mechanism for transferring thermal energy.

Thermal radiation is much like visible light, but there’s one big difference: It’s not, well, visible to humans. But that doesn’t mean it’s imperceptible.

Theory

Here’s one vocabulary word that is really important for this activity: radiation. Physicists use this term for whatever is given off by something that emits electromagnetic radiation (anything that “glows”, in any part of the electromagnetic spectrum). The radiation spreads out from its source.

Visible light is radiation. So are x-rays. Some radiation is dangerous, but most isn’t; in fact, electromagnetic radiation is responsible for all life on Earth! Visible light and thermal radiation are both types of electromagnetic radiation, but they have very different wavelengths. Visible light has pretty short wavelength, about 0.0005 mm (500 nm). A typical thermal radiation source emits electromagnetic waves with a wavelength of 0.010 mm (10,000 nm), 20 times longer than that of visible light.

The other big difference is in the energy of the photons. A visible light photon has enough energy to cause a molecular transition (a conformational change) in proteins within the eye’s retina. A thermal radiation photon doesn’t have this same effect. A typical thermal radiation photon can only make molecules wiggle around a bit — it can’t cause a transition in the retinal proteins. This wiggling increases temperature, so it can warm things up, but it doesn’t trigger the neuronal pathways that lead to vision. But you can still sense it...

Doing the activity

This is a nice experiment to do when you are just beginning your discussion of electromagnetic radiation. Infrared and thermal radiation can seem very abstract; in this experiment, getting a chance to perceive it will help students get a handle on just how real it is!

Necessary materials:

• ceramic reptile heater* with metal stand
• optional: blindfolds

*You can also do this activity with a “heat lamp”, but we prefer the reptile heater since it gives off no visible light whatsoever.
**SAFETY NOTE 1:** Do not touch the ceramic reptile heaters! They get very hot.

**SAFETY NOTE 2:** You may choose to have the students do this experiment wearing blindfolds. If you do, please be certain to have your students use caution, so that they don't trip, fall, or touch the hot bulb!

The experiment goes like this:

- Have your students close their eyes or wear blindfolds, and then hold their hands out in front of them.
- Move the ceramic heater (turned on!) near your students.
- Have them move their hands to see if they can tell where the heater is. (Again, ensure that students don’t touch the heater.) This is pretty simple to do if they are close, a bit trickier if they are far away.

Students will quickly figure out how to move their hands to sense the infrared. They detect it by measuring the heating of their palms when the infrared strikes their skin. This is the same mechanism certain snakes use to sense thermal radiation. Pit vipers, such as rattlesnakes, have a second set of “eyes” (called, appropriately enough, pits) that contain tissue which can detect the thermal radiation emitted by warm prey animals. Such snakes can easily detect a warm mammal on the cool sand of the desert even in total darkness! They detect the thermal radiation that their prey emits.

**Summing up**

This is a good introduction to thermal radiation. The story of energy transfer within the Earth system is dominated by radiation, so it’s important that students know that this form of energy is quite real.

**For more information**

Little Shop of Physics: [https://www.lsop.colostate.edu](https://www.lsop.colostate.edu)

Colorado State University College of Natural Sciences: [https://www.natsci.colostate.edu](https://www.natsci.colostate.edu)