Absorption and Reflection

Setting the Scene: Black Gets Hot; White Stays Cool

Imagine that it is a hot summer day, and the sun is shining brightly overhead. You take off your shoes and go outside barefoot to play. As you walk across the white concrete sidewalk, you realize that it is really warm, maybe even to the point of being uncomfortable. Then as you step on the asphalt street, OUCH. The asphalt is too hot to touch.

What accounts for the different temperatures under the same exact conditions? The answer is simple: dark surfaces absorb more energy than light surfaces, so they get hotter. In this science project, you will experiment with white objects and black objects to see how they absorb and reflect heat.

The Basic Science: Reflecting or Absorbing Light

The full range of energy that radiates from the sun is called the "electromagnetic spectrum," and it is measured by its "wavelength." Visible light is medium wave radiation, and it is really just a tiny part of the whole spectrum. You see the span of visible light in a rainbow in the sky or when light passes through a prism.

The wavelengths that are just shorter than visible light are called "ultraviolet." Wavelengths even shorter we call gamma rays and x-rays. Just above visible light, the wavelengths of solar radiation are called infrared. You've probably noticed infrared lights at a local restaurant. They are the orange-ish lights above the french fry platter that keeps the fries warm. Above infrared, the radiation at the very long-wave end includes radar, microwaves, and radio and television signals.

Infrared radiation is converted to heat when it strikes surfaces on the earth. Light-colored materials reflect this radiation in exactly the same way they reflect light. Dark-colored materials absorb the radiation and get hot.

Investigating Absorption and Reflection

You can do some simple experiments to test this basic science principle. With further experimentation, you can determine how much temperature difference colors make, as well as other types of surfaces and materials.

Use these tips below to develop an experimental model. Before you begin, work out your materials, procedures, and data keeping methods. Start by stating a hypothesis: what results do you expect to get from this experiment?

1. Obtain two identical containers, such as empty coffee cans, jars, or shoe boxes. Paint one of the containers black and the other white. (Any type of paint will work, as long as it sticks to

the surface of the container. You may want to experiment with dull or glossy paint or different colors, such as red and yellow, to see their effects.) Put a thermometer inside each of the containers, and record their temperatures. Now move them into the sunlight or place them under bright light. Record their temperature at regular intervals over a period of time. Graph your results. You may want to start with just one type of container and then do additional rounds of experiments with other types of containers, colors, coatings, and times of day.

2. Fill your containers with water (instead of air). Plot how quickly they get hot and then how quickly they get cool. Try heating them in sunshine and allowing them to cool in a very dark space, such as a closet or drawer. Try the same experiment with other liquids, such as rubbing alcohol or mineral oil, and compare the results with the results you obtained using water.

3. Repeat your experiment during the day and at night. During the day, start with room temperature water in cans. Compare the rates the two different containers warm up in sunlight. At night, start with warm water in both cans. Record and graph the rate at which they cool down. Did one of the cans cool down faster than another? How much faster? Was it the container that you thought would cool down faster? (This process is called "radiational cooling," and it is an important phenomenon to understand.

4. Go outside on a hot, sunny day, and take a change of clothes with you. If you are wearing dark clothes, take white clothes with you, or vice versa. After you have been in the sun for a few hours, change clothes and continue the same activity. Do you think you are warmer or cooler when you wear dark clothes or light clothes? Do you think the color of your clothes makes a significant difference in your comfort level?

5. Do you think clouds help to keep the surface of earth cool, or do they help to warm it up? Test and explain your response.

6. Buy a "radiometer". (It is a glass globe with alternating white and black "flags" that spins in the presence of direct sunlight. You can find them in gift shops or on the Internet for about $10.) Observe its operation in various light levels. Explain why it works and how you could use those principles in building better housing, better transportation, or better use of our resources.

7. Go to the Internet and research "absorption and reflection."

<u>Historical and Cultural Overviews</u>

Historically, people have used principles of science before they really understood them. Explore whether people used the principles of absorption and reflection to keep themselves comfortable in the days when air conditioning and central heating systems did not exist. Here are just a few examples for you to pursue.

1. The Bedouin, nomads in the Arabian deserts, covered themselves in long, white robes to protect themselves from the heat of the sun. Explain whether you think this clothing was a good idea.

2. Southern Mediterranean villages are built of white stucco housing with narrow passages that prevent sunshine from entering the interior. Explain how this building style may have kept residents more comfortable.

3. In today's modern world, we often hear of the dangers of heat waves for city residents. Many urban environments become "heat traps." Look at images of cities like New York City, Chicago, and Miami and discuss whether absorption and reflection might play a role in how hot these cities sometimes become.

4) Look at the architecture, city layouts, and clothing styles of your region. Do they seem designed to maximize comfort levels in your climate? Write a critique based on a what you know about absorption and reflection. Take one or more of these areas and develop a more climate-friendly, science-wise design.

Putting it Together

Create a display to demonstrate how you experimented with the effect of absorption and reflection on temperature in different types of containers. Provide an example of your experimental set with a graph or chart of your results, along with a brief discussion of the results. Build a model or create other visuals to show one or more of your conclusions from Applying the Science and Historical and Cultural Perspectives.