Absorption and Reflection

Objective
To investigate how different colors absorb or reflect light, and to extend these observations to infrared radiation.

Engage
Ask students what color of car or car seats are the hottest on a hot summer day. Discuss whether black pavement or gray pavement is hotter.

Explore/Explain
Explain to students how they will investigate which colors get the hottest and why.

Materials
- copies of activity
- construction paper (black, bright green, light brown, and white, or equivalent)
- 4 thermometers per group
- sunny day or a heat lamp
- stopwatch or clock

Procedure
Divide students into groups of 2-4 and provide a set of materials and activity sheets to each group. Read over the instructions as a group and then let students work on their own to set up the experiment. If you're lucky enough to have a sunny day, groups can go outside and collect data at the same time. Depending on class organization, only one student is required to read the thermometers. If a heat lamp is used, be certain that all four envelopes are at the same distance from the heat lamp.

Expand
An infrared detector will see a warmer object as "brighter" than a cooler one. The warmer object gives off more infrared radiation. Encourage students to predict which objects will be brighter in infrared.

Answers to student challenges
The white paper is "brightest" in visible light: black paper will be "brightest" in the infrared.

Interdisciplinary Connection:
Clothing, especially in desert regions, is based on reflecting sunlight. Students can do reports on how different cultures dress and compare their dress to the environmental conditions of the area, science explaining "fashion!"

KAO Connection
The two pictures of Jupiter--one in the visible and the other in the infrared--provide an introduction to what the KAO will be observing. Notice that the areas of Jupiter's atmosphere which are dark in visible wavelengths are bright in infrared. This is often the case: darker areas are warmer than lighter ones. During the live Observing Missions, students will use this information to predict which of Jupiter's moons will be the brightest.

A thermometer measures the temperature or amount of heat energy in an object.

For this experiment you need

- construction paper (black, green, brown and white)
- 4 thermometers, a hot sunny day, or a heat lamp

With the construction paper, make small envelopes to cover the bulbs of the thermometers. Then place the four thermometers inside their paper covers in a sunny area without much wind. All four thermometers should receive the same amount of sunlight and should not be touching. Predict which color will get the warmest, most quickly.

Record the temperature shown on each thermometer as the experiment starts, and again after 5, 10, and 20 minutes.

Color	As the experiment starts	After 5 minutes	After 10 minutes	After 20 minutes
White				
Brown				
Green				
Black				

Infrared radiation from the sun does not reach the earth's surface, but the sun's visible light can be turned into heat. Bright colors reflect visible light. Dark colors absorb visible light and convert the light energy into heat. These hot objects can re-radiate the sun's energy as infrared radiation.

Which piece of construction paper is the "brightest" in visible light? _____

Which is "brightest" in infrared radiation? _____

Study these two images of Jupiter: one in visible light and the other in the infrared. Use the experiment above to explain differences you observe in the two images. (The images were not made at the same moment, so the features do not match exactly.)

KAO Corner:

Aboard the KAO, sensitive solid state detectors measure infrared radiation. Warm objects that are dark in visible light can be very bright in infrared
wavelengths.

Q&A

QUESTION: When you guys do your work do you enjoy it?

ANSWER: from Wendy Whiting (Mission Director for the Live From the Stratosphere flights)

Overall, I enjoy my work very much. It's great to be working with a unique facility like the KAO. We are the only airborne astronomical observatory in the world, and we're very proud of the work we do.

I'm guessing that what you really want to know is whether we enjoy the actual KAO flights. The typical KAO flight takes off around dusk and lands seven and a half hours later. The environment in the cabin is not all that comfortable, as it is noisy and can be cold. We all wear headsets throughout the flight, which helps to protect our hearing and to communicate since it's so noisy. All this combines to make the flights somewhat stressful! However, at the end of a successful flight, I usually feel a real sense of accomplishment at having reached the goals we set out to achieve. And that's a great feeling!

Sometimes people tend to think that this work must be very glamorous and exciting all of the time. While it is that way sometimes, we also have lots of regular, everyday types of work to do. My office is in the KAO hangar, and on days when I'm not flying I spend my time on activities such as planning for expeditions, or working on other administrative or engineering projects. In summary, I have to say my work for NASA on the KAO is very interesting and absorbing, and enjoyable.

Sky Fever

Jim Cockrell, KAO crew member

I must up to the skies again, to the
lonely, dark night sky,
And all I ask is a telescope, and a star
to steer her by,
And turbulence, and compressors whine and
PFC* shaking,
And a grey mist in the tracker field,
`fore the grey dawn's breaking
I must up in the skies again, for the call
of the stratosphere,
Is a wild call and a clear call that I
shall always hear;
And all I ask is a jet stream with low
water vapor,
And a bright source with some broad lines
for a grad student's paper
I must up to the skies again, in my
preflight ritual,
With the aperture wide open, and the tanks
filled with fuel
And all I ask is some oxygen, half way
twixt earth and heaven,
And a coffee cup, and a flight lunch in
the aft galley oven
I must up to the skies again, to the

starry black night sky,
Where the chopper's pulse and the engines
drone are a Kuiperman's lullaby
And all I ask is a good flight plan to
get me through the night,
And a quiet sleep and a sweet dream at
the end of the data flight.

(The "PFC" is the Passive Flow Control, the fairing along the aft edge of the telescope opening: you'll find some of the other more technical terms
defined in the Mission Glossary.)