PHASE ONE: BREAK DOWN
SUNLIGHT OVEN

Mission: How does the color of a material affect how much sunlight it absorbs?

Age: 8+
Materials: $8

Time: 45 min
(Set-up: 15 min Activity: 20 min with wait time Clean-up: 10 min)

What you need:

Materials:
- Colored paper (black, white, red, and blue)
- 1 stick of butter at room temperature (don't use margarine or butter alternatives)
- Aluminum foil
- Tape
- Large box
- Data sheet (found on page 5)

Equipment:
- A cool, indoor sunny location
- Timer
- Table knife
- Ruler
- Pen/pencil
- Scissors
- (Optional) Cell phone or video camera

What to do:

1. To build your sunlight oven, line the inside of your box with aluminum foil, using tape to attach. Find a place in your house with direct sunlight, such as near a window. Make sure that sunlight reaches the entire inside bottom of the box.

2. Cut a 3 inch (7.5 cm) square of each color of paper (black, white, red, and blue). Tape each square to the bottom of your sunlight oven.

3. With a table knife, cut a 1/8" (3 mm) thick slice of butter, then cut crosswise to make four identical smaller squares of butter.

4. Make a prediction: Which color of paper will make the butter melt the fastest? Which will be the slowest? Think about how it feels to wear a dark or light shirt on a sunny day. Use the data sheet to record the order of your predictions.

5. Time to test! Take your four pieces of butter and place one on the center of each paper square. When you are ready to start the experiment, carefully move your oven near your window so the sunlight reaches all four squares. Start a timer.

What to do:

6. (Optional) Scientists often use tools to record their experiments. You can try this technique by cutting a small hole in the top of your box and positioning a cell phone camera above. You can take pictures at regular time points (like every minute), or set a time-lapse recording to do it automatically. You'll be able to watch your experiment in a flash at the end!

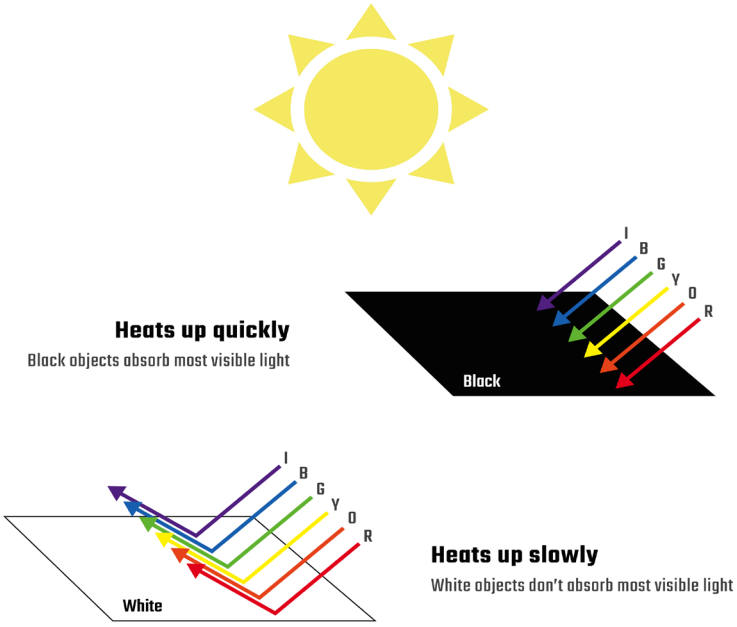
7. After the first 6-7 minutes, the butter should begin melting on some of the colored paper squares, forming a ring around each piece of butter. Observe and record which colors are melting from fastest to slowest on the data sheet. Repeat your observations and ranking after 10 minutes and again after 15 minutes in the sun. If a square of butter has fully melted, record the time when you saw it fully melted.

8. You can continue the experiment until all the pieces of butter have fully melted, but expect to wait another 20 minutes at least. You may have to shift the location of the box to keep all the squares in the sunlight. On what color of paper did the butter melt fastest? Slowest? Did your results match your prediction?

Clean-up:

Tip the box into a trash can and allow the melted butter to drain out. Remove the paper squares and throw them away. If you want to experiment with other colors of paper, wipe the inside of the box with a damp paper towel to remove excess butter before adding new paper.

What's happening?

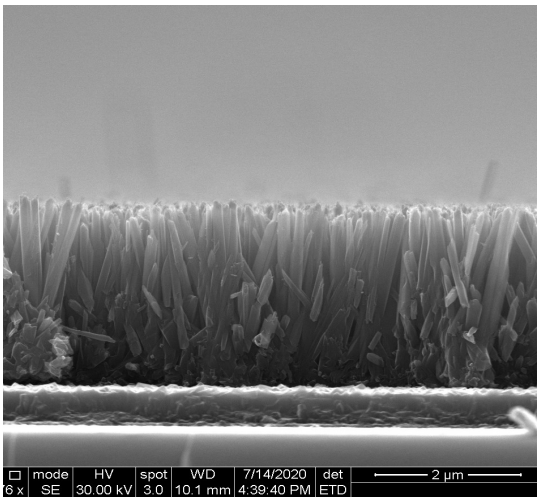


Sunlight is composed of many wavelengths of light, including visible wavelengths. These visible wavelengths are the colors that you can see! When sunlight hits a material, it's absorbed as heat energy. The more sunlight absorbed, the warmer the material becomes. However, not all materials absorb the same types of light. Darker-colored materials absorb many wavelengths of visible light which makes them heat up fast. Lighter-colored materials don't absorb as much light, so they heat up slower.

But what gives a material its color? The color is produced by the light that the material doesn't absorb. For example, materials that don't absorb red light will look red to our eyes. So, the amount that a colored material heats up depends on the colors of visible light it absorbs.

Sunlight that reaches Earth has more red light in it than blue light. Since blue dye absorbs the more abundant red light, blue paper should heat up faster than red paper, which does not absorb that light. Does this match up with what you observed in your experiment?

So What?



Sunlight can be transformed into many other types of energy, including heat energy and electricity. Scientists are trying to design materials that can capture the energy in sunlight and convert it into other forms of energy that we can use to power our lives. They also need to understand how those materials absorb light, in order to make materials that can capture as much sunlight as possible. For example, tiny structures called nanowires within materials can improve the ability for sunlight to be captured and converted into other forms of energy. Designing better solar materials will allow us to invent new technologies that can make solar fuels from water, drive chemical reactions, and keep our planet healthy.

DATA SHEET

SUNLIGHT OVEN

PAPER	PREDICTED ORDER (RANK 1-4)	OBSERVED ORDER (6 MIN)	OBSERVED ORDER (10 MIN)	OBSERVED ORDER (15 MIN)	FULLY MELTED? (YES/NO)
Black					Yes No Time: min
White					Yes No Time: min
Red					Yes No Time: min
Blue					Yes No Time: min
					Yes No Time: min
					Yes No Time: min
					Yes No Time: min
					Yes No Time: min

NGSS Alignment of Sunlight Oven Activity

The information below may not include every area that this activity can be linked to NGSS concepts

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- **Grade 4**
  - ◇ Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
- **Middle School**
  - ◇ Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer

- **Grade 4**
  - ◇ Light also transfers energy from place to place.
- **Middle School**
  - ◇ Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Performance Expectations

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Crosscutting Concepts:

Energy and Matter

- Grade 3-5
  - ◇ Energy can be transferred in various ways and between objects.
- Middle School
  - ◇ The transfer of energy can be tracked as energy flaws through a designed or a natural system.

Engineering and Science Practices

Constructing Explanations and Designing Solutions

- Grade 3-5
  - ◇ Apply scientific ideas to solve design problems.
- Middle School
  - ◇ Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

Planning and Carrying Out Investigations

- Grade 3-5
  - ◇ Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.