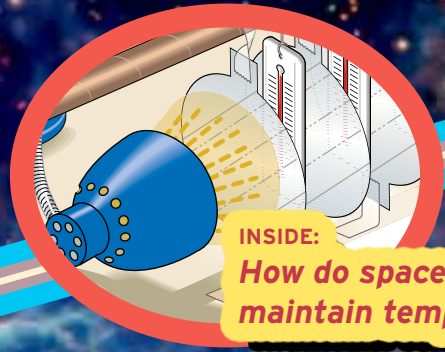


PLANETARY SOCIETY KIDS

FREE!

Enceladus Pullout Poster!
ON THE BACK



INSIDE:
How do spacecraft maintain temperature?

TOO HOT or TOO COLD in SPACE?

When you hold your hand up on a sunny day, or in front of a nice warm fire or room heater, you feel the warmth. The heat is passing right through the air onto your hand. We often think of sunlight traveling in "rays," so we say heat "radiates" from the Sun or a heater. It's "radiant" heat.

When you're under a blanket or quilt, there's a layer of air that's held still. Heat doesn't pass through it very easily, so you stay warm.

When your spacesuit or spacecraft is in space, the side

getting hit with the rays of the Sun gets very hot indeed. But the other side, the side in the shade, is facing outer space. There is nothing to hold its heat, no blanket or layer of air.

Heat flows through the metal or plastic of your spacesuit from the Sun side to the cold side, the same way a spoon feels hot if you leave it in a cup of hot water. The side of the spacesuit facing away from the Sun gets somewhat or even a lot warmer than the cold blackness of space. So the dark side has its heat flow, or radiate, away into the dark. Even though it's cold, it's still warmer than space.

Electronics can be delicate, like the circuits in our *LightSail-1*.

After all, we're moving electrons around at the speed of light between astonishingly small molecules. If electronics get too hot or too cold, they're ruined. So, how can we protect our spacecraft's electronics if there's no air in space to help a blanket do its job?

We use a type of insulation that doesn't rely on air. Instead, the insulation controls the way heat radiates from one piece of material to another.



DID YOU KNOW THAT ... Mercury's extreme temperatures fluctuate from some of the hottest in the solar system (about 430° Celsius / 810° Fahrenheit) to some of the coldest (about -170° Celsius / -280° Fahrenheit)?

Demonstrating Radiant Heat at Home

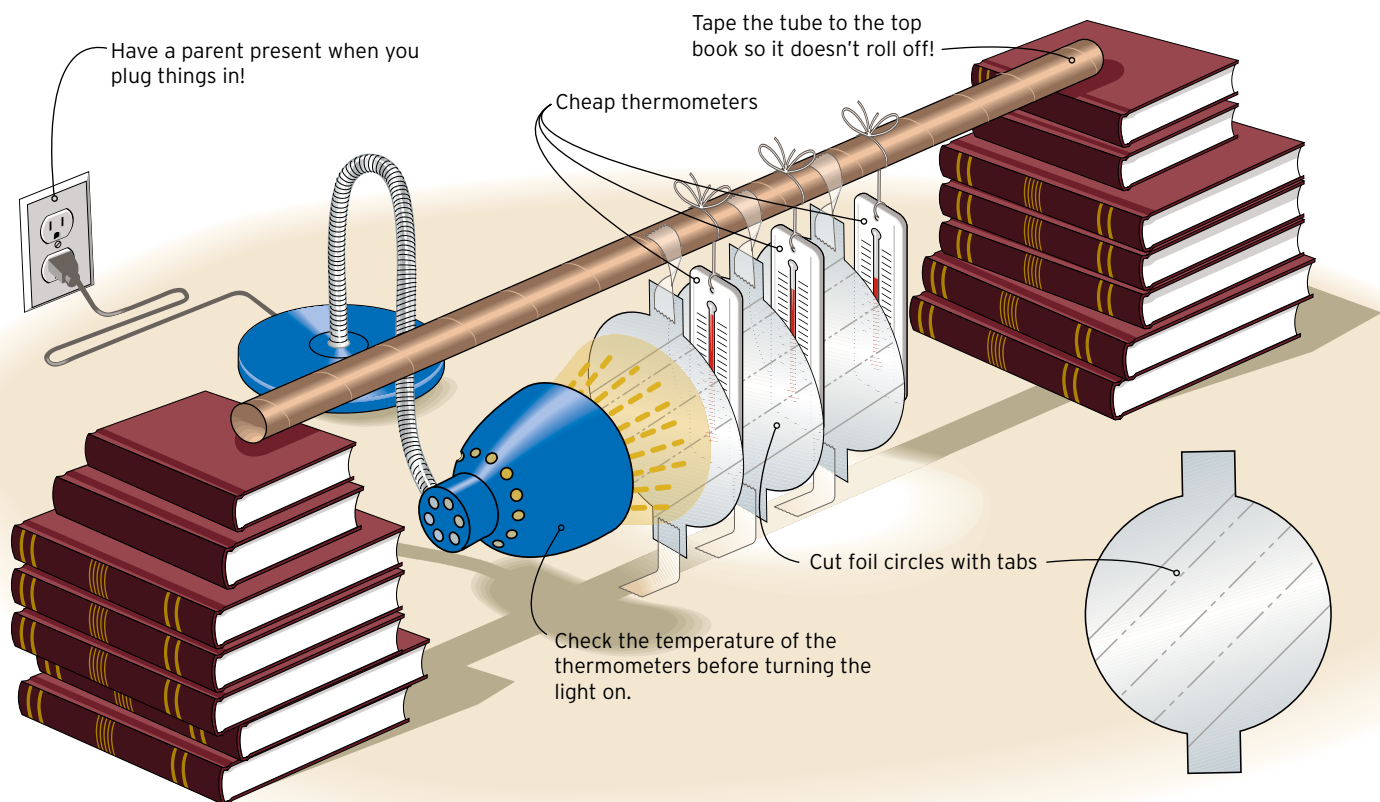


Illustration: Dave Merrill

Try This!

THE QUESTION:

How can we insulate things in space if there's no air?

Here's what you need:

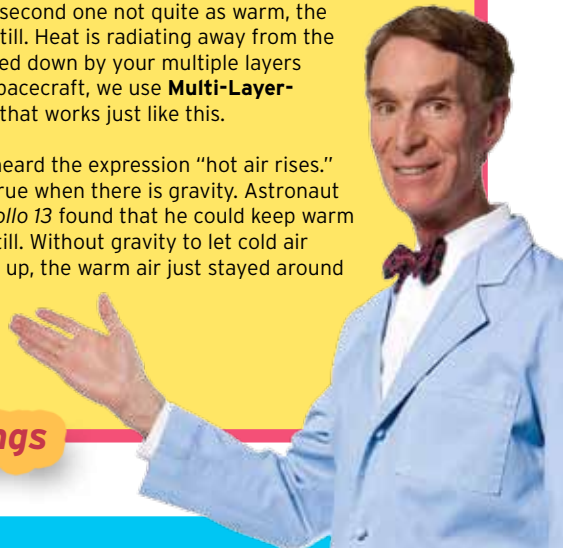
- Aluminum foil
- 3 thermometers, all the same (The first time I did this, I bought three thermometers at a store where everything [well, almost everything] is 99 cents)
- Very bright reading light that gets hot
- Scissors
- Tape
- Two big stacks of books
- Wrapping paper tube
- String (optional)

1. Using your scissors, cut three pieces of aluminum foil into circles with two tabs, or "ears;" the pattern is shown on the picture.
2. Set up two large stacks of books so that they're higher than the thermometers are tall.
3. Tape the long tube to the top of each stack of books.
4. Using string or tape, hang the three thermometers along the tube; place them about 5 cm. apart.

5. Tape the pieces of foil between the light and the first thermometer, then between the next two thermometers.
6. Before you turn the light on, write down the temperature of each thermometer.
7. Set up the reading lamp so that it shines right against the first piece of foil, then turn it on.

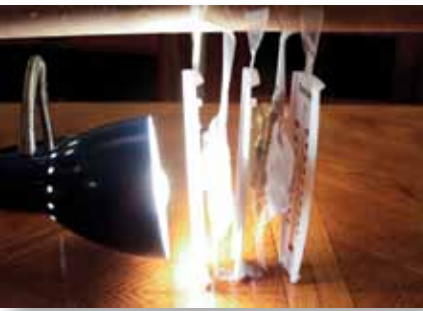
Watch the thermometers, and write down their temperatures every five minutes or so. The one closest to the light will be the warmest, the second one not quite as warm, the third one cooler still. Heat is radiating away from the light, but it's slowed down by your multiple layers of insulation. In spacecraft, we use **Multi-Layer-Insulation (MLI)** that works just like this.

You've probably heard the expression "hot air rises." Well, that's only true when there is gravity. Astronaut Fred Haise on *Apollo 13* found that he could keep warm if he held really still. Without gravity to let cold air squeeze warm air up, the warm air just stayed around his body. Wild.



Don't forget! Report back to us on your findings at planetary.org/kids

As soon as you set up the lamp (don't burn yourself—have a parent help you), the thermometers will start changing temperature. It's amazing—you have now created spacecraft insulation! What would happen if you added a fourth thermometer and another layer of foil?



WORD SEARCH

How many space-related words can you find?

W U G O S U R F A C E S M O I
 A N A Z E N I T H O R S U N O
 V I L A D A U R O R A K G D N
 E V A A S T R O N O M Y C A O
 L E X E L T P L A N E T O R S
 I R Y N A I E F A A M R M K P
 G S C B S S E R A V Q I E M H
 H E R F E O T N O V A O T A E
 T O N U R X R A Y I W B P T R
 Y G A S E O U S R A D A Y T E
 E C L I P T I C H U B B L E D
 A S T O B A R Y C E N T E R N
 R R F N A M E T E O R D L L E
 I S O L A R F L A R E U N P T

Looking for heat? You have to be cold...



ZERO DEGREES ABSOLUTELY

Put an air-filled balloon in a refrigerator, and it will shrink. Move the balloon to a freezer, and it will shrink more. Imagine it being so cold that the air in the balloon shrinks to nothing, taking up no volume at all.

That's the temperature that we call absolute zero. There is no way to get any colder than this: -273 degrees Celsius (-460 degrees Fahrenheit).

We measure temperatures like this in a scale called "kelvins." Absolute zero = 0 kelvins.

In space, we have to keep our instruments very cold to be able to measure the slightest changes in temperature, so the James Webb Space Telescope will keep its detector around 6 kelvins.

What's 6 kelvins in degrees Celsius? Look it up!



BLANKETS OF ATMOSPHERES

The nearest planets, Venus and Mars, as well as Earth, have atmospheres that hold heat and keep the surfaces of the worlds warmer than they would be without an atmosphere. The atmospheres are mixtures of gases. Carbon dioxide, in particular, holds in a great deal of heat. Because the gases work in a way similar to the glass in a plant-growing greenhouse, this heat-retaining action is called the "greenhouse effect." On Earth, we stay warm enough to keep most of our water liquid. On Venus, the surface is so hot that even the metal lead would be a liquid.

The planet Mercury is less than half as far from the Sun as we are. How can it be colder on Mercury's surface than it is anywhere on Earth?

Check out Bill's new page at planetary.org/kids

ASTRONOMY
 ALIEN
 ASTEROID BELT
 AURORA
 BARVCENTER
 COMET
 CORONA
 DARK MATTER
 ECLIPIC
 DAY
 FUSION
 GASEOUS
 GALAXY
 HUBBLE
 IONOSPHERE
 LASER
 LAVA
 LIGHT YEAR
 METEOR
 NOVA
 ORB
 PLANET
 SKY
 SOLAR FLARE
 STAR
 SUN
 SURFACE
 UNIVERSE
 WAVE
 X RAY
 ZENITH

WORD SEARCH ANSWERS

DID YOU KNOW THAT ... so far, the highest recorded temperature on Earth is 58° Celsius / 136° Fahrenheit?

This image shows Enceladus' explosive south pole, captured by the *Cassini* spacecraft during its close flyby on November 21, 2009. Plumes issue from all four of the large "tiger stripes" at Enceladus' south pole. Image: NASA/JPL/SSI



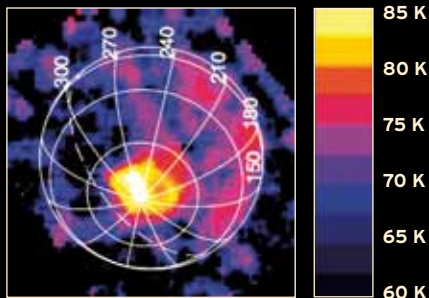
ENCELADUS

MOON OF SATURN

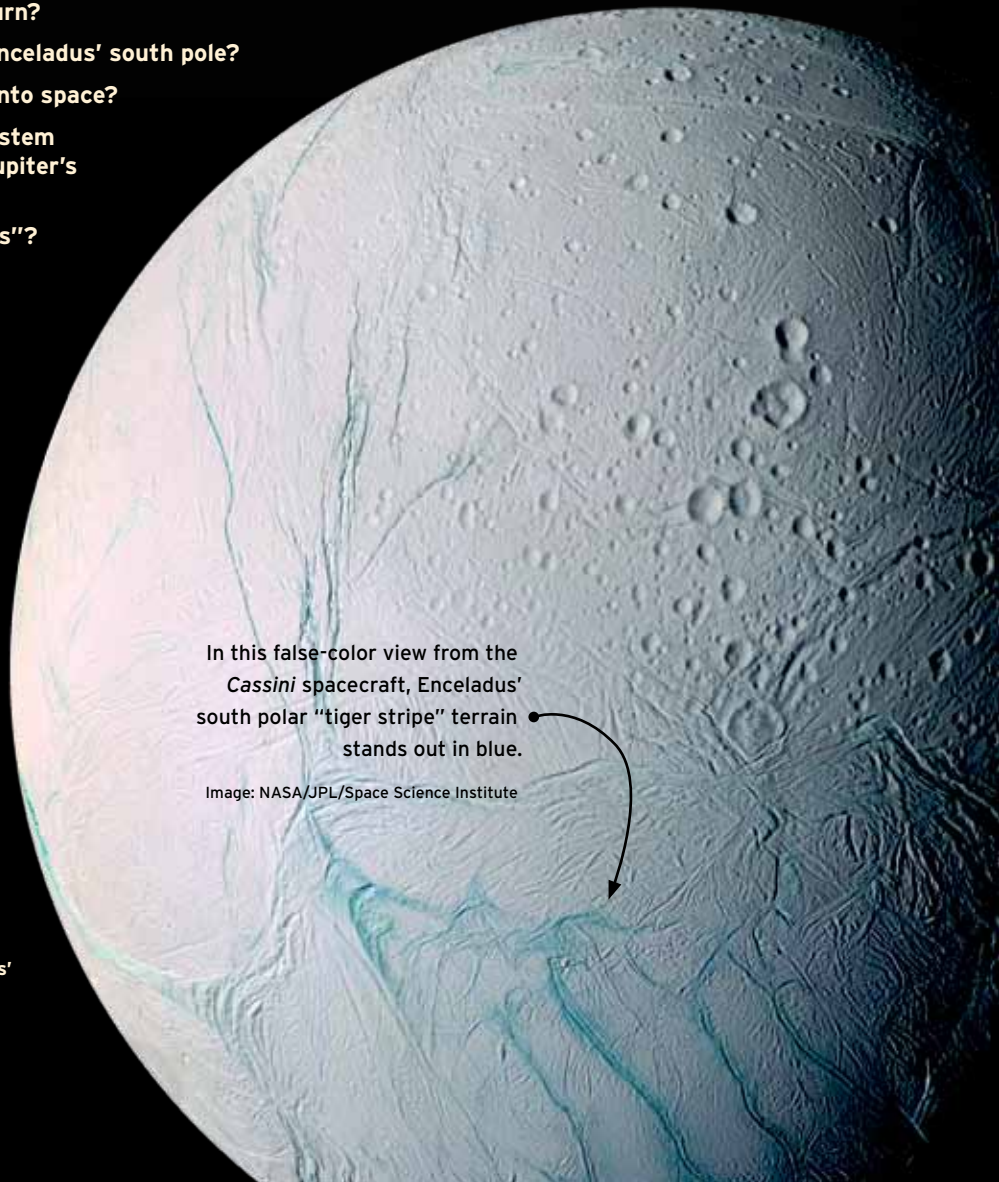
Want more information on Enceladus? Go to planetary.org/kids/

DID YOU KNOW THAT . . .

- ▶ Enceladus is the sixth largest moon of Saturn?
- ▶ Geysers erupt all the time from cracks in Enceladus' south pole?
- ▶ The geysers shoot hundreds of kilometers into space?
- ▶ There are three other places in the solar system where we've seen things erupting: Earth, Jupiter's moon Io, and Neptune's moon Triton?
- ▶ Scientists call the long cracks "tiger stripes"?
- ▶ The tiger stripes—Alexandria Sulcus, Cairo Sulcus, Baghdad Sulcus, and Damascus Sulcus—are named for cities in the *One Thousand and One Nights*?
- ▶ The geysers are much, much colder than the freezing temperature of water here on Earth?
- ▶ No one knows if the geysers are liquid, streaming from ice within the cracks, or gas, evaporating from a salty underground sea?



On November 9, 2006, *Cassini*'s Composite Infrared Spectrometer (CIRS) captured its first view of Enceladus' south polar "hot" spot. The distribution of heat suggests that most of the heat comes from the "tiger stripes," more formally known as "sulci," that cross Enceladus' south pole. Peak south polar temperatures reached about 85 kelvins (-306 degrees Fahrenheit).
Image: NASA/JPL/GSFC/SwRI



In this false-color view from the *Cassini* spacecraft, Enceladus' south polar "tiger stripe" terrain stands out in blue.

Image: NASA/JPL/Space Science Institute