



Teacher's Guide for:

Heat Conduction Liquid Crystals

Note: All activities in this document should be performed with adult supervision. Likewise, common sense and care are essential to the conduct of any and all activities, whether described in this document or otherwise. Parents or guardians should supervise children. Rock-it Science assumes no responsibility for any injuries or damages arising from any activities.

NOTE: This is the transcript of a lesson that was videotaped during an actual Rock-it Science class with real students, not actors. The students' brainstorming comments are included on the video but are not transcribed here because they're not part of the lesson presentation.

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Title Page of Video

Heat Conduction Liquid Crystals
A Rock-it Science Lesson
Filmed July, 2009

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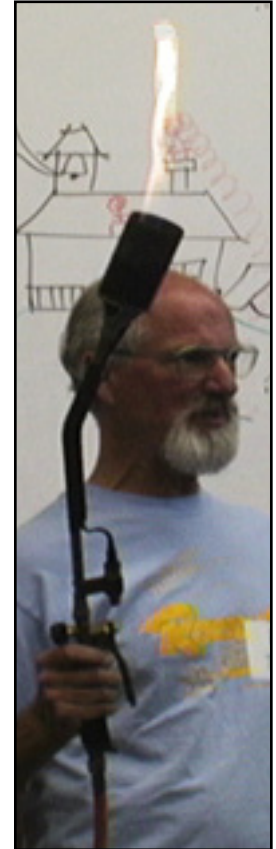
(No Intro):

Demo Quick Recap: *Space Shuttle Tiles*

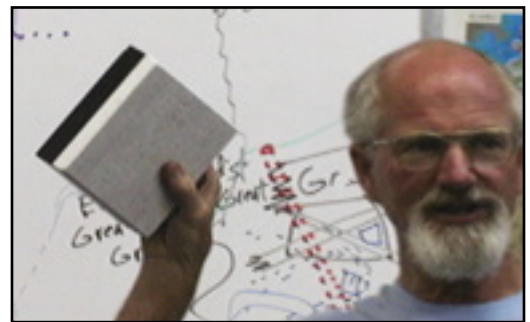


Fire Brick

- If you're in a spaceship floating around the Earth, you're going about seventeen or eighteen thousand miles per hour.
- As you come back down into the air, the air rubs against the spacecraft and makes it really hot.
- Show fire brick in roughly the shape of a space shuttle, attached to a long metal rod.
- Light a large propane torch and hold the fire brick in the flame until it gets red hot. (Students wear earmuffs for this.)
- Show students a real space shuttle tile. One side is glass with bubbles in it, like foamed glass. The other side is very high temperature glass.
- They glue thousands of these tiles onto the space shuttle to protect it from blowing up on re-entry.
- Repeat the demo using the torch on the white side of the real space shuttle tile, showing how it turns red-hot but doesn't burn.
- A guy on the internet gets one of these tiles red-hot in the oven and then touches it with his finger. You can do this because the material is so light that the heat doesn't burn you even though it's really hot.



Propane Torch



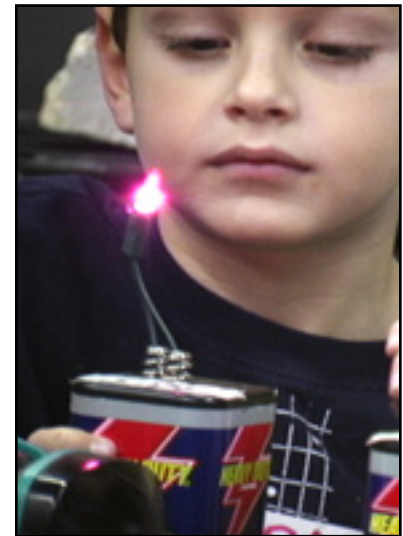
Space Shuttle Tile

Experiment Quick Recap:

- If you wear a sleeping bag, you feel hot inside. If somebody put dry ice on the outside, it would take awhile for the coldness to get through.
- Experiments will show ways to keep heat from getting through stuff.
- Show how to attach a christmas light (a small “person”) to a 6-volt lantern battery to make sure the light works, then attach it with cables and alligator clips.
- Experiment is to wrap the “person” in stuff to see if the heat gets through.
- To do this, we use fat, or lipid, which is in a temperature card.
- Put a temperature card against your forehead to show students how it changes color in response to temperature.
- Give each student a temperature card and let them fool around with it.
- Then give them each a christmas light and a battery, and have them test the light.
- Then give them 2 cables with alligator clips and have them connect the light.
- Students place the thermal card on top of the light to see how the color changes.
- Give students a sheet of sponge to put between the light and the card to see if the heat still comes through.
- Give them a sheet of aluminum foil and repeat.
- Give them a piece of plastic and repeat.
- Have students put all three insulators over the light at once and see if they keep out the heat.
- Students get to keep the thermal card.



Temperature Card.



Testing the Light.

Equipment List: "Heat Conduction Liquid Crystals"

Items needed for Instructor:

- Torch, propane, large
- Fire brick shaped like space shuttle, on metal rod
- Space shuttle tile, black & white square
- Postcard thermometer

Items needed for Students:

Consumables (per student):

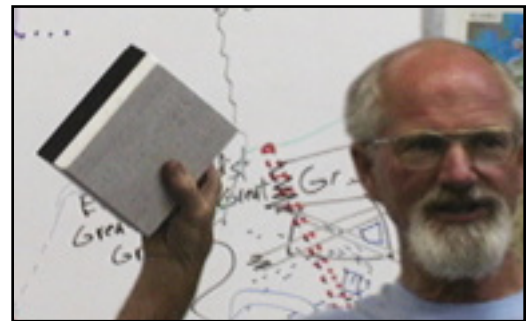
- Thermal color-change sheets, about 4" x 4"
- Xmas lights, individual
- Battery, 6-volt lantern
- Aluminum foil, about 1 ft sq.

Other:

- Ear muffs
- Insulated cable with alligator clips, 2 per student
- Plastic square, about 4" x 4"
- 1/4" sponge, about 4" x 4"

Prep Work:

- Cut string of christmas lights into singles
- Cut thermal sheets into 4" x 4" pieces.
- Tear off aluminum foil into 1-ft squares



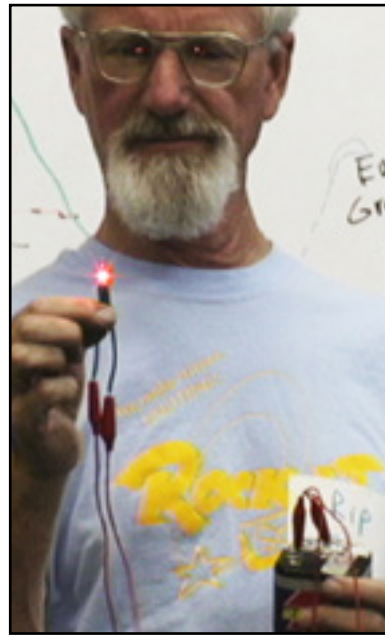
Space Shuttle Tile



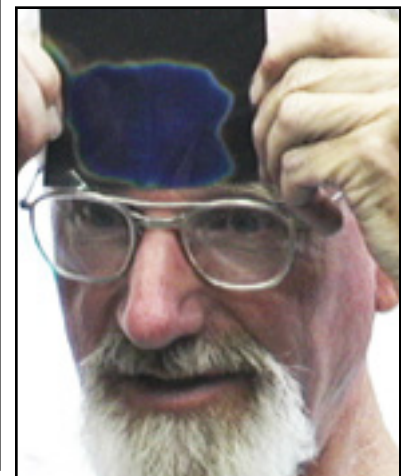
Torch



Fire Brick

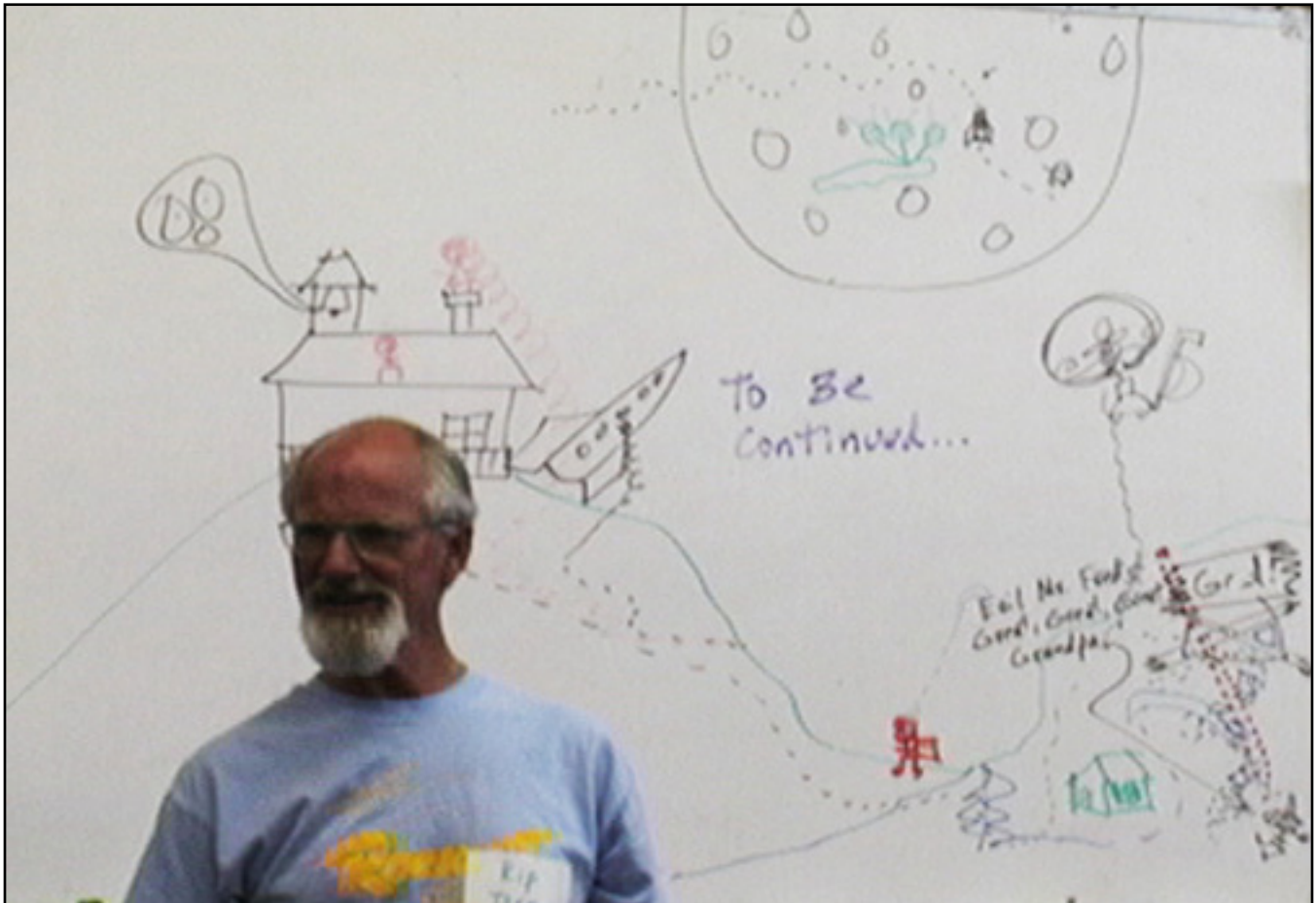


Light connected to Battery with Alligator Clips



Thermal color-change sheet

Story Recap: "Jack & Jill's Missing Heat Shield"



Part 1:

- (NOTE: This story is a continuation of the story "The Ghost in the Gold Mine," from the lesson "Lasers and Mirrors." If this lesson is presented by itself, the story could be told without Jack being a ghost.)
- Jack and Jill had just destroyed a ghost at the bottom of an old gold mine. There was nothing left but its mustache.
- Jack put on the mustache, which made him turn into a ghost.
- The ghost they killed was Evil Mister Fred's Great-great-grandpa, so he was angry.
- To escape from Evil Mister Fred, Jill called the Acme Store of Everything and ordered a spaceship.
- They flew to the Moon, but Evil Mister Fred followed on his vacuum cleaner with a fishbowl on his head. He sent out some minions to sneak up on Jill and see what she was doing.
- Jack and Jill found a three-headed alien, who told them they could get rid of Evil Mister Fred by giving him gold, silver, diamonds, etc.
- Jill didn't know where to get treasure, but the alien told her to follow her instincts.

Story Recap (cont.)

- So Jill flew back to Earth and passed over Egypt, where she saw a bunch of treasure between the pyramids. She was going to land and get it for Evil Mister Fred.
- But Evil Mister Fred flew close to her space ship and ripped off her heat shield so the ship would burn up on re-entry.



Ending:

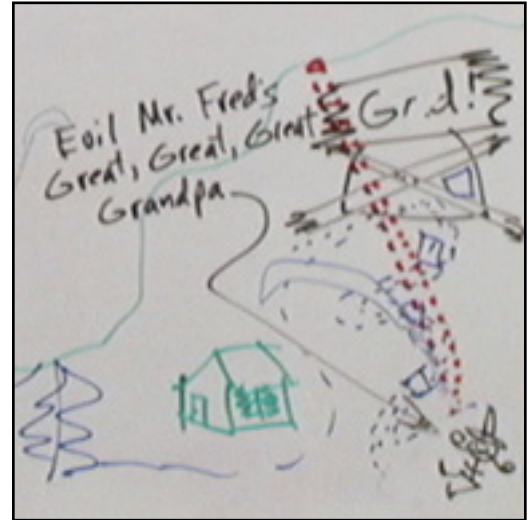
- Jack and Jill needed their heat shield in order to land safely, so they tried to catch up with Evil Mister Fred and get them back from him.
- Even though their ship could fly faster than his vacuum cleaner, he could change direction more quickly, so they couldn't catch him.
- Jack and Jill were almost out of fuel and knew they'd have to go down into the atmosphere even without their heat shield.
- Jill had been having a bad hair day, so Jack suggested she put her hair outside the ship.
- So Jill wrapped about a hundred million pounds of hair around the ship so it was all covered with hair.
- Then they turned on one of their little rockets and slowly started descending.
- When they hit the atmosphere, the hair started to burn. There were flames coming off it, like a comet.
- Evil Mister Fred came closer so he could watch Jack and Jill burning up.
- A big chunk of burning hair fell off and surrounded Evil Mister Fred.
- Jack and Jill just barely made it and landed in the ocean.

Transcript: (No Intro. Lesson begins with the Story.)

Story: "Jack & Jill's Missing Heat Shield"

[Note: This story starts where the "Lasers and Mirrors" story ends, with the Ghost in the Gold Mine. If this lesson is presented by itself, the story can be told without Jack being a ghost.]

Jack and Jill are trying to get rid of the ghost at the bottom of the mine. Grandma told them to try pepper, she told them to try salt, didn't work. Then she said, "You have to drill a hole in there and make the sun shine right on the ghost." So they got a gopher, and the gopher dug a hole through the mountain, but the hole didn't end up in the right place. And the sunlight didn't shine perfectly through it, and it didn't hit the ghost. And they said, "Oh, no. Too bad." So they called the Acme Store of Everything and they ordered a bunch of mirrors. And they bounced the light from mirror to mirror -- boing, boing, boing, boing, boing, boing -- and hit the ghost. And the ghost started to fade away. "Nooo, pleeease, aaaaaahhhh!" He got dimmer, and dimmer, and dimmer, until just his mustache fell off. And that was the end of the ghost.



Ghost at bottom of the Gold Mine.

And Jack and Jill looked all around, and they shuffled in the dirt, and Jack picked up a piece of his mustache and wiggled it around. "Wow, this is really weird -- ghost mustache! I wonder what you can do with it." Then he picked up the other piece and he put them on his own face, and they stuck! And now Jack had a ghost mustache stuck on his face. And Jill said, "Whoa, Jack, that's weird. Let go." And it wouldn't come off. And Jill said, "Let me help you with that." And she started pulling on the mustache, but it wouldn't come off. And she said, "Oh, no. This is bad. You know what it means when a ghost mustache sticks to your face? It means you're going to become a ghost." Jack said, "Yeah, I want to be a ghost! That'd be cool. I'd be invisible. I could sneak up on people and do all kinds of things." And Jill said, "Yeah, I guess it would be kind of fun to be invisible."

And so they went back out of the mine, and when they got out of the mine, Jill turned around and said, "Jack!" And there was no Jack. She looked all over the place. And Jack was gone. And she felt, felt, felt, felt, but Jack had turned into a ghost. She said, "Jack, are you there?" And Jack was right behind her. And in his voice he said, "HI!!!" And Jill went, "AHH!!!" And Jack said, "This is so cool! I can do anything I want, and no one can see me." And Jill said, "Oh boy, oh boy, oh boy, oh boy, Jack. You're strange."

Well, word got out that Jack was now a ghost, and that Jack and Jill had gotten rid of Evil Mister Fred's Great-great-great-Grandpa. And Evil Mister Fred came around to see what was going on. He's been flying overhead on his vacuum cleaner. And he dropped one of his minions down there, and the minion bounced -- boing, boing, boing, boing -- and

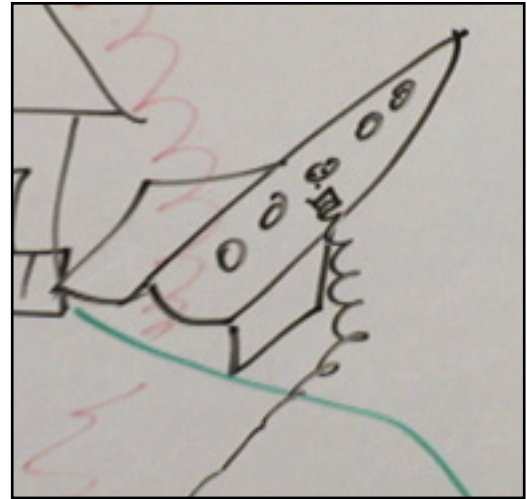


Evil Mister Fred on vacuum.

he told the minion, "Run down into the cave and see if Grandpa's still there." The minion ran all the way to the bottom of the cave, came all the way back up and said, "Evil Mister Fred, nobody's there. It's empty." Evil Mister Fred said, "Ah! Just as I thought. That Jack and Jill have wrecked my Grandpa. Well, I'll show them."

And Jill was running around, going back to her house, over the river, through the woods, past Grandma's house, up the hill, and into the house. Jack was with her, but nobody could see Jack. And Evil Mister Fred said, "Now, that's strange. Jill is by herself. Where's Jack?"

And Jill saw Evil Mister Fred flying around on his vacuum cleaner. And she said, "Uh, oh. He's going to be mad. His Grandpa's gone. He's really going to be mad. I'd better do something." So she called the Acme Store of Everything and ordered a space ship. And there's some windows on it. And there's Jill's eyes. And there's a special trap door just for Jill hair to come out, like that. And she took off -- vroommm -- out into space. And Evil Mister Fred said, "She can't lose me. I've got a special way to go into space." So he put a fishbowl over his head. And he followed her. And Jill said, "Oh, no. Evil Mister Fred is following me into space. Well, I'll lead him on a wild goose chase. I'll take him to the Moon and lose him at the Moon."



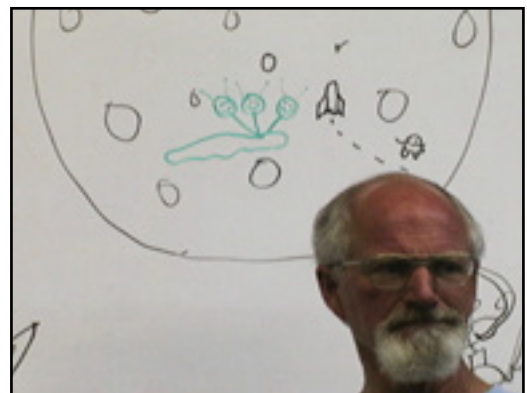
Jill's Space Ship



Evil Mister Fred's fishbowl.

So Jill went up to the Moon. And the Moon had all kinds of big holes in it -- craters. And Jill flew up there and landed on the Moon. And Evil Mister Fred wanted to sneak up on her and see what she was doing. But he didn't want to do it himself. So he sent out a bunch of minions, and the minions are now wandering around the Moon trying to find out what Jill is doing there. And Jill went to an Alien and said, "Hey, Alien, Evil Mister Fred is following me." How many heads should our Alien have? Three heads? How many bodies? One body? It's kind of a sluggy body with three heads. Those are heads. [Student: Give it antennae.] Okay. She said, "Hey, Alien, Evil Mister Fred is following me, and I don't know what he's up to. He's really mad because we kind of got rid of his ghostly Grandpa." And the Alien said, "Well, you can easily get rid of Evil Mister Fred. Just give him gold, silver, diamonds, and pearls. He'll be rich and he'll go away." Jill said, "But I don't have any of that stuff." And he said, "Ah, but treasure is where you find it." He was a very wise Alien. And Jill said, "Okay, where's that?" And the Alien said, "Follow your instincts." And Jill said, "Follow my instincts? Hmmm. Does smell kind of bad in here. But I don't know where my instincts are leading me." The Alien says, "Just go, young lady, go find your treasure."

So Jill took off in her space ship and said, "Okay, follow my instincts. Where are my instincts leading me?" And as she flew



Alien, Space ship, and Minion on the Moon.

away, Evil Mister Fred followed her. And she came around, now she's orbiting the Earth, going around and around. And as she was orbiting the Earth, she happened to look down and saw Egypt down there. Egypt's a big country with pyramids. And she looked at the pyramids, and she looked at the ground, and she said, "What's that? There's like a hole in the ground between the pyramids." And then she looked, and she said, "Do I see gold and silver and rubies?" She said, "Yeah, right between the pyramids. There's treasure there. Yeah, I'm going to go get that." So now she's going to re-enter the Earth's atmosphere. And Evil Mister Fred said, "Awh, awh, awh! She's got to go into the Earth's atmosphere at twenty-five thousand miles an hour, while I in my vacuum cleaner can just slowly go down. She's going to get really hot, and I'm going to get nice and cool. This is going to be great." So he flew over to her space ship and he ripped off her shields, the ones that keep the space ship from melting when it goes into the atmosphere. And Jill saw Evil Mister Fred through the porthole, flying by on his vacuum cleaner, going, "Mwah, ha, ha, ha!" with pliers in his hand. And Evil Mister Fred attached himself to her space ship, and she heard this mreek, mreek, mreek, rrrriippppp --- and Evil Mister Fred took off her thermal protective shields. And Jill said, "Stop! You can't do that!" And Evil Mister Fred put his face by the window and he said, "Yes, I can!" and flew away. Now Jill and Jack are in the space ship. Jack's a ghost, Jill's not. They don't know how they're going to get back to Earth. If you were Jack and Jill, what would you do?

Imagination and Brainstorming Time

[Students make suggestions] (THERE ARE NO WRONG ANSWERS! Whatever they say, you should reply: "That's a good idea," "They might do that," etc. After brainstorming, proceed with the experiments, then finish the story.)

And we're going to leave this "To be continued . . ."

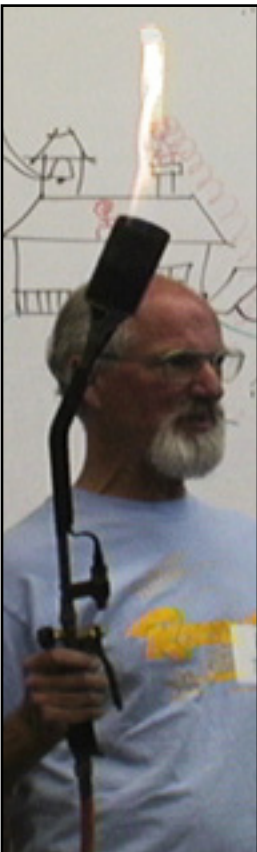
Demo: *Space Shuttle Tiles*



Fire Brick

If you're in a spaceship and you're floating around the Earth, you're usually going about seventeen or eighteen thousand miles an hour. And when you want to come back down, you come down into the air. As you come into the air, the air rubs against the spacecraft and makes the spacecraft hotter. You don't tend to think of air or wind making it hot, but if you're going at eighteen thousand miles an hour, it makes it really hot. If you're not careful, it'll burn it up.

I wanted to show you what it would look like for a spacecraft to come into our atmosphere. Here is a -- it used to be a brick that kind of looked like the space shuttle, but the space shuttle broke. So we're going to pretend like this is the space shuttle flying in space, and it's going to come down into the atmosphere. And we can't make it go eighteen thousand miles an hour, but I can make air go pretty close to eighteen thousand miles an hour with my little cigarette lighter [holds up a large propane torch]. This is my cigarette lighter. It's a big cigarette lighter, actually. You see the flame on it? Now, that's when it has just a little bit of gas. When I turn on a lot of gas, it'll make a loud noise. Are you ready for a loud noise? Okay. [Fires torch briefly.]

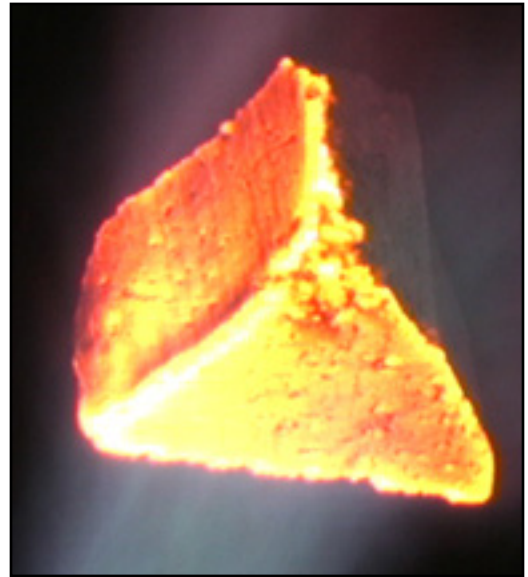


Torch

So here's the space shuttle. We need to pretend like it's going eighteen thousand miles an hour. The gas coming out of that is going to be hot and really fast. [Turns on torch, turns off overhead light, and places fire brick in the flame until it turns red.] Now you can see how hot it gets as it tries to come into our atmosphere. This fire brick is kind of like the stuff that's on the space shuttle tiles. If you're inside of the spacecraft, the outside is white-hot. It's so hot that you could melt steel on the outside of it.



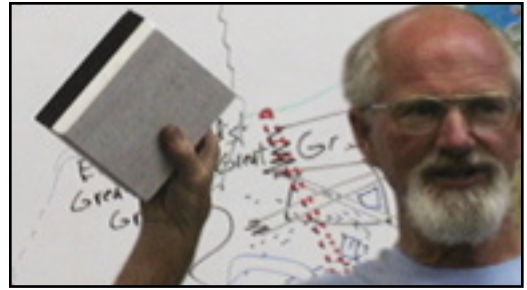
Holding Fire Brick in Torch flame.



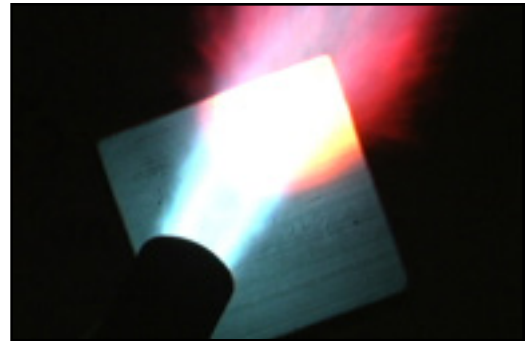
Fire Brick gets red-hot.

I want to show you a real space shuttle tile. It's got this white stuff that's glass, and they blew bubbles in the glass. Like foamed glass. On the back, the black stuff is a thin layer of really high temperature glass. They put glue on it, and they glue thousands of these onto the space shuttle to give it its heat protection. Whenever the shuttle takes off, they have cameras now that go around and look at all the tiles to make sure they're not damaged, because they had an accident where one of the tiles, actually several tiles, fell off. And then when they tried to come back down, the heat from re-entry melted the metal underneath and the space shuttle blew up. So these kinds of things are supposed to protect it from blowing up. We can get this really hot and see what it looks like, compared to a regular fire brick. Earmuffs on. *[Turns on torch, turns off overhead light, and places the white side of the tile in the flame until it turns red.]* And it gets red just like the other, but it doesn't melt either.

Now, there's a guy on the internet that has one of these, and he gets it red-hot in the oven, and then he touches it with his finger. And you actually can -- you can touch it when it's red-hot. It's so light that you won't burn yourself. The MythBusters did a show on that, where they had a big fire and a long pit. And they walked through the fire, and they didn't -- well, some of them burned their feet because they didn't walk right. And this kind of stuff, it's so light that the heat doesn't burn you even though it's really hot, temperature-wise.



Space Shuttle Tile



Space Shuttle Tile in Torch flame.

Experiment:

Well, we're going to do some experiments with heat and see if you can find ways to keep heat from getting through stuff. Now, if you wear something like a sleeping bag, you feel hot inside, right? It's a hot night. But what if somebody put you in a sleeping bag and put dry ice on the outside? It would take awhile for the coldness to get through then, huh?



"Small Person" and Battery

We have some small people. There's a small person [*holds up a tiny christmas light with two wires attached*]. There, there's a small person [*attaches wires to the terminals of a 6-volt lantern battery so the light turns on.*] He's all lit up, and all he needs to do is be warm to be a small person. You're going to get a small person, and you're going to hook him up with some alligators so he stays lit up. And when he gets lit up, he'll have a little bit of warmth. He's about a six-volt person.

Now, we want to find out if we can put something on him so that his heat doesn't get through to the outside. Now, we could wrap him in stuff and then feel the outside to see if the heat gets through, but there's a better way to do it.

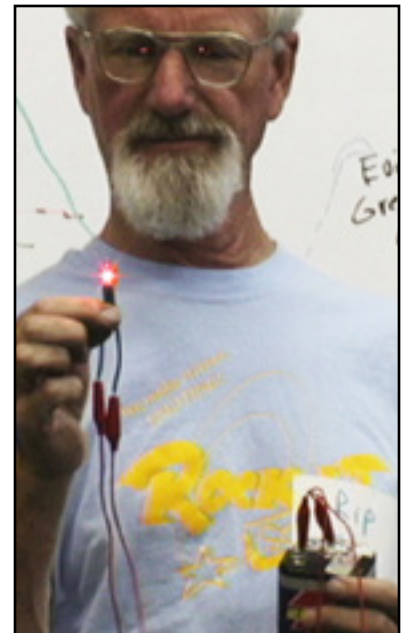
We're going to use fat. We're going to use some fat to see if the heat gets through. And we have some fat in a box. Another name for fat is lipid.

At some places, they sell these post cards, and what it really is, is a thermometer. You put it on your forehead. Does it do anything when it's on my forehead? No? [*Student: Makes you hotter.*] It makes me hotter?



Thermometer Card

Well, do you see any colors on it? Oh, I see changes. The colors indicate the temperature. Now, this one has a line right here at 80-85 degrees, and a line at 75-80 degrees. If I put my finger on it, it turns from green to blue. And if I put my hand up here, that one turns from green to blue. And you can see these things. Inside of it is like a soap bubble. There's a thin layer of fat. And when the light goes through it, the light makes colors. The light makes colors according to the temperature. This one says the temperature is somewhere between seventy-five and eighty-five degrees in this room. Well, they gave us a whole bunch of sheets of this stuff without the numbers.



Light connected to Battery with Alligator Clips

If I put this on my forehead, will it do anything? [*Students: Yes.*] What's it doing? [*Students: Tuning blue.*] Are there any other colors around the blue? [*Students: Green, red, and yellow.*] When you get fat hot, it changes size. It gets thicker when it gets hotter and thinner when it's cooler and changes the color that you see. First we're going to give you each one of these, and you're going to see if you can

make it change colors. Then we're going to give you a person, and see if the person can make it change colors. And then we're going to give you some insulators to see if you can make it so that the person's heat can't get through. So this is going to be our handy-dandy thermometer. It's a really nice one because you can see where the heat is coming from on it as it changes colors. They used to sell these in stores on rings, and they'd call them mood rings. And then by the color, you're supposed to know whether you're in a good mood or a bad one. But really, it's just measuring your temperature.

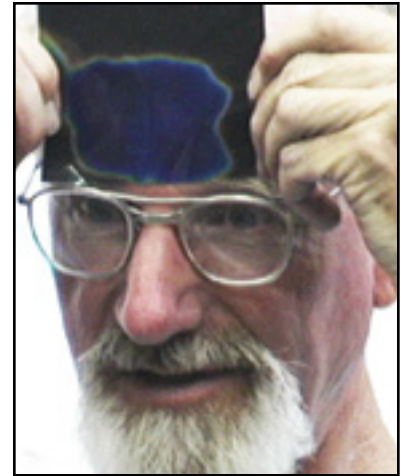
[Instructors pass out a thermal-change sheet to each student and they fool around with it to see how the colors change. Then they pass out a christmas light, a battery, and 2 cables with alligator clips to each student.] When you get a light bulb, test it and see if it works. Then we'll give you two wires and you can hook it up so it stays on.

[Note: Part of the video is missing here. After hooking up their lights to the battery, students see how the light changes the color on the temperature card. Then they are given various insulators: a piece of plastic, a thin sheet of sponge, and a sheet of aluminum foil, to see if any of them will block the light's heat from reaching the temperature card.] Put a sponge and a piece of plastic and a piece of aluminum foil all together, and see if it will stop it. Put them all together. Does the heat get through the plastic and the foil and the sponge?



Thermal-change sheet placed over three insulators: sponge, plastic, and foil.

[Student: Do we get to keep these?] You get to keep the colorful card -- the one that changes colors.



Skin temperature makes the card change color.



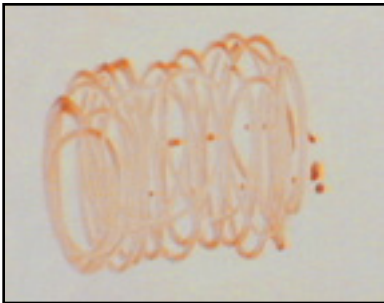
Trying out thermal-change sheet.

End of Story

*** DO NOT * present this part of the lesson until after the experiments!**

So Jack and Jill were orbiting the Earth. Evil Mister Fred tore off their heat shields. And they said, "Oh, no, we're going to die! We can't get back to Earth. We're just going to float in space forever." And Jack said, "Jill, I think we have a solution to this problem. Evil Mister Fred is out there flying around with our heat shields. And we can't get them, but he can. We just have to catch Evil Mister Fred." And Jill said, "Ooh, that could be fun. We can chase him with our rocket ship. He's only on a vacuum cleaner. Once we get him, we can put our heat shields back on." So Jack and Jill started zooming after Evil Mister Fred. But even though they could go really fast, Evil Mister Fred could change directions really quick, and they couldn't catch him. And Jack said, "Well, looks like we're done for. Almost out of fuel, we've got to go back down, and we've got no heat shields." And Jill said, "Yeah, and I've been having a bad hair day. I try to comb my hair and it just goes phhhhhh! It foofs out everywhere." Jack said, "Well, just throw it outside. We'll get rid of it. It grows infinitely fast." Jill said, "Ooh, good idea!"

So Jill opened the air lock and put about a hundred million pounds of hair around the space ship. Now



Ship wrapped in Jill's hair.

Jack and Jill are flying in a giant hairball. Here's the spaceship, and there's hair wrapped all around the outside. *[Student: Could they see?]* No, because it's all covered with hair. And Jack said, "Well, it's worth a try. Let's go in this way." So they did. They turned on one of their little rockets and it slowly made them go down. And then when they started hitting the atmosphere, the hair started to burn. And there were flames coming off of it, like a giant comet going into the Earth's atmosphere. And Evil Mister Fred said, "Yes! They're burning up. This is so good. I want to get a closer view."

So Evil Mister Fred came closer on his vacuum cleaner so he could watch Jack and Jill burn up. There he is, practically floating, waiting for them to come by. And Jack and Jill were inside, and they were coughing and gasping because of the smoke from the burning hair. And they thought, "Uh, oh, we're not going to make it." And pieces of hair kept falling off as it burnt up. And Evil Mister Fred said, "Ooh, yeah!" And Jack and Jill came to the very lowest part, where they should have been hottest, and a big chunk of hair fell off -- foooshh! And the hair surrounded Evil Mister Fred, and now Evil Mister Fred is captured in a ball of burning Jill hair. And Jack and Jill's space ship just barely made it and didn't burn up. The outside was so hot it was red, but inside they were still alive. And they landed in the ocean -- pshhhhhh! And Evil Mister Fred was going, "Aaaah! Aaaah! What a horrible way to go! Surrounded by burning Jill hair. Oh, my poor evilness!" And foof! -- Evil Mister Fred burned up. And they all lived happily ever after, except Evil Mister Fred.



Evil Mister Fred on fire.

End of Lesson -- If you have questions about this lesson, please ask them through the [online Teacher Support Forum](#) on our web site.