



Teacher's Guide for:
Destructive Testing

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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Destructive Testing
A Rock-it Science Lesson
Filmed July, 2009

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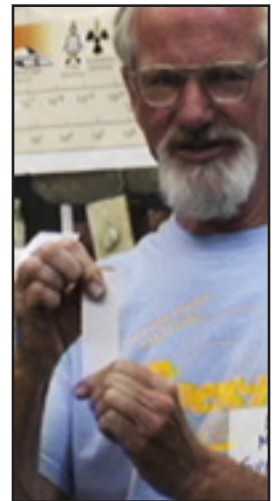
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Intro Quick Recap:

- A magician can make someone seem to hover in midair. To do that, you need something really thin so it's invisible to the audience, but also strong.
- They used to use fish line, but now we have other materials that are stronger and thinner.
- We're going to experiment with stuff to see what's strong, and if there's anything strong that can be almost invisible.

Experiment Quick Recap: "Destructive Testing"

- We're going to pretend that Jack and Jill have a bunch of stuff that's like Jill's hair. They want to make ropes out of it, and they want to see which ones will hold their weight, and which ones won't.
- During the experiment, don't use your teeth.
- When engineers want to test the strength of a material, they do a tensile test. They put it in a machine that pulls it perfectly straight up and down, without twisting and tearing.
- For the first test, pull straight up and down to see if you can make it break.
- Then rip it into little pieces.
- Instructor passes out various materials, one at a time, for students to test:
 - 1. Ordinary paper (Students can tear it.)
 - 2. Circle of Tyvek (Can be torn if they find a weak spot on the edge.)
 - 3. Clear plastic that's fairly easy to tear
 - 4. Clear plastic that's thicker and not easy to tear. Instructor cuts a tiny nick on one edge so students can start tearing it there.
- Ask students which of the four materials they just tested would be good for a rope.
 - 4. Rubber band. Give students a rubber band that's been cut so it's a straight piece instead of a loop. Have them hold it against their forehead and stretch and relax it repeatedly to see how it feels. (It should feel warmer when they stretch it and cooler when they relax it.)
 - 5. Garbage bag. Give students a strip of a garbage bag and have them stretch it very slowly to see how long they can make it.
 - 6. Caution tape. Instructor has a "tug of war" with each student in turn, using yellow caution tape. When it breaks, student gets to keep the broken piece.
 - 7. Ordinary cotton string. Tell students to try to break it. Some will figure out that they can separate the individual strands. Then have them try to break one strand.
 - 8. Kevlar thread. Tell students to grab it in both hands and pull hard. Then pull out one fiber. Then put it in the air and let it go. They can blow on it to keep it floating. Then try a bigger piece.
 - 9. Monofilament fishing line. Have students try and stretch the nylon.
- Pass out ziplock bags so students can put their samples in it to take home.



Pull paper straight up and down.

Equipment List: "Destructive Testing"

Items needed for Instructor:

- Scissors

Items needed for Students:

Consumables (per student):

- Ordinary paper, 2" x 6"
- Circle of Tyvek, 4" across
- Clear plastic (thin), 1" x 6"
- Clear plastic (thicker), 2" x 8"
- Rubber band, thick, cut so it's a straight strip
- Garbage bag, 1" x 12"
- Caution tape, approx. 10 ft per student
- Cotton string, 12"
- Kevlar thread, 12"
- Monofilament fishing line, 12"
- Ziplock bag, 1-qt size

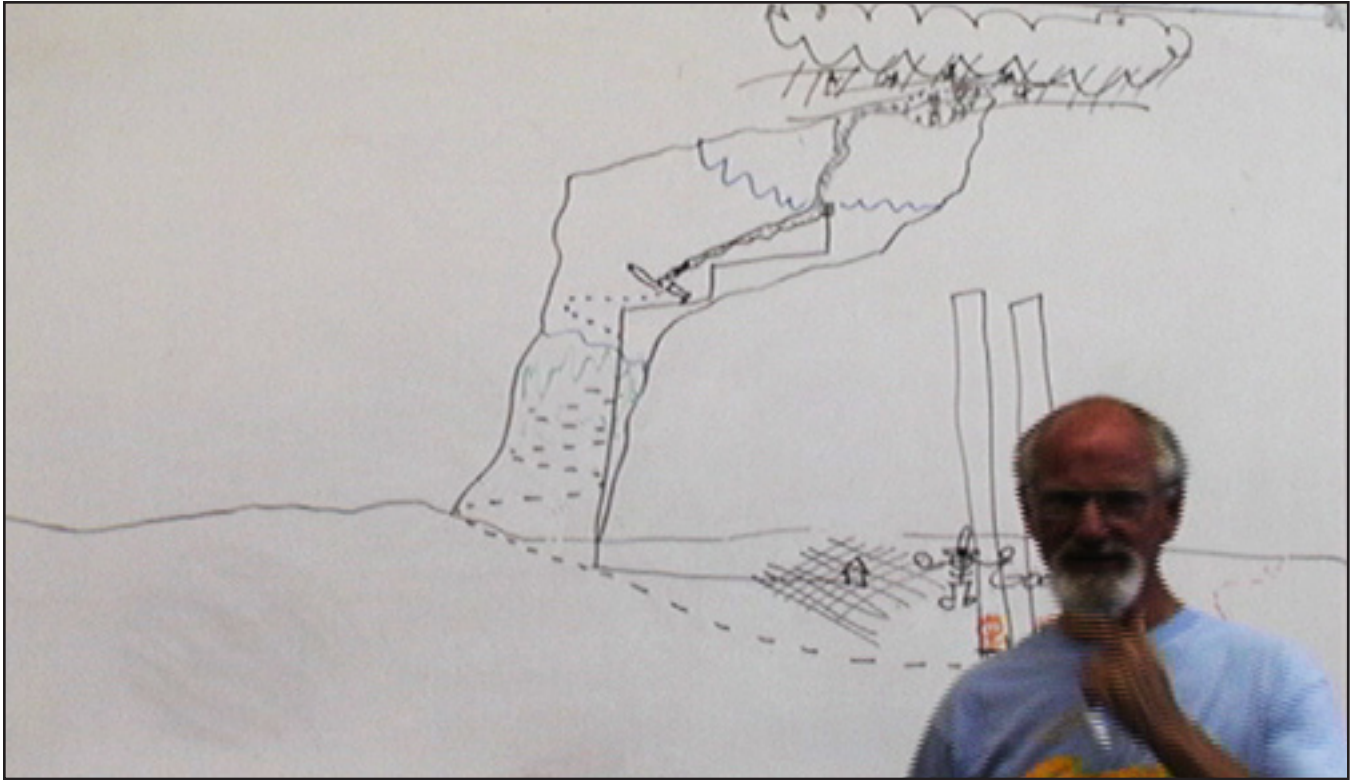
Other:

- Markers, permanent, colored (to write name on bag)

Prep Work:

- Pre-cut the testing materials
- NOTE: Some of the materials used in this experiment, such as the kevlar thread, were manufacturing rejects. We found them at R.A.F.T. (Resource Area for Teaching) in San Jose, CA.

Story Recap: "The Mountain of Death"

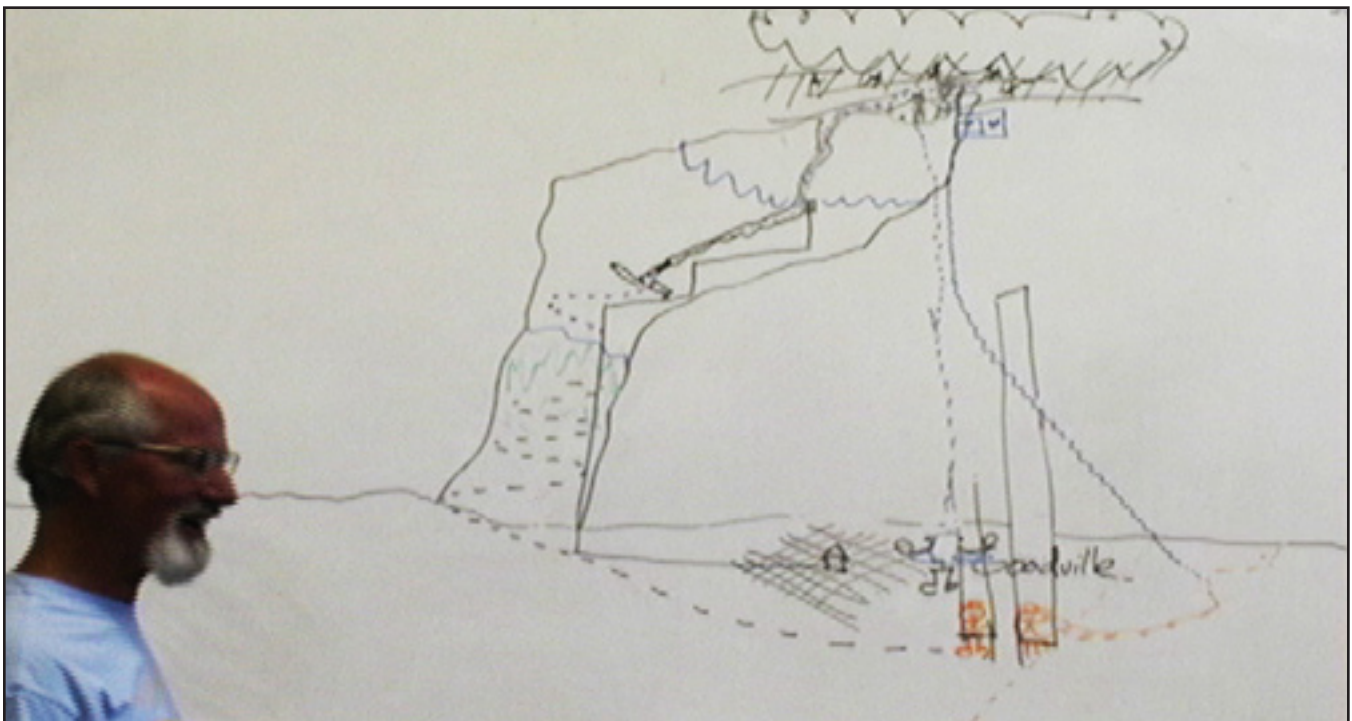


Part 1:

- There was a tall mountain with a big crack in it, and people came from all over to climb it. There were trees partway up, but above ten thousand feet it was all rock. Near the top there was snow.
- Below it was a town where every year a new mayor was chosen by lottery. Whoever was chosen got to decide what jobs people would do. So every year their jobs changed.
- One year Evil Mister Fred was chosen as mayor. He assigned the worst people to do the important jobs. He put a burglar in charge of the bank; a poisoner in charge of the restaurant; a deaf guy in charge of the band; a guy who couldn't count was making change in the store.
- But instead of doing the wrong things, these people decided to try to do the right thing for a change. So instead of everybody being miserable, everyone was happy.
- Evil Mister Fred went stomping off into the woods and came upon Jack and Jill on a hike. They had just crossed the city line, so they had to do whatever job Evil Mister Fred assigned to them.
- He asked Jack and Jill what they were afraid of. They said they were afraid of heights. So he made them be guides for mountain climbers who were going up the Mountain of Death.
- He gave them giant packs filled with heavy junk. He gave them loose shoes and covered the soles with grease.
- Jack and Jill didn't know the route, so Evil Mister Fred offered to show them. He led them up the mountain to the big crack.

Part 1 (cont.):

- He showed them how to climb the crack by putting their hands and feet against the sides. But when he turned the corner and was out of sight, he twisted a secret rock that opened a hidden elevator. He got in and rode the elevator to the bottom.
- Jack and Jill thought Evil Mister Fred had gone on ahead, so they kept climbing. They got all the way to the tip.
- A storm came and it started to rain, and then to snow. The whole mountain was covered with a layer of slippery ice.



Ending:

- Jack had to go to the bathroom, and he found an outhouse on the mountain.
- Meanwhile, Jill started weaving her hair into a rope.
- Jill decided to slide down her hair, but Jack thought that was too easy.
- After Jill slid down on her hair, Jack made a rope from toilet paper and started sliding down.
- Partway down, the toilet paper rope started to break because it wasn't as strong as Jill's hair.
- Evil Mister Fred had just bought a new ten-gallon hat and was standing beneath Jack.
- Jack landed on Evil Mister Fred and forced his hat down over his head, and he got stuck that way.

Transcript: Intro

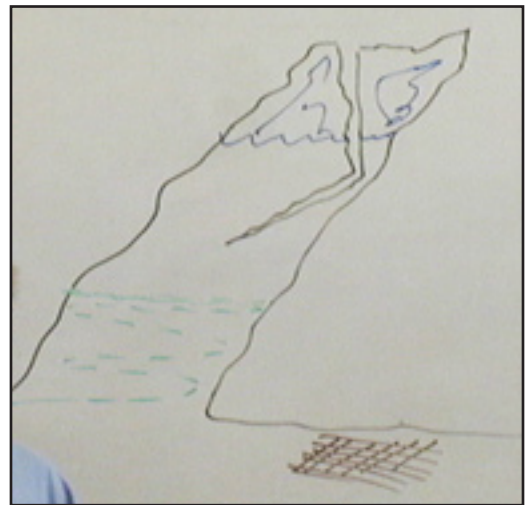
You've probably seen cases where a magician will make somebody hover in mid-air. If you're going to lift up a hundred-pound person, and you want to do it with something really thin, that's where the science comes in, because you want it to be invisible to anybody that's in the audience. Some kinds of fish line are pretty strong, but nowadays they have other things that are a whole lot stronger and a whole lot thinner than they ever had before. And today you guys are going to experiment with stuff to see what's strong, and if there's anything that's strong that can be almost invisible. But first, we need a crazy story.

Story: "The Mountain of Death"

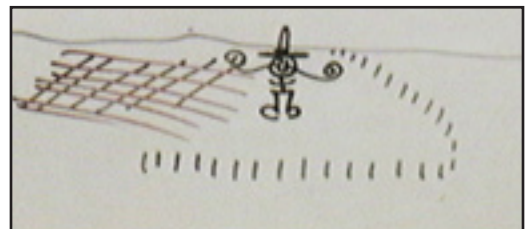
Once upon a time, there was a tall mountain. And the mountain had a crack in it. There's the crack in the mountain, like that. And people came from all over the world to climb the mountain because it was such a hard one to climb. There were trees partway up it, and at about ten thousand feet the trees ran out and the rest of it was rock. And near the top, there was snow, like that. And down below, there was a little town. And this town, they chose a mayor every year. And they just did it by lottery. They put the names of everybody in the town in a big hat, and then somebody would close their eyes, reach into the hat, and pull out one of the pieces of paper. And whoever it was got to be mayor. The mayor had lots of power, and the person who was chosen mayor got to decide who did which job. So every year people kept changing jobs.

Well, one year they reached into the hat and lo and behold, they picked out Evil Mister Fred for mayor. And Evil Mister Fred said, "Wow, this is great. I love this job." He had everybody in town come in front of him, and he knew who was doing what. And so there was a burglar in town, a guy who'd sneak around and rob things. He says, "Burglar, you're in charge of the bank." And the burglar said, "Yeah! Bank! I love this, it's great!" And there was another guy in town who was in charge of poisoning people. And he made him in charge of the restaurants. There was another guy who was deaf, couldn't hear a thing. He was in charge of the band. And, let's see, what would be good? Another guy who couldn't count was in charge of giving money out at stores. Evil Mister Fred gave everybody the worst possible jobs. And he said, "My work is done here. Tomorrow, these guys are all going to do their jobs, and it's going to be a big mess. People are going to cry, they're going to shout, they're going to be angry. I love it!" And so he went to sleep, happy as he could be.

The next day, everybody woke up. And the burglar went to the bank. And he had the combination to the vault. He opened it up. There was all the money, and nobody to say he couldn't take it. He went, "Yeah!" But then he said, "Eh, just for the fun of it . . ." He started acting like a real banker and didn't steal the



Mountain of Death with crack in it.



Evil Mister Fred became mayor.

money. The guy that usually makes poisons went to the restaurant. He said, "Oh, oh, oh!" He started cooking stuff, and he said, "You know, just for the fun of it, I think I'll try to cook things the right way." And everybody tried to do the jobs correctly.

Evil Mister Fred woke up and the lights were still off. He listened for sounds of cars crashing on the road, but he didn't hear any. He didn't hear people screaming. He didn't hear sirens going off. He said, "What's wrong?" He went out there and looked around. Everything was working perfectly. And he went from place to place, and he said, "What's wrong with you? How come you're not stealing the money?" And the guy says, "Eh, I was just trying this out."

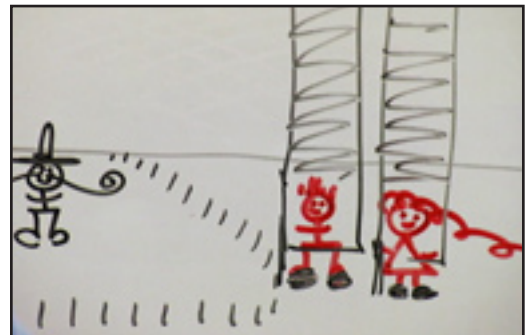
And Evil Mister Fred was really mad. He went stomping off. And he was out in the woods, just shouting and screaming, when along came Jack and Jill on a hike. And Evil Mister Fred said, "You just crossed the city line. You belong to me." And Jack and Jill said, "What? We did?" "I'm mayor. You've got to do what I tell you."

Jack and Jill said, "Well, what do we have to do?" Evil Mister Fred said, "What's your greatest fear?" And Jill said, "Well, I don't like heights. I hate being in high places." And Jack said, "Me, too. If it's high, and there's a long way to fall -- no, I'm not going there." And Evil Mister Fred said, "Perfect. Then you guys are going to be guides for mountain climbers climbing the Mountain of Death." And Jack and Jill said, "Nooo!" And Evil Mister Fred said, "Yeeeessss!"

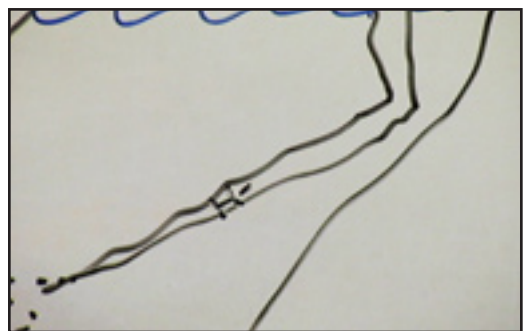
So he got Jack and Jill walking sticks. He gave them backpacks. And he filled their backpacks with all kinds of junk -- rocks, tv sets, frying pans, anything he could think of. They were really, really heavy. And then he gave them loose shoes. He said, "These are perfect hiking shoes." And the bottoms were really slippery, and he coated them with grease.

So Jack and Jill are trying to walk around with all this stuff. They go, "Argh, I can hardly walk." And Evil Mister Fred said, "Now, you're going to go climb that mountain." And Jack and Jill said, "But we don't know the way." Evil Mister Fred said, "No problem. I'm a good guy. I'll guide you."

So Evil Mister Fred took them up the mountain. And Jack and Jill never looked back. They didn't look down. They just looked at the trail right in front of them so they wouldn't be scared to death. And they came to the crack, and Evil Mister Fred said, "Now, the easy part. You just put your hands against both sides, and your feet against both sides, and kind of walk up inside this crack." And Jack and Jill said, "Whoa." Evil Mister Fred was in there, and he put his hands on the sides and his feet on the sides, and he could work his way up this crack. He says, "Come on, you sissies! Go!" Jack and Jill said, "Oh, man!" And they started going up and up.



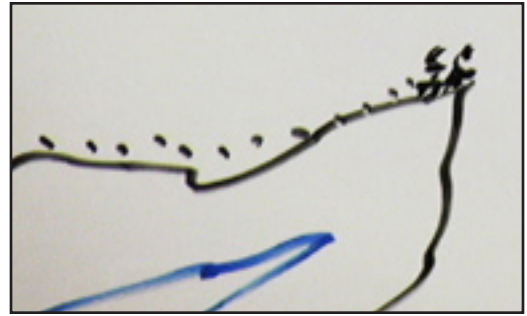
Evil Mister Fred gave Jack & Jill huge packs filled with heavy junk, along with loose shoes coated with grease.



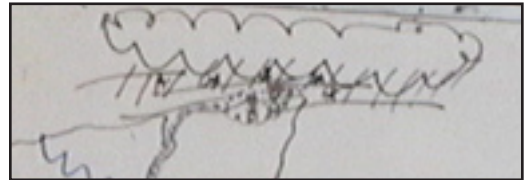
Evil Mister Fred climbing in the crack.

When Evil Mister Fred got to the turn in the crack, he only went a few feet. He could hear Jack and Jill struggling behind him, and there was a rock on the wall. And it was a special rock. In fact, it wasn't a rock at all. Evil Mister Fred grabbed it and gave it a twist. When he did, the wall opened up. There was an elevator there. Evil Mister Fred got into the elevator, pushed the down button, and the elevator went right to his office in town. And Evil Mister Fred said, "Now Jack and Jill are up on the Mountain of Death." Jack and Jill came around the turn. No Evil Mister Fred. And they said, "Oh, he must be at the top."

So they climbed and climbed and climbed until they got to the top. They went out to the tip, and no Evil Mister Fred. And they didn't dare look down. And then, as luck would have it, along came a storm. And it started to rain. And it rained on Jack and Jill. And then the rain turned into snow. And the snow turned into ice. And the whole top of the mountain was covered with a layer of slippery, slippery ice. And Jack and Jill said, "That's it. We've got to get down fast or we're going to freeze to death and die." They hardly dared to move because the ground was so slippery. If you were Jack and Jill and you were up there, what would you do?



Jack & Jill at the tip of the mountain.



Storm on the mountaintop.

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.)

We'll leave this To Be Continued . . .

Experiment: "Destructive Testing"

We're going to do the experiment now. And in the experiment, we're going to pretend that Jack and Jill have a bunch of stuff that's like Jill hair. And they want to make ropes out of it, and they want to see which ones will hold their weight and which ones won't. During the experiment, you don't get to use your teeth, because your parents like your teeth -- mostly while they're still in your mouth. And we'll give you samples of stuff, and what you're going to do is tear them or break them.



Testing plain paper.

The first one is really simple. Whenever you give an engineer a sample and you say, "Here, tell me how strong it is," they usually do something called a tensile test where they put it in a machine. And the machine pulls on it perfectly straight up and down. The machine doesn't twist or tear in any direction. So for your first test, you're going to pretend you're a robot. And you pull straight and see if you can just make it break by pulling on it. It's pretty strong when you pull straight. If you pull crooked, then it'll tear, but if you pull like a robot, then it's strong. And then when you get tired of doing that, then you rip it all into little pieces and leave the pieces on the table. *[Instructor passes out pieces of paper, about 2" x 6", and students try to break them.]*

Now we have some other pieces of paper. These are circle-shaped. See if the shape makes any difference. First, pull on it and try to break it by pulling on it. And then tear it to pieces. *[Instructor passes out circles of Tyvek, approx. 4" across, and students attempt to tear it, without success.]* If you put two thumbs really close together and twist, somewhere along the edge you'll find a weak spot. You just have to keep trying and trying, and you might find a weak spot. And you've probably discovered that this is not paper. *[Student: This is plastic.]* Yes, it's plastic fibers all smooshed together. Strong like bull.



Testing Tyvek circle.

Next one is clear plastic. *[Instructor passes out pieces of clear plastic, about 1" x 6", and students tear them.]*



Trying to tear plastic.

Now we're going to pass out thicker clear plastic. *[Instructor passes out pieces of clear plastic, about 2" x 8", and students can't tear it.]* This is not a tearable piece of plastic, but some have weak spots and some don't. Now, when one of us comes by, we're going to put a little tiny cut in it. Just a little cut. And give it back to you. And you try and find the cut and tear it where the cut is. *[Instructor uses scissors to make a tiny cut on one edge of each piece of plastic, then gives it back to the student to tear.]*

Now, suppose you had to make a rope out of the things we've given you so far. Would you make a rope out of paper? Would you make a rope out of the tyvek plastic stuff? Would you make a rope out of the plastic? Would you make a rope out of the thin plastic?

We're going to give you a cut rubber band. When you get your cut rubber band, you're going to stretch it while it's touching your forehead, like this. It does something when you stretch it on your forehead, and



Stretching rubber band on forehead.

then when you let it go, it does something else, as long as you keep it in contact with the skin. So we'll give you a piece of rubber band. Try stretching it on your head. *[Instructor passes out cut rubber bands.]* You can try it on your upper lip, too, if you don't have a mustache and see if it does the same there. *[Student: It burns your forehead if you turn your forehead.]* Does it feel like it gets warmer when you stretch it? *[Student:*

Yes.] [Student: No.] You're not stretching it enough. Stretch it until it can't stretch any more. And then let it go. Does it feel cold when you let go? *[Student: Yes.]* It should go hot, cold, hot, cold, hot, cold *[Instructor stretches and releases rubber band on his forehead repeatedly].* Now hold it out in front of you and see how long it is, and stretch it and see how long it gets before it doesn't stretch anymore. On MythBusters, they made rubber stretch about five times its original length.

Now, we're going to give you another sample, of a garbage bag. When you get your sample of garbage bag, you're going to pull verrrrrry slowwwwwly. So when you pull, you hold it up and watch while you pull, and see how it changes. If you pull slowly enough and carefully enough, you should be able to stretch it a lot farther than I did. Maybe that far *[holds arms outstretched at sides]*. Try it and see. *[Instructor passes out strips of a black garbage bag, about 1" x 12", and students try to stretch them.]*



Slowwwly stretching a strip of garbage bag.

[Next, Instructor brings out a roll of yellow caution tape and each students takes a turn holding one end in a "tug of war" with the Instructor until the tape breaks. The student gets to keep the piece that breaks off. If it breaks too short, or not at all, the Instructor tears off a length of the tape and gives it to the student.]

Next one is a piece of ordinary cotton string. When you get your cotton string, break it into two pieces. Don't use your teeth. *[Instructor passes out pieces of string, about 12" long.]* You can break it any way you want. *[Some students realize they can separate the strands of fiber in the string.]* How many can you get out of it? *[Student: Six.]* Are there six in there? Okay, now try to break one of the six.



Separating strands of string.

Next, we're going to use bullet-proof vest material. The bullet-proof vest material is called kevlar. First, we're going to cut off a piece for each person. Then you're going to try and grab it and break it the regular way. And then you're going to try to take it apart and break the pieces. See how many pieces there are in it. They're really fine pieces. *[Instructor cuts approx. 12" strands of kevlar thread and gives them to students.]*



Tug-of-war with caution tape.

Next, we're going to use bullet-proof vest material. The bullet-proof vest material is called kevlar. First, we're going to cut off a piece for each



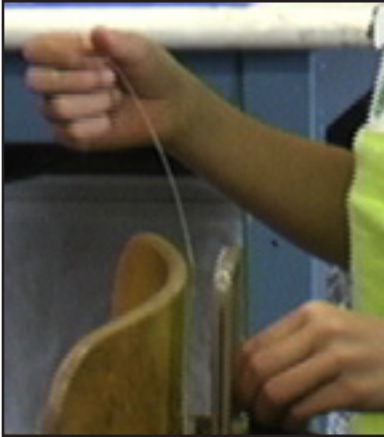
Spool of kevlar thread.

person. Then you're going to try and grab it and break it the regular way. And then you're going to try to take it apart and break the pieces. See how many pieces there are in it. They're really fine pieces. *[Instructor cuts approx. 12" strands of kevlar thread and gives them to students.]*

When you get your piece of string, grab it in both hands and pull hard. If you get a paper cut, you get extra points. If you bleed all over the floor, you get double extra points. *[Students try to pull on the thread.]* After you do the pull test, try to pull out one fiber. When you get one little tiny piece, put it in the air and let go. There it is. *[Fibers float in the air, and students can blow on them to keep them floating.]* Then try a bigger piece.



Kevlar fibers floating.



Fishing line is almost invisible.

Next, we're going to have samples of fishing line, called monofilament fishing line, made out of nylon. *[Instructor passes out fishing line, about 12" long.]* Try and stretch the nylon.

Now, stuff all your samples into a little bag. *[Instructor passes out zip-lock bags.]* Tomorrow morning, when you get up and you're ready for breakfast, you put milk in the bag and you eat it like cereal. *[Students: No!]* Okay, don't eat it. Write your name on the bag.

End of Story

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



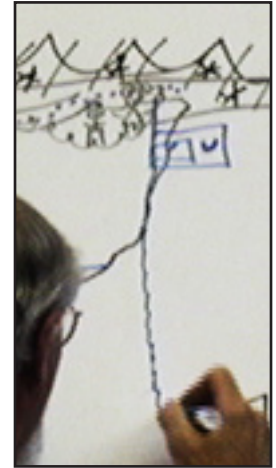
Jack's dangling bathroom.

So Jack and Jill are stuck on a mountain covered with ice. And Jack said, "Well, this is a real problem. We can't get down from here. And I've really got to go to the bathroom." So he looked around and he found a restroom up there. [Student: *A dangling one.*] Yeah, a dangling restroom with a big half-moon on there. So Jack went to make a pit stop. And Jill sat down and started to weave her hair into a rope. And Jill made this really long rope. It went down here. And it was kind of windy that day, and her hair was just blowing in the wind, off in this direction. And she said, "Jack, I'm just going to slide down my hair." And Jack said, "Oh, yeah. I suppose you could do that. But that's too easy." And

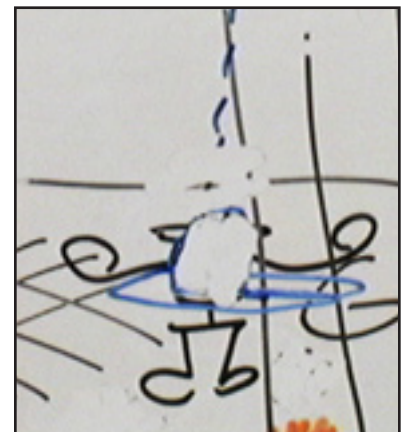
Jill tied her hair to a rock and she started sliding down. She said, "Jack, what are you going to do?"

Jack says, "I'm coming down on toilet paper." So Jack grabbed the toilet paper and he started twisting it up. And he twisted and twisted until he thought he had a rope. Then he tied it to the toilet, and he started sliding down on the toilet paper. Jack's toilet paper wasn't as strong as Jill's hair. And pretty soon, Jack started to fall -- aaaaaaahhhhhh!

Now, Evil Mister Fred was down there, and he had just bought himself a brand new ten-gallon hat. Big hat. And he was really proud of that hat. Whenever people came along, he'd say, "Do you like my hat? Isn't this a great hat? I love this hat." And he heard this noise from up above -- aaaaaaahhhhhh! -- but he didn't pay any attention, because he doesn't care when people are screaming. And Jack landed right on top of Evil Mister Fred's brand new ten-gallon hat. And it stuck down on top of his head, and he couldn't get it off. And Jack jumped off of Evil Mister Fred and said, "Hey, thanks, Evil Mister Fred. That was nice of you to be standing there." And he and Jill went off to go do some games and stuff. And Evil Mister Fred spent the rest of the day going "rrrr-rrrr-rrr" because he was stuck inside of his own hat. And they all lived happily ever after, except Evil Mister Fred.



Jill's rope of hair.



Evil Mister Fred's new hat stuck down over his head.

End of Lesson

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