



Teacher's Guide for:
Boil Water in a Cup

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.

Contents:

Quick Reference Sheets:

- Intro:page 2
- Experimentpage 3
- Equipment List: *Boil Water in a Cup*page 4
- Story, Part 1: *Jack & Jill and the Pancake Rocket*page 5
- Story, Ending.....page 6

Video Transcript:

- Intro:page 7
- Story, Part 1 : *Jack & Jill and the Pancake Rocket*page 8
- Experimentpage 10
- Story Endingpage 14

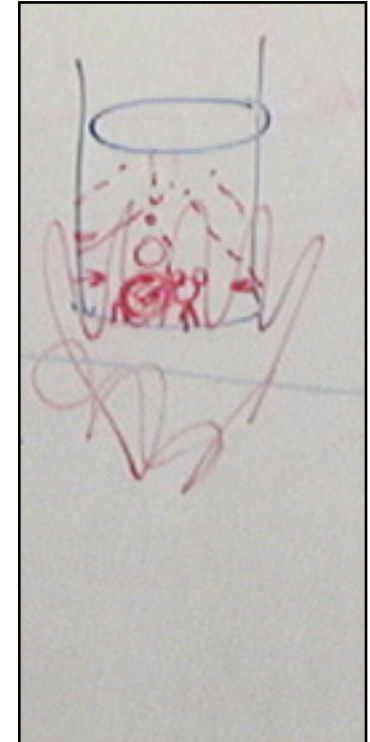
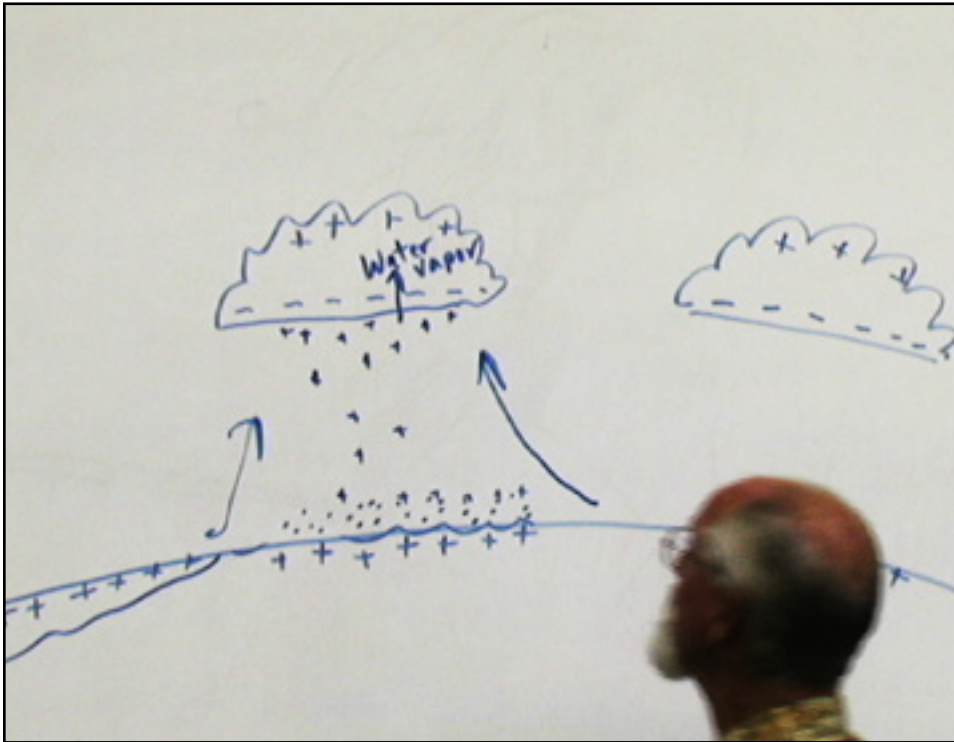
Title Page of Video

Boil Water in a Cup
A Rock-it Science Lesson
Filmed September, 2009

Rock-it Science
2110 Walsh Ave, Unit F
Santa Clara, CA 95050
www.rockitscience.org

(c) 2013 Rock-it Science Educationally Useful Programs. All Rights Reserved

Intro Quick Recap:



- There are clouds over the Urf. Clouds have negative charge at the bottom and some positives at the top.
- On the ground or the ocean, there'll be a positive charge wherever a cloud passes by.
- If the ocean is perfectly flat, water just evaporates and makes clouds.
- If there are breaking waves, they create tiny droplets that also have positive charge.
- Positives hate positives, so the droplets start going upwards because they're attracted to the negative charges on the clouds.
- On the way up, they might evaporate, and when they get to the cloud, they help decrease some of the negative charge. They also feed the cloud with water vapor.
- Boiling water is different. When you put a cup of water over heat, the cup gets hot and conducts heat to the water.
- The water closest to the cup gets hot first, and the molecules get all jiggly, so they bang into the other molecules and make them get hot.
- If you get it hot enough at the bottom, the water turns into a bubble of steam (not an air bubble).
- The bubbles start big, then get smaller and smaller as they rise.
- When it becomes a full rolling boil, the bubbles escape all the way to the top.

Experiment Quick Recap: "Boil Water in a Cup"

- Instructor demonstrates how to safely use a propane torch: how to use the knob to turn the gas on and off, how to hold a match correctly to light it, and how to use the knob to regulate the gas flow to make the flame larger or smaller.
- Each student has a plastic cup of water nearby for a fire extinguisher. It's best to pour the water onto the burning object rather than dropping it into the cup, because the plastic cup can catch fire.
- Students work in groups of two or three. Each group gets an aluminum roasting pan, a propane torch, a lab stand for the torch, and some duct tape to secure the torch to the stand.
- Chairs are pushed back from the table and students work standing up.
- Students can choose either a stainless steel cup or an aluminum cup. The aluminum cup is lighter and conducts heat better. Students are cautioned that the torch is hot enough to melt aluminum but not stainless steel. If the aluminum cup is held over the flame with no water in it, the flame will melt a hole in the cup.
- Since the aluminum cups will be too hot to hold, students use pliers to hold their cups for boiling. For stainless steel cups, pliers are optional, because the heat won't be conducted to the handle as quickly.
- Students put water in their cup (they can decide how much to put in) and hold it over the flame until it boils, then hand it off to the next person in their group. After everyone's had a turn, they pour the boiling water into their fire extinguisher cups.
- Next, students boil water in a paper cup. Before they begin, Instructor demonstrates that a paper cup with no water in it will immediately catch fire when placed over the flame.
- Next, students repeat the experiment with a plastic cup. The flame quickly burns a hole in the bottom of the cup and the water drains out.
- If the water drips into the torch nozzle, it will put out the torch. If it won't re-light, blowing very hard into the nozzle will clear it.
- Next, students repeat the experiment with a styrofoam cup. The cup quickly begins to burn, so students need to place it in the aluminum roasting pan and pour water on it.
- Next, the students go outside, find some large leaves, and try burning water in the leaf. It works, but if the water runs out of the leaf, the leaf will burn.



Holding aluminum cup with pliers over flame.

Equipment List: "Boil Water in a Cup"

Items needed for Instructor:

Consumables:

- None

Other:

- Barbeque lighter
- Matches, wooden safety, 1 box

Items needed for Students:

Consumables (per group of 2 students):

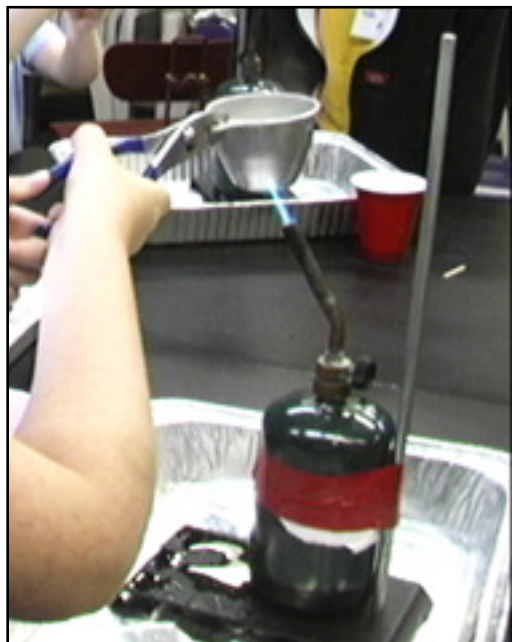
- Water
- Cup, paper, small
- Cup, souffle, 2-oz
- Cup, styrofoam, 16-oz
- Leaf, large

Other (per group of 2 students):

- Metal cup, approx. 8 oz., some aluminum and some stainless steel
- Pan, aluminum roasting
- Lab stand
- Propane canister
- Propane torch nozzle
- Pliers
- Cup, plastic, 16-oz (for water)
- Tape, duct, about 18"
- Matches

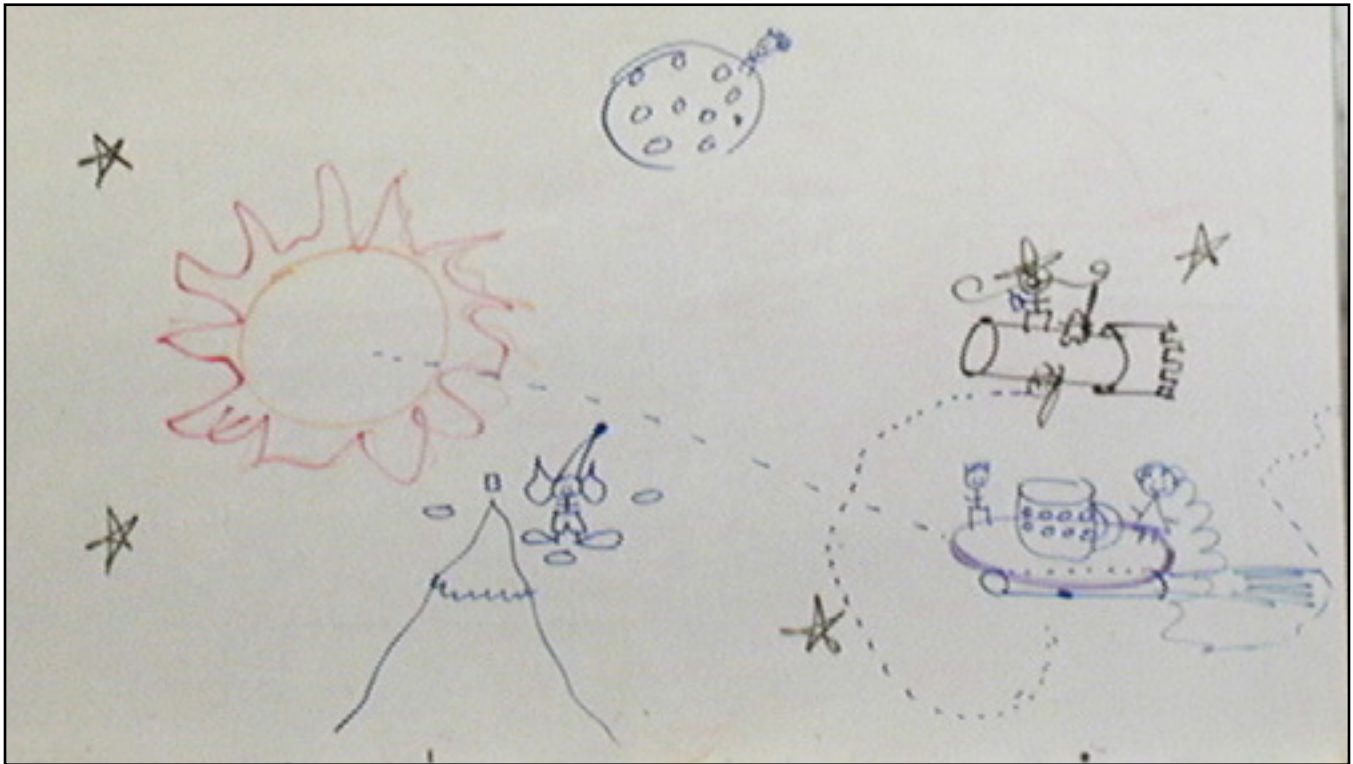
Prep Work:

- Test propane nozzles



Equipment setup: Propane torch duct-taped to lab stand placed in aluminum roasting pan.

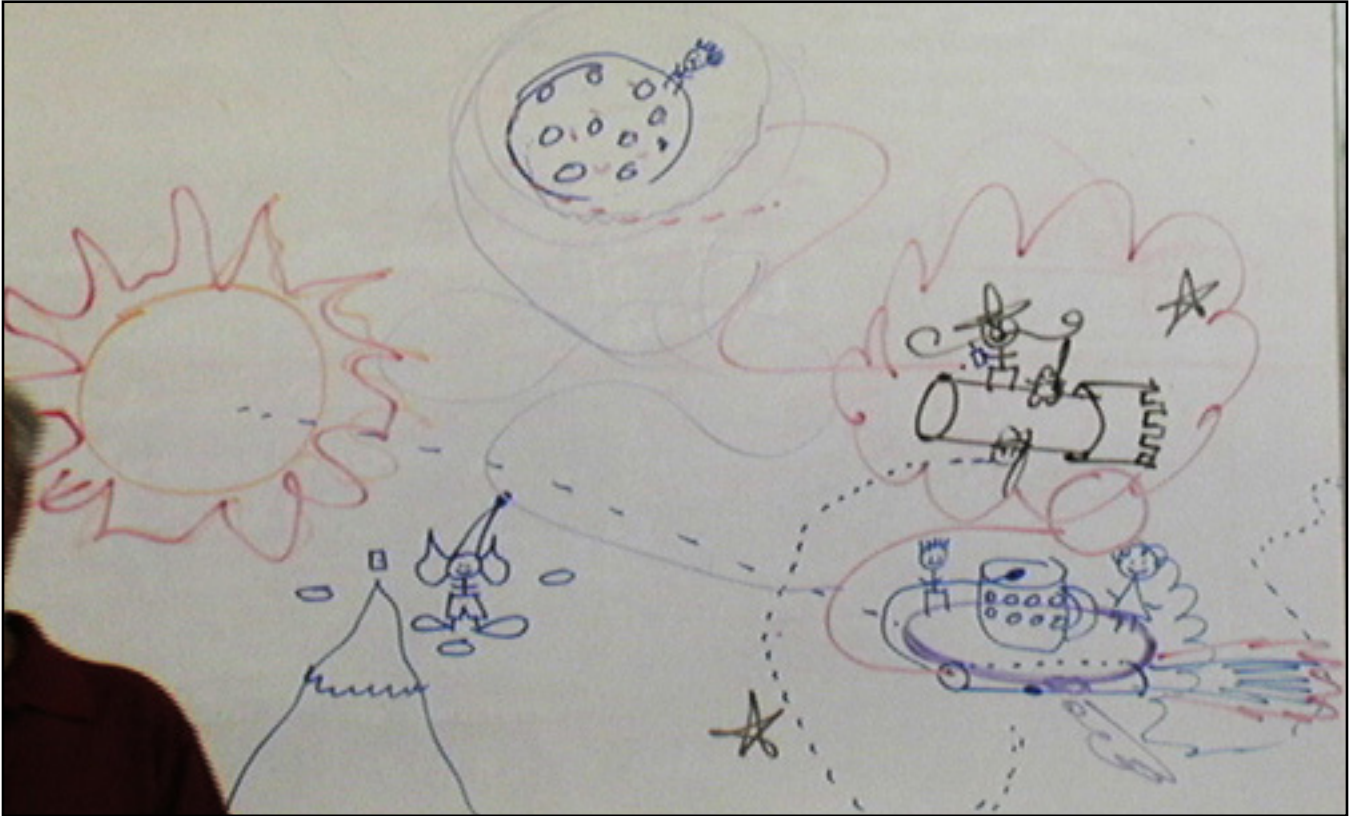
Story Recap: "Jack & Jill and the Pancake Rocket"



Part 1:

- Evil Mister Fred is flying through space on his castle with his minions.
- Jack and Jill are also in outer space, flying on a giant blueberry pancake with a giant vat of syrup. They're going to deliver it to a planet where the people have pancakes but no syrup.
- Evil Mister Fred wanted to wreck Jack and Jill's plan. He called the Acme Store of Everything and ordered a rocket engine and a bunch of bubble gum.
- He had the minions chew up the bubble gum and stick it on the rocket engine.
- He sent some minions with spray cans to guide the rocket engine over to Jack and Jill's pancake.
- They secretly flew under it and stuck the rocket engine to the bottom of the pancake with the bubble gum. Then they pushed the button that said, "Do Not Push," then got out of the way.
- The rocket engine took off, and Evil Mister Fred used a remote control to send it toward the sun, where it would explode.

Story Recap (cont.):



Ending:

- Jack and Jill realized the rocket engine was sending them into the sun, but they couldn't stop it. So Jack decided to have some fun.
- He took the syrup, which was mostly sugar and had a lot of energy in it, and stuck it into the front of the rocket engine. This made it go even faster and shoot out even bigger flames.
- Then Jill called the Acme Store of Everything and ordered a large water balloon.
- She poked a hole in it and let the water flow into the rocket engine. But instead of putting it out, the water turned to steam and gave it even more power, so they were zooming toward the sun faster than before.
- Then Jack started pouring more syrup in. But he poured in too much, and it burned a small hole through the side of the rocket engine.
- This made the rocket go out of control, because the big flame was making it go forward and the small flame was making it go sideways.
- It zoomed around and around the planet a few times, and Jill's infinitely long hair wrapped around the planet. Jack tried to free her hair by yanking on it, but instead they got yanked off their pancake and started falling through the atmosphere toward the pancake planet.
- The rocket kept zooming around like crazy and hit Evil Mister Fred, creating a giant fireball.
- Jack and Jill landed safely on the planet, and Jill's hair was covered in syrup everywhere.

Transcript: Intro

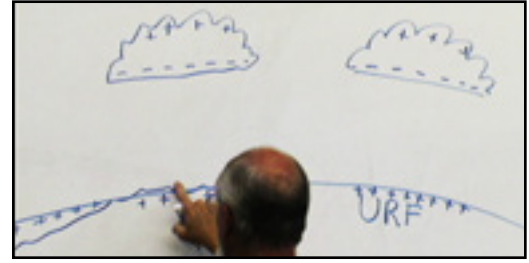
Here is the Urf. And there are clouds over the Urf. And the clouds almost always have a negative charge at the bottom. They have some positives at the top. Now, when you consider what's going on, on the ground below them -- if it's dirt, then there'll be a positive charge wherever a cloud passes by. Same thing if it's ocean. Here's some ocean here. There's positive charge under the clouds. Now, if the ocean is perfectly flat, not much happens. It's just sitting there flat. Water evaporates, goes up and makes those clouds.

But if there are waves, and the waves break and create little tiny droplets, all those little tiny droplets also have positive charge. Positives hate positives. So the positive-charged droplets start going upwards, because they're attracted to the negative guys. On the way up, they might evaporate, probably do, and once they get to the cloud, they help decrease some of the charge in the cloud. But they also feed the cloud with water vapor as they evaporate. And that's how clouds form. The heat evaporates a bunch of the water, gets it going up there to get them started, and the process is accelerated by the static charge.

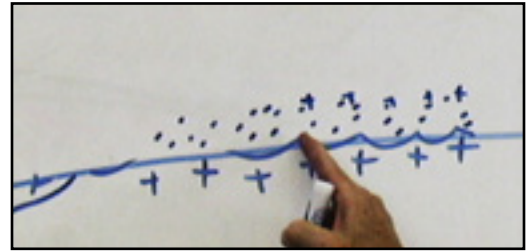
Boiling is a little different. If you have a cup and it's full of water, and you put a flame under it like that, then the cup gets hot. And when the cup gets hot, it conducts heat into the water. And the water right near the cup gets hot first. Now all the guys down there go and hit the surface of the cup, whatever the cup's made out of, and they go, "Whooooaaaahhh!!!" And it makes them all shake and jiggle, and they go and bang into the other guys and make them get hotter.

So you're conducting heat from the bottom and the walls inwards. And if you get it hot enough at the bottom, water actually turns into a bubble. And the bubble isn't air, it's not nitrogen, it's not oxygen, it's ordinary steam. So a whole bunch of steam forms. And if you watch bubbles in a boiling pot, they start off big and then they get littler, and littler, and littler, and littler, and littler, and sometimes just disappear. Until it gets to be a really rolling boil and they escape all the way to the top.

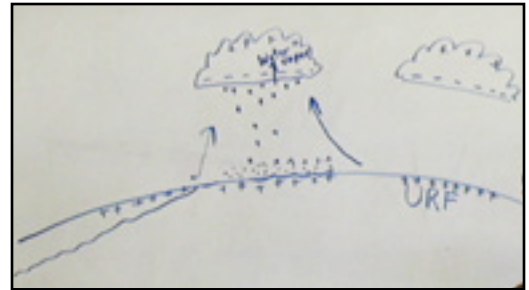
Well, today we're going to be boiling some stuff, and we'll see what happens. But first we need a crazy story.



Negative charges on bottom of clouds, positive on earth and ocean.



Breaking waves create droplets.



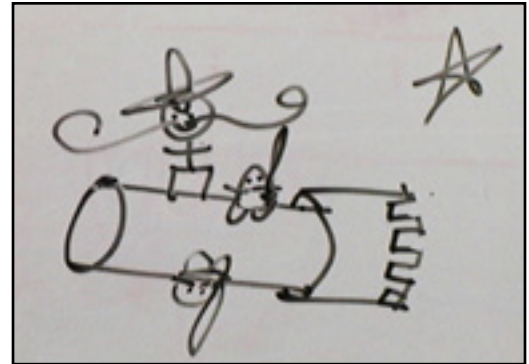
Droplets are attracted to the cloud.



Bubbles in boiling water.

Story: "Jack & Jill and the Pancake Rocket"

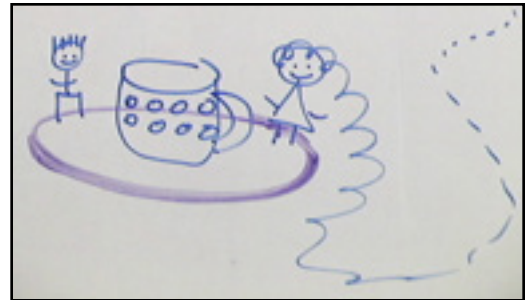
Let's suppose that this story takes place in outer space. There's stars out there, like that. And let's put a big star close by. And let's suppose that Evil Mister Fred is flying through space. He flies through space on a castle. And Evil Mister Fred has helpers. These guys are called minions. And they have mustaches, but they have no arms. And their mustaches are very strong, and they carry baseball bats. He wants to make an army out of his minions and take over the world with minions. He can't give them any real weapons because they'll kill each other, but he can give them baseball bats. Their heads are so hard that they can't hurt each other by batting themselves on the head.



Evil Mister Fred and his minions.

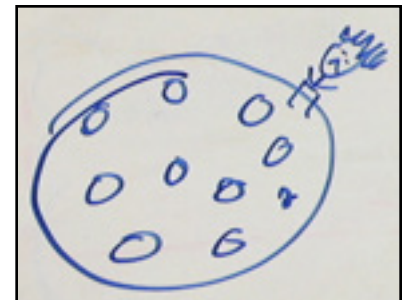
And Jack and Jill also happened to be out there. They're flying around on a blueberry pancake. And they've got to be flying in something. If you're Jack and Jill and you're going to be flying around in space in something that's totally unlikely . . .

[Student: A vat of syrup.] A vat of syrup, okay. So Jack and Jill are flying around in a vat of syrup. We'll put a handle on it, and some windows so they can see out. And Jack and Jill have to be doing something good, because they're always doing things that are good. Should they be bringing food to the poor? Or medicine to the sick? [Student: How about bringing syrup to those who need it for their pancakes?] Okay, then we need a whole planet where people have pancakes but no syrup. Have you ever eaten a pancake without syrup?



Jack & Jill's pancake space ship and vat of syrup.

So let's put a planet up here. There's pancakes everywhere, and people there that are sad because they have no syrup. And Jack and Jill are bringing a huge amount of syrup for the whole planet, for everybody.



Pancake planet with no syrup.

Evil Mister Fred heard about it, and he says, "We can't let that happen.

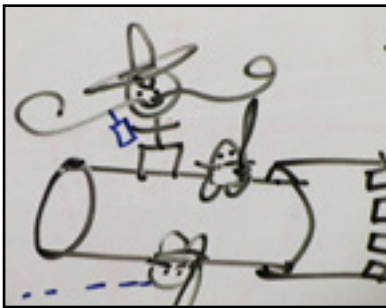


Acme Store of Everything.

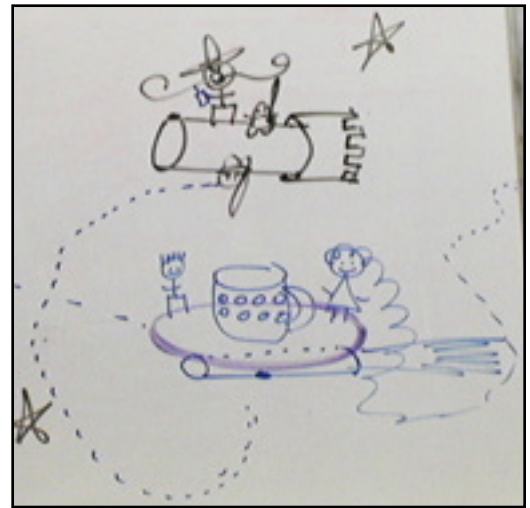
Goodness going on in our universe? I don't think so. We need things to be terrible. We're either going to wreck their syrup or get rid of them altogether." So Evil Mister Fred called the Acme Store of Everything. If you haven't heard of it before, picture Mount Everest. There's Mount Everest, 29,000 feet tall. On top of Mount Everest there's a door floating in midair. If you walk around the door, it looks like a door from the front, it looks like a door from the side, and it looks like a door from the back. But if you grab the doorknob and twist it and pull, it'll open up. And what you'll see inside is a vast warehouse that goes on forever and ever. And the warehouse has got a whole bunch of little elves running around in it. And the elves probably have hats, and they have really big ears. And when you're in the Acme Store of Everything, with the big

ears like that, you can hear anything that anybody says. So if somebody anywhere on the planet says, "Hey, Acme Store of Everything! I need a slingshot that shoots blackbirds." Well, they hear that and run over to the shelves, grab the slingshot that shoots blackbirds, and ship it off to you, and poof! It appears in your hand. They do it because in their warehouse there are wormholes. Wormholes are a distortion in the space-time continuum, and they can throw the slingshot down the wormhole, and it'll appear exactly in your hand.

So Evil Mister Fred called the Acme Store of Everything and said, "Hey, Acme Store of Everything, I need a rocket engine and a bunch of bubble gum." And foom! -- it appeared immediately. "Yeah, this is great." And so he has a rocket engine. He has the minions chew up all the bubble gum and stick it on the rocket engine. And then he sent a couple of minions out with spray cans to guide the rocket engine, and sneak up underneath Jack and Jill's pancake, and stick the rocket engine to the bottom of their pancake without them knowing it, and then push the button that said, "Do Not Push," and get out of the way. When the minions did this, they actually did it right, which doesn't often happen. They stuck it on the pancake, they pushed the button, and vroooooommm -- the rocket engine took off.



Evil Mister Fred's remote control.



Rocket engine under Jack & Jill's pancake.

And Evil Mister Fred has a remote control. He's guiding Jack and Jill's pancake with the huge vat of syrup right into the sun, where it's going to explode. Now, if you're Jack and Jill, and you're stuck on a flying pancake being sent into the sun, 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.)

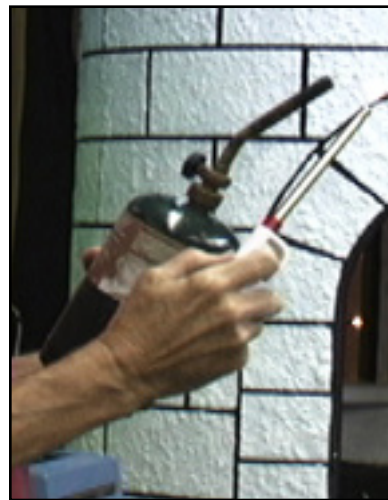
We'll leave this "To be Continued . . ."

Experiment: "Boil Water in a Cup"

Now we're going to do some experiments. During the experiments we'll be using flames. And the type of flames we're using come as propane torches. They call them propane torches because they're full of syrup. No. They're full of propane. And the propane comes out through this valve. And you can hear when it's coming out because it makes a sound. And you can smell when it comes out, because it stinks *[walks around table with propane torch so students can smell it]. [Student: Smells like Pam.] Pam? Oh, that's because actually they do use propane as a propellant for things like Pam and other products.*

There's a little tiny hole behind the bigger holes. The propane shoots out there, air gets sucked in through those holes and mixes with the propane in there, and then you can light it *[lights torch with a barbecue lighter]*. And you can change the size of the flame. You can have a really tiny flame, or you can get a flame like that.

Now, if you happen to have hair on your head, and you lean over the flame, first thing your hair will do is curl up. And an instant after it curls up, it'll go phttt! -- and catch on fire. And then you might do the "ooh-aah ooh-aah dance" as you're running around with your head on fire. So whenever you're using flames like this, you need a fire extinguisher. So if your head catches on fire, you can put it out. And for fire extinguishers we use cups full of water. These will be sitting all over the table. So if somebody catches on fire, you dump this on their head. Or wherever you're burning. The cup is made out of plastic. Plastic burns. So it's not a good idea to take the burning object and throw it into the cup, because then the fire extinguisher catches on fire. Better to pour the water on whatever is burning. The table surfaces don't burn very well, so you could just set them on the table surface and pour water on them.



Demonstrating the torch.

So why are we telling you all this? We're telling you this because we want to boil stuff, and we need you to boil it. So we're going to put whatever we're heating up so that whatever is burning will fall into that *[places an aluminum roasting pan on the table]*. We could put the torch in there, but it's all kinds of tippy. So we need an un-tippy way to put the torch in the thing. So we have these handy-dandy things. This is a torch holder-upper *[places a lab stand in the pan]*. And you can set that in there and you can put your torch on it. And then we're going to put some duct tape around the torch so it doesn't fall over.

Then we're going to try heating up some water so it boils. You get a choice of things to put the water in. This is a pan made out of stainless steel. There's a handle on it, which is kind of good. And here's one made out of aluminum, with a short handle. Stainless steel doesn't conduct heat very well. So the heat can get through the stainless steel into the water not too bad, but it usually doesn't get up to the lip. So if you're out backpacking or camping and you're making hot chocolate, you can use a stainless steel cup, heat it over the fire, and then get the hot chocolate nice and hot, stir it and everything, take it off



Torch on lab stand in aluminum pan.

and go *[blows on the cup]*, and it cools off the rim. And you can drink right out of the cup and not burn your lips. Backpackers like aluminum cups better because they're light. It'll heat up the chocolate faster. And the only problem is, aluminum conducts heat really well. So when you go to drink the hot chocolate, the aluminum will burn your lips. So you get a choice between big cups or small cups, aluminum cups or stainless steel cups. It's probably not a great idea to hold the aluminum ones in your fingers, so we have clamps *[holds cup handle with pliers]*. You can heat them that way. If you heat an aluminum cup with no water in it, the flame on the torch is two thousand degrees. And aluminum melts at about one thousand degrees. So if there's no water in there, you'll end up with a hole in the bottom of your cup. Stainless steel -- you can't even melt it with the torch. You can hold that on there with no water in it all you want.



Aluminum and stainless steel cups.

The idea is to boil the water. You don't drink the water. Get it really boiling good, and then see how long it takes for some of it to go away. Then we're going to try and boil water in other things. We're going to try to boil water in a plastic cup. We're going to try to boil water in a paper cup. If I find some other things, we might try boiling water in styrofoam.

In the last class, one of the kids said, "Hey, you can boil water in a leaf." So at some point, if we have time, I'm going to go outside and find a leaf and try to balance some water on there. . . *[Student: Will it catch on fire?]* It might. And see if you can get the water to boil. But first we're going to be boiling it in metal containers. So you need to pick someone to work with. You can be in groups of two. You can be in groups of three.

[Instructor passes out aluminum roasting pans, one to each group, then bases and stands, and bottles of propane and torch heads, and a strip of duct tape. Students assemble the torches and attach them to the stands with duct tape. Students select either a stainless steel or aluminum cup and fill it with water.]

Have you ever spilled boiling water on yourself? Is it more likely to stick on you if you're standing up or sitting down? *[Students: Sitting down.]* So when you're boiling stuff, you don't want to be sitting down. So you need to push your chairs back a mile or two. *[Students push chairs away from table.]* So far back that you can't sit in them.

First thing you have to do is learn how to control your torch, how to turn it on and off and light it. With these matches, you can strike them anywhere, but we're going to strike them on the box. When you go to strike your match, if you hold it like that *[holds match with head pointing down]*, you'll burn your fingers. If you hold it like that *[holds match with flame at the top]*, it might stay lit, or it might go out. If you hold it sideways *[holds match horizontally]*, it'll stay lit a long time. It's kind of odd that some people hold it that way *[flame pointing down]*, because that hurts. *[Students: Yeah, but it burns better*



Torch secured to vertical rod with duct tape.

that way.] Yeah, it does burn better that way. And you need a fire extinguisher. Come and get a cup here and fill it full of water. Test the knob on your torch so you can see which way to turn it to make it turn on. When you want to light it, you want to turn it on just a little ways. And then turn them off because they stink up the place.

[Student: Should we light it?] No, we've got to turn them off first, because if we fill the whole room full of gas and then light one, bad things happen.

So you get a box of matches and see if you can get yours to light. The person who's lighting does the match and the other one turns the knob. And if you have it on too high, it will put out the match. You'll find that out. When you're done with your match, pass the matchbooks on. Try to make the flame grow bigger and smaller. *[Students light their torches and practice turning the knob to adjust the flame. Then they select a metal cup and a pair of pliers and start boiling water in their cups. After it starts to boil, the first student puts the cup down and lets the other student pick it up and hold it over the flame. When they finish boiling their water, they pour it into their "fire extinguisher" cup and turn off the torches.]*



Boiling water in a metal cup.

We're going to be boiling water in a paper cup. Just because there's always some skeptics around, we will show you that these are really paper cups. *[Instructor lights a torch, picks up an empty paper cup with pliers, and holds it over the flame. It immediately catches fire.]* So that's a paper cup without water in it. So you're going to put water in your paper cup, hold it with pliers, and see if you can boil water.



Boiling water in a paper cup.

You can try it any way you like, but if I were you, I'd grab the paper cup with as much grab as you can get. And then see what happens. Some will succeed, some will not. To save time I'm going to bring around a lighter and you can just light it that way. You can decide how much water to put in. See if you can make it boil. *[Students put water in their paper cups and hold them over the flame with pliers. In most cases, the water begins to boil without burning the cup. If they use only a small amount of water, the cup may begin to burn.]*

When both of you have a chance to do it with a paper cup, you're going to try it with a plastic cup. *[Students put water in a plastic cup and hold it over the flame. The*

flame quickly burns a hole in the bottom of the cup and the water drains out. Students then place the cup in the aluminum pan and pour water on it if it's still burning. If the water drips into the torch nozzle, it may put out the flame. If it doesn't re-light, blowing hard into the nozzle will clear it.]



The bottom falls out of this styrofoam cup as it quickly burns.

When you're done with your styrofoam cups, go outside and find as big a leaf as you can and bring it back. [Students come back with leaves, put some water in them, and hold them over the flame with pliers. Water begins to boil, but if it boils off or runs out of the leaf, the leaf will burn.]

[At end of experiment] Everything that looks like burned-up garbage, put it in the blue trash can. Untape your torches. [Students disassemble their torches and stands, put the equipment away, and throw away the trash.]



Plastic cup melts very quickly.

[Students repeat the experiment with a styrofoam cup. The flame quickly makes a hole in the bottom of the cup, and the cup begins to burn.] When it burns, pour water on it so it doesn't smoke up the room too much.



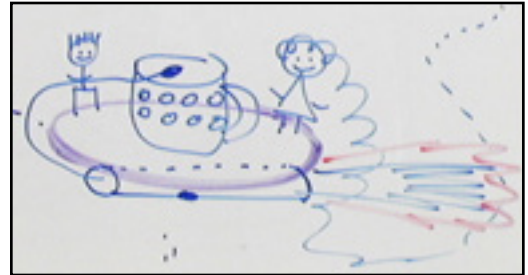
Boiling water in a leaf.

End of Story

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

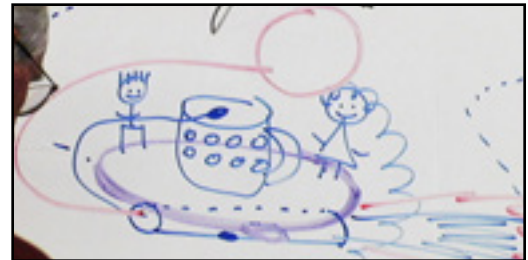
So when we last left off, what were Jack and Jill doing? *[Students answer.]* Right. A remote controlled engine is stuck on the bottom of their blueberry pancake. They were taking syrup to the poor people on the pancake planet that had no syrup. Evil Mister Fred has an awesome plan to send them into the center of the sun. And Jack and Jill realized they lost control of their pancake. They looked down over the edge of the pancake, and they could see the rocket engine there, and said, "Uh-oh! We're in trouble."

And Jack says, "Hey, as long as we're in trouble, let's have some fun." And Jill says, "But we're ready to go get incinerated, right into that sun." Jack said, "All right, cool, that's okay." So he grabbed some of the syrup and he stuck it into the front end of the rocket engine. And the syrup -- sugar has a lot of energy in it. As the sugar went in there and hit the pressure and temperature in there, it shot out even bigger flames out of the rocket engine. And Jill said, "Hey, you're supposed to be putting it out, not making it more powerful!"

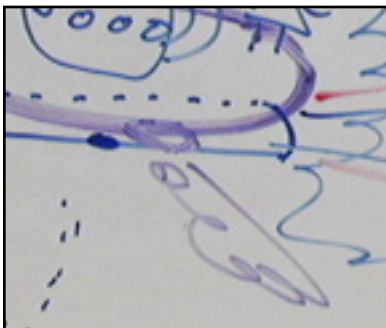


The syrup made the flames bigger.

So Jill called the Acme Store of Everything and ordered some water. And she got a big bag of water instantly delivered in the form of a water balloon, poked a hole in it, and let the water go into the rocket engine. The water turned into steam and gave it even more power than it had before. So now they were zooming toward the sun quicker than they ever were. Jack said, "I like this! Woo-hoo!" And he's pouring more syrup in there.



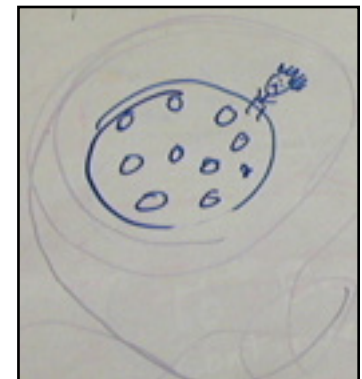
Jill's water balloon.



Flame coming from a hole in the side of the rocket engine.

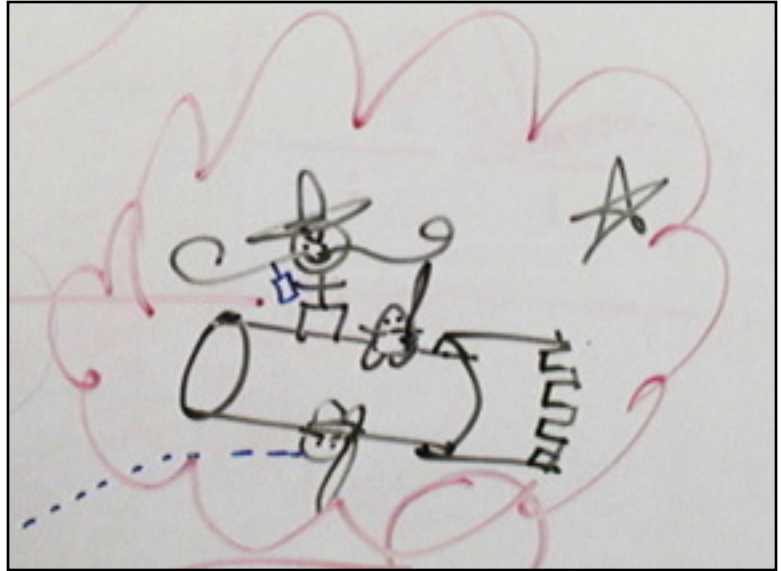
Well, he accidentally poured in too much and cut a hole in the side of the rocket engine. It burned through. It happens. And now the pancake is really out of control. It's got a big flame going that way and a shorter flame going this way. As they're heading toward the sun, it's kind of going zoom, zoom, zoom *[indicates the rocket swerving back and forth all over]*, like that. And Jack and Jill said, "Oh, this is great. Who knows where we're going to end up?"

And they happened to zoom by the planet and went around it a couple of times. Jill has infinitely long hair. Her hair wrapped around the planet. And now Jack said, "Hey, your hair's getting stuck. Let me pull it free for you." And Jill said, "No, leave it alone." And Jack tried to pull on her hair, and next thing you know, Jack and Jill get yanked right off their pancake and are falling through the atmosphere onto the pancake planet.



Jill's hair wrapped around and around the planet.

Meantime, their rocket ship is zooming around like crazy in space. Now, space is huge. Billions of miles of nothing. What are the odds that a pancake shooting like crazy through space would hit Evil Mister Fred? You know, two hundred and twenty million to one! But of course, that's what happened. And there's a big giant fireball in space. Jack and Jill land safely on the planet, the syrup was stuck in Jill's hair, so now there's Jill hair covered in syrup everywhere. And they all lived happily ever after, except Evil Mister Fred.



Evil Mister Fred's ship became a giant fireball in space.

End of Lesson

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