



Teacher's Guide for:  
**Mentos and Soda**

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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Mentos and Soda  
A Rock-it Science Lesson  
Filmed October, 2010

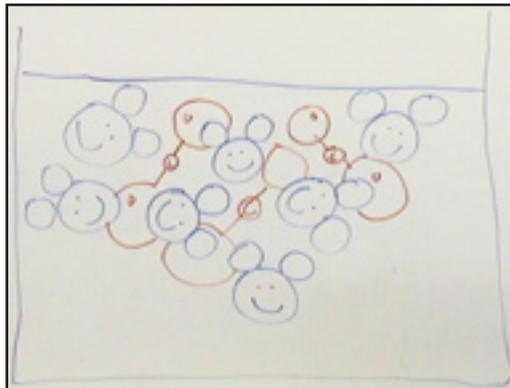
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## Intro Quick Recap:

- Mentos are mint-flavored candies, and when you suck on them, the cover comes off. The cover is almost completely sugar, and when you drop it in soda it dissolves very quickly.
- Draw diagram of a container of water consisting of Mickey Mouse molecules. Carbon dioxide molecules like to jam themselves in between the Mickey Mouse molecules.
- The colder it is, the more carbon dioxide molecules you can jam in.
- The MythBusters discovered that you can jam in even more carbon dioxide if you add caffeine, sodium benzoate (a preservative), and phosphoric acid, all of which are found in ordinary soda like Coke or Diet Coke.
- The tap water in this building contains chlorine (to kill bacteria), flourine, or flouride (to prevent cavities), and ammonia (to prevent legionnaire's disease). The combination of chlorine and ammonia creates chloramine, which is a poisonous gas. But it's okay to drink it -- we think.
- If you want to jam some carbon dioxide into tap water, you could blow into the bottle, because there's carbon dioxide in your breath when you breathe out. But you can only push about one-half of a psi, and you need more like fifty psi.
- Use a tank of CO<sub>2</sub> with a hose connected to the bottle of water and turn it on. If you hit the bottle, more CO<sub>2</sub> goes into the water.
- If you shake a can of soda and then open it, it will spray all over. But if you tap the top of the can before you open it, it won't spray.
- Turn the CO<sub>2</sub> pressure up to about 45 psi. Shake the bottle to make the water absorb more CO<sub>2</sub>.
- Shake the bottle and open the cap to see if it fizzes. It should be slightly fizzy.
- When they make soda pop, they use about 80 psi so the soda is super fizzy.
- In today's experiment, we're going to try to make the fizz come out.



Water & CO<sub>2</sub> molecules.



CO<sub>2</sub> bubbling into the water.

## Experiment Quick Recap: "Mentos and Soda"

- Place a bottle of soda into a plastic tub on the table, remove the cap, and drop one Mento into it to see how much it fizzes. Then drop a second one, then a third, to see if it continues to fizz.
- Show students a sample of a cap with a hole drilled in it and Mentos with holes drilled in them. The Mentos are threaded onto a wire in groups of five, and the wire is threaded through the hole in the cap. The caps have different-sized holes drilled in them, and a few also have nozzles.
- Students work in groups of two or three. Each group chooses a bottle of soda and a cap.
- Outside, each group takes turns testing their bottles. They place the bottle in a bucket of sand to stabilize it, remove the cap, replace the cap with the one holding the Mentos, then release the wire and let the Mentos drop into the soda. A chart on the side of the building shows how high the soda spurts.
- After each bottle is tested, the Instructor places them on the ground in order of how high they went so students can see which caps worked best.
- For the second part of the experiment, students modify the caps to make the soda go higher. They can use drills, straws, or whatever is around the lab.
- After modifying their caps, each group chooses another bottle of soda and they go outside and repeat the experiment.



Screwing cap with Mentos onto bottle.



This one squirted higher than the building.

## Equipment List: "Mentos and Soda"

### Items needed for Instructor:

#### Consumables:

- Water 1.5 liter, boiled and cooled
- Carbon dioxide (from tank)

#### Other:

- 2 liter Plastic Bottle
- Carbon Dioxide Tank
- Hose to attach to tank
- Bottle cap with 1/8" hole in center
- Wire (straightened jumbo paper clip)
- Mentos, with 1/8" hole drilled in center, 5 each strung on wire
- Vertical scale poster for building
- Rope & pulley to hoist poster
- 5-gal bucket, half-filled with sand
- Plastic pitcher
- Bottle of refrigerated soda (for outside test)
- Safety cones
- Caution Tape
- Garden Hose
- Rolling Cart

### Items needed for Students:

#### Consumables (per group of 2 or 3 students):

- 5 Mentos per bottle (2 sets per group)
- Sodas, 2-liters, regular & diet (2 bottles per group)

#### Other (per group of 2 or 3 students):

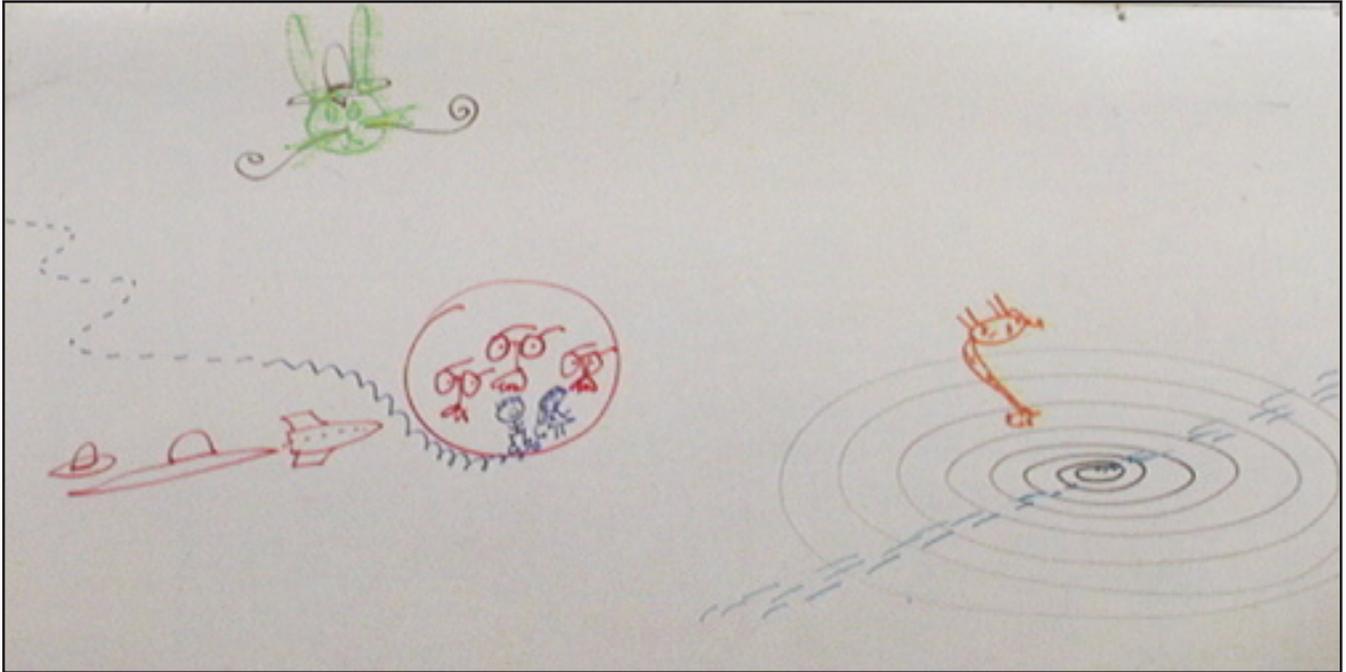
- Bottle caps with various size holes in center, some with nozzles, 2 caps per group
- Wire (straightened jumbo paper clip) per set of Mentos
- Drill bits in various sizes
- Plastic straws, craft sticks, etc. for modifying caps
- Glue guns

### Prep Work:

- Get tank of Carbon Dioxide
- Boil water, allow to cool
- Refrigerate one of the sodas, leave others at room temp
- Drill various size holes in bottle caps, add nozzles in some
- Assemble 5 Mentos on wire for each cap
- Attach vertical scale to outside building
- Put sand in bucket
- Set out safety cones & caution tape



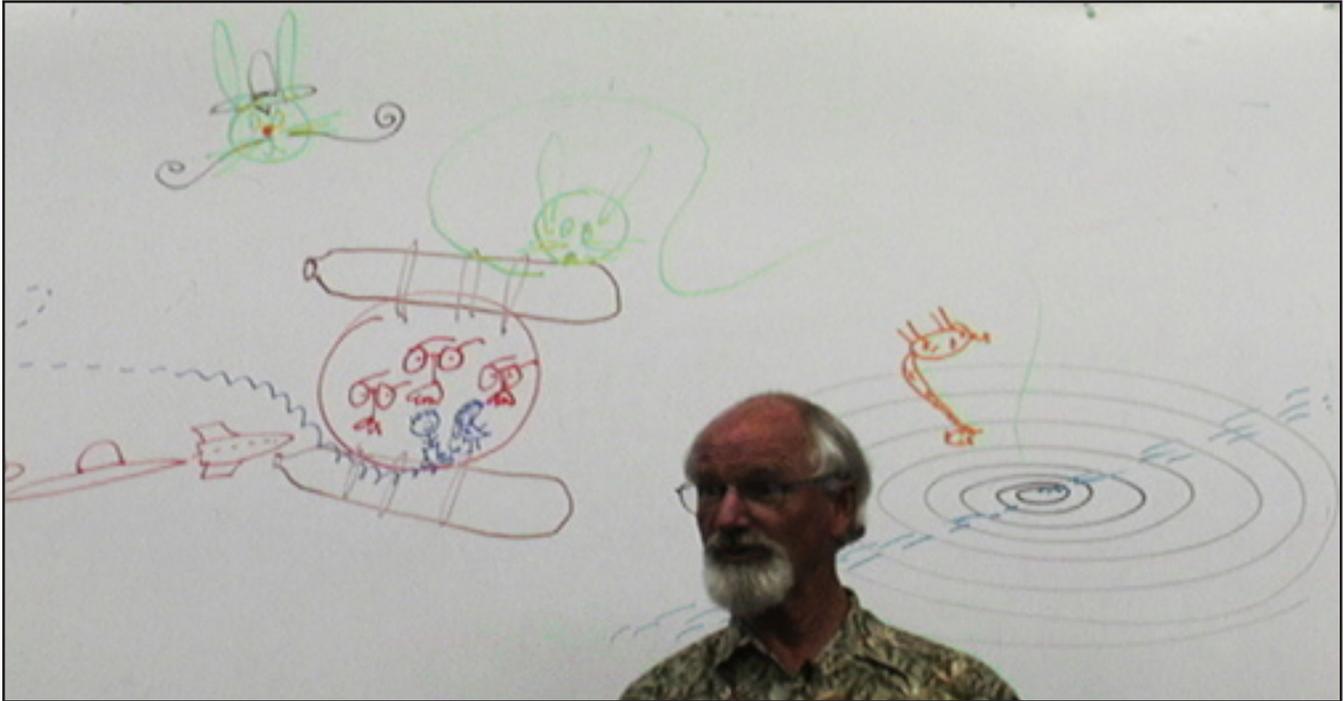
## Story Recap: "Jack and Jill and the Black Hole"



### Part 1:

- In outer space, there's a planet of Know-it-Alls.
- People come from all around to have the Know-it-Alls solve their problems.
- The Know-It-Alls can solve everyone's problems but their own. So they ask Jack and Jill to help organize all the people who come to them with problems.
- Jack and Jill interview the people in the line of space ships and organize them from the most important problems to the least important.
- One day the Know-It-Alls just stop answering problems. They say there's no point, but they won't say why.
- Jack and Jill look through their binoculars and notice a black hole that's about to suck in the Know-It-All's planet.
- Evil Mister Fred was nearby on a death star that looked like a bunny rabbit. He saw the black hole and decided to watch it suck up the Know-it-All's planet instead of blowing it up with his death star.

## Story Recap (cont.):



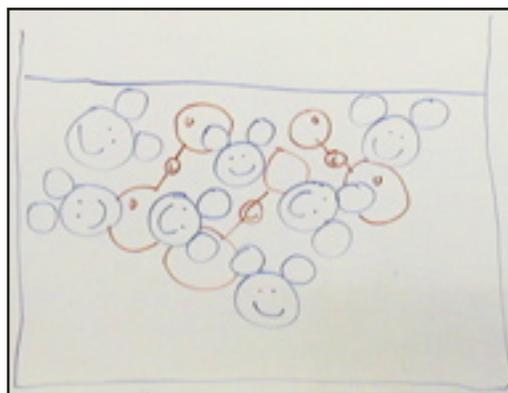
### Ending:

- The Know-It-Alls knew their planet was doomed, and they didn't want to wait. They wanted to get it over with and propel their planet right into the black hole.
- Jack and Jill called the Acme Store of Everything and ordered two giant bottles of soda and duct taped them to the planet, aiming for the black hole.
- Evil Mister Fred thought the Know-It-Alls were planning to propel their planet toward the black hole so they could somehow ricochet off it, and he wanted to make sure they got sucked up instead.
- He ordered his minions to row toward one of the soda bottles and rammed it. This turned the planet around so it was pointing away from the black hole.
- When the bottles fired off, the duct tape couldn't hold, and the one that Evil Mister Fred was stuck on to came off the planet and spiraled into the black hole.
- The Know-It-All's planet started spiraling like crazy because it only had one bottle on it, and it created an anti-black hole of its own and was able to escape.

## Transcript: Intro

Today we're going to be mixing soda and Mentos, just because it's fun. What a waste of Mentos. You know, you go down to the store and you buy Mentos. They're these mint-flavored candies, and when you suck on them, the cover comes off. Here's a single Mentos -- I drilled holes in them. It's got a white cover and then it's kind of a cream-colored inside. Yeah, they're kind of gummy after you eat the cover off. The cover is almost completely sugar, but then there's some flavoring in it, too. There's mint flavor in it, and it has the unusual property of dissolving very quickly when you drop it in soda, which for our purposes is great.

And if you got a bottle full of water, the Mickey Mouses are water molecules, and the brown thing is a carbon dioxide. It's a carbon with two oxygens on it. For some reason, the carbon dioxides like to jam themselves between Mickey Mouses. And they get stuck there. They just find places where they want to be and fit right in the middle. And the odd thing is, the colder it is, the more of them you can jam in. Water, when you get it cold, first it keeps getting smaller and smaller and smaller and smaller, and then, when you get it close to the freezing point, it does something weird. It gets bigger. So like the Mickey Mouses first get closer and closer together as it gets colder. Then when it gets to a certain point, they move further apart. And as they move further apart, you can jam in all of these carbon dioxides.



Water & CO<sub>2</sub> molecules.

And the MythBusters did a great experiment with this. They wanted to find out how to cram the most carbon dioxides in there. And they started adding stuff. They got some pure caffeine, which is a white powder that dissolves in water. And they poured some of that in, and with the pure caffeine, you can add more carbon dioxides. And then they got some sodium benzoate, which is a preservative. They threw some of that in there, and you could add more. And some phosphoric acid, and you could add more. So the chemical makeup of ordinary soda pop, like Diet Coke or regular Coke just happens to be balanced just right to jam in the most CO<sub>2</sub>.

Now, I imagine you've messed around with CO<sub>2</sub> before, or soda pops at least. You shake them and point them at somebody with your thumb over the top. Have you done that before?

Well, if you want to fit some in regular water, this is tap water. In this building, when you first put tap water into the bottle, it's whitish, almost milky colored, and if you let it sit for awhile, then it gets clear. In the pipes, there are gases they put in the water. One of the gases is chlorine. Breathe that, and you die. And it used to be there was only chlorine in there, and the chlorine kills the bacteria. It makes the water taste bad, but you don't get sick. And then they thought, well, your teeth will not get cavities so much if you add flourine -- flouride. So they add a salt of flouride. Then they had a problem with legionnaire's disease. Over at Hetch Hetchy Reservoir there's legionnaire's disease in the water, and it works its way down to our pipes. If it gets into a big dead end pipe, then it sits there and cooks during the summer, and the legionnaire's disease expands and expands and it comes out and people get sick. So they figured,

“Well, we’ve got to kill the legionnaire’s disease and, unfortunately, chlorine doesn’t do it. So they put in ammonia. Usually, if you add chlorine and ammonia, you get a poisonous gas. And it does when you put it in the water, too. And the gas is called chloramine, and the chloramine kills the legionnaire’s disease -- and fish -- and cats don’t like it. So the water we have in our taps now has chloramine in it and probably a little bit of fluoride, depending on where you live. If you have an activated charcoal filter, it takes all that stuff out. You can drink it. It won’t hurt you to drink the chloramine -- at least, we don’t think it will. Maybe a few hundred years from now, they’ll say, “Wow, those people were really dumb. Look what they did.” But we won’t know until then.

Now, suppose I wanted to jam some carbon dioxide in there. I could just put my mouth over it and go *[blows into bottle]*, because there’s carbon dioxide in my breath when I breathe out. But I can only push



Tank of carbon dioxide with hose attached to bottle cap.

about one-half of a psi by doing that. We’d like it more like fifty psi. So I have a tank down here with carbon dioxide in it. There’s carbon dioxide gas coming out. I’m now filling this room with pollution. This is a toxic gas -- aaagghh! *[Student: Shouldn’t the door be opened?]* No, it’s the same pollution that’s in your breath when you breathe out. It’s the same pollution that plants breathe to stay alive, to produce oxygen so we can live. And it’s the same stuff that makes the bubbles in soda pop.

So we’re going to put this lid on it. Then we’ll turn on the CO<sub>2</sub>, and the bottle *[taps bottle]* it rings. CO<sub>2</sub>



Hose from carbon dioxide tank.

is trying to get into the water. There’s not a lot of it happening there. You smack it and more goes in. This is kind of weird that if you hit it, the CO<sub>2</sub> goes in better. You know they say that if you shake a can of soda pop and then you give it to somebody, well, they don’t want to open it, because as soon as they do it’ll spray all over their face. But if you tap the top, it won’t spray on their face. You’d have to try that and see.

Now, this is at some pressure -- it’s at about thirty psi. We’ll take it up to about forty-five. And if you shake it, it has the same effect. This is kind of odd. Usually, if you want the CO<sub>2</sub> to come out, you shake the stuff. But when it’s under pressure, if you want it to go in, you shake the stuff. Or hit it.

Now, how long do you think you could keep hitting this before it finally won’t let any more in? If you do this for about five minutes, it will eventually stop adding more CO<sub>2</sub>. The bottles are good for about 150 psi. The hose isn’t. The hose usually leaks at about fifty. So how long should we stand here hitting

this thing? We could stay here for five minutes. It's good to toughen up your hands if you're in karate class. *[To student]* Here, hit it. Slap it. That's the way. Take that! Pretend like it's somebody evil. Evil Mister Fred -- take that!

Okay, I'm bored with this now, and my hand is starting to hurt. So we'll turn off the pressure and then we'll open up the bottle. There. Now it's slightly fizzy water. How can we test it to see if it's really slightly fizzy water? We could drink it, sure. We could shake it. That'd be a good idea. I'll shake it. *[Shakes bottle, then squirts a little toward students.]* Or we could shake it this way *[shakes bottle up and down]*. You can tell it's slightly fizzy.

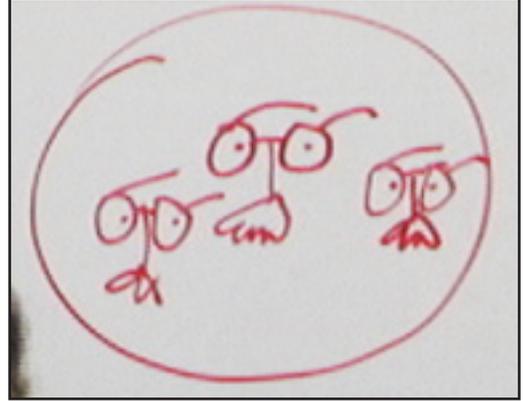
At the place where they make soda pop, they increase the pressure quite a bit. They go to about eighty psi, and they really punch it in there so the soda is super fizzy. And today we're going to try to make the fizz come out. But first we need a crazy story.



Hitting the bottle makes more bubbles.

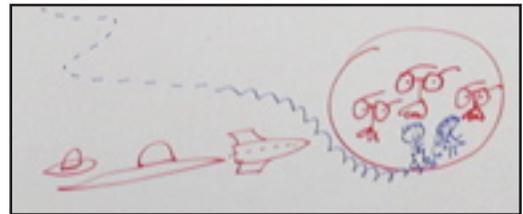
## Story: "Jack and Jill and the Black Hole"

For this story, let's make it take place in outer space. And we need a planet of Know-It-Alls. And Know-It-Alls have to wear glasses. There's a Know-It-All. Does he need feet? Let's give him one foot. There. There's a Know-It-All. There's a whole bunch of them there, and the funny thing about them is, they really do know it all. Even though they have no brains. People come from the entire universe to this planet just to talk to the Know-It-Alls and solve their problems. If they're at a planet there and they've got pollution and something else is going on, they go right here and say, "What should I do?" And the Know-It-Alls say, "Well, you've got to do this and this and this and this and this, and your problem will be solved." And they go back and do it, and sure enough, their problem is solved. So there's always a line of spaceships out here, guys coming, weird spaceships, to talk to the Know-It-Alls.



Planet of Know-It-Alls

Well, pretty soon the Know-It-Alls got tired of this and they didn't know what to do about it though, because there were so many people with problems and they had to help them solve their problems. So they called for some help. They can solve other people's problems but not their own. So they called Jack and Jill. They said, "Jack and Jill, you've got to organize those people so they don't bother us so much." And Jack and Jill said, "Okay." And Jack and Jill started interviewing the people in line, and arranging them from the most important problems to the least important problems. And then one day, the Know-It-Alls just said, "Stop. That's it. We're not doing any more." And Jack and Jill said, "Well, why?" And the Know-It-Alls said, "Because it's all pointless." And they wouldn't say any more. And Jack and Jill said, "Huh. Why would they say it's pointless?"



Line of space ships waiting to have Know-It-Alls solve their problems.

Now, Jack and Jill were out there one day and they're looking with their binoculars, and they saw not too far from their planet -- this thing. And they saw that the thing had kind of like two blue streaks shooting out from the sides, like that. And they saw something like a giant giraffe getting sucked into it. And they said, "Uh-oh! That's a black hole! That's why the Know-It-Alls said it's pointless to continue, because their planet's going to get sucked into the black hole. Oh, this is not good!"



The black hole.

Well, whenever there's a disaster that's going to happen, it attracts flies and Evil Mister Fred. So Evil Mister Fred didn't know about the black hole when he created his thing. Evil Mister Fred had designed a death star. He was going to blow up the Know-It-All planet just because he didn't want everybody to know stuff. So he made this vicious death star in the shape of a bunny's head. But his minions wouldn't

get on until he put a mustache on it, and a hat, and a frown. There. And the objective was to use the death star to blow up the Know-It-Alls' planet. Then when he got there, he saw the black hole. He said, "Wow! This is great. I don't even have to waste energy blowing it up. They're going to get sucked right into the black hole. I like this job. I'm going to just sit out here and watch."

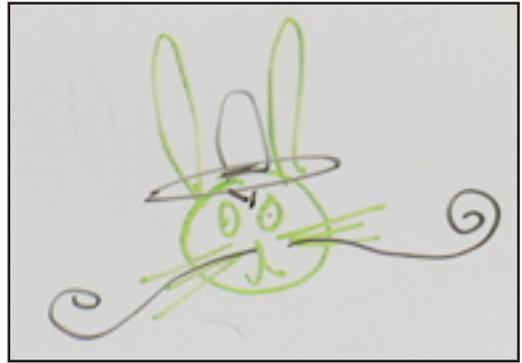
Now, whenever something gets sucked into the black hole, it stretches out like a long spaghetti noodle. It becomes more and more massive, and then it breaks up into pieces, goes right into the black hole, and then some of its energy shoots out sideways into these plasma beams. And Evil Mister Fred said, "Yeah! I wonder what's going to shoot out in those plasma beams. Might be something good."

Now, if you were Jack and Jill, and you're stuck on a planet and it's doomed, 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 . . .



Evil Mister Fred's death star.

## Experiment: "Mentos and Soda"

Now, I bought a whole bunch of sodas. Some of it is Diet Coke and some of it's Diet Pepsi. They happened to have one on sale one day and another one on sale another day. So we're going to compare them. We have one bottle that's really cold in the refrigerator, and we have one bottle that's just water -- carbonated water. Now, we're going to test those outside. You may have seen a white thing hung up on the building with numbers on it. We're going to drop Mentos in there and see how high they squirt.

We should try one here first just so you can see what it does. *[Places a bottle of soda in a plastic tub on the table and removes the cap, then drops a single Mento into it.]* We'll just put in one Mento and see what it does. *[Some of the soda fizzes out of the bottle.]* So it works pretty fast. If you add more Mentos, let's add another Mento and see if it does anything to it. *[Drops in a second Mento.]* The second one gives a little bit of a reaction. *[Drops in a third Mento and almost nothing happens.]* So you don't need a whole lot of Mentos to make it work.



Soda with one Mento dropped in.



Mentos on wire.

What you guys are going to be doing is taking batches of five Mentos that are on a wire. And then you'll have a cap with a hole in it, and you get to choose the size of the hole. And some of the holes are big, some are small, some have tubes attached, some don't. Then one of you will screw this onto your soda bottle and then drop the Mentos, and it will squirt through the hole. Theoretically, the smaller the hole, the higher it should squirt. That's true, if there was no air.

But there is air. So you're going to each have your own bottle -- you're going to work in groups of two, or three if you like. And for the first test, you're just going to randomly choose some cap. Only one person in each group is going to fire theirs off, and see how high it goes with whatever cap you happen to pick. And then you'll say to yourself, "Aha! With my superior brain power I will now choose a better cap. And make it squirt higher than before." Because you'll get to see what everybody's does.



Caps with various size holes and nozzles.

We'll try one that's really cold, and we'll try one that has no caffeine or any of the other stuff added to it. You don't get to eat the Mentos. If we figure out a way to do it, we'll put in one with ten. The problem with putting in one with ten is, you put it in and the bottom ones already dip into the soda and start fizzing while you're trying to put the cap on. *[Student: What happens if you put Mentos in with the cap on it?]* Oh, yeah, if you just drop a bunch in and try to screw the cap on while they're sitting in there? Nothing happens. It's really pretty boring. You get squirted a lot.

So pick a group. Over there you get to choose one bottle, either a Coke or a Pepsi, but not the clear one. And then you come, choose a cap amongst whatever's there. For now, it's one bottle per group. Pick one cap with a hole in it for your bottle. And then come over here and grab a wire with Mentos on it, one per group. Don't eat them. Don't take the cap off. One's on the bottle, and one you're going to screw on with the Mentos sticking to it. Okay, when you have your Mentos and a bottle and a cap, come outside.

*[Outside, teams take turns testing their bottles. They place the bottle in a bucket of sand to stabilize it, remove the cap, replace the cap with the one holding the Mentos, then release the wire and let the Mentos drop into the soda. A chart on the side of the building shows how high the soda spurts. After each bottle is tested, the Instructor places them on the ground in order of how high they went so students can see which caps worked best. The Instructor also tests the bottle of carbonated water, which hardly spurts at all.]*



Measuring scale on side of building.



Setting the bottle in the bucket.



Getting ready to screw on the cap with the Mentos.



This one went as high as the building.



After testing, bottles are lined up according to which cap spurted highest.

So you can see the effect of all the caffeine and all that other stuff. It stores a lot more carbon dioxide. Now go look at all the bottles and the lids that they have. If you want, you can choose one of these lids, and you can modify it any way you want. And there's other lids inside. Leave the bottles there. Just take the lid, but not the bottle. Okay, go inside, choose another bottle.



Drill bits for modifying bottle caps.

*[Students modify the caps to try to make them shoot the soda farther, using drill bits, straws, etc., then take them outside and test them.]*



Ten Mentos.



Two very small holes in cap.



A plastic straw nozzle.

So if you want it to not go very high, you use it really cold or you add no caffeine or any other stuff. If you want it to go real high, you either make the hole small or you put in a whole bunch of Mentos. Okay, everybody grab all of your bottles and caps and stuff and take them back inside. Pour the extra soda in the bathroom sink. You can't drink it.

## End of Story

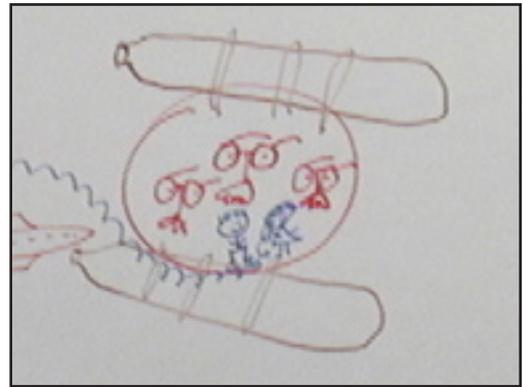
***\* DO NOT \* present this part of the lesson until after the experiments!***

So the Know-It-Alls knew it all. They knew their planet was doomed, and they told Jack and Jill to send all the spaceships away. And they said, "We want it to go faster. We don't want to delay our doom. We want to propel this planet right into the black hole." And Jack and Jill said, "Okay, what do you want to do?" They said, "Call the Acme Store of Everything. Order two giant sodas." So they did. And some duct tape. And they duct taped the sodas to the planet, aiming directly towards the black hole.

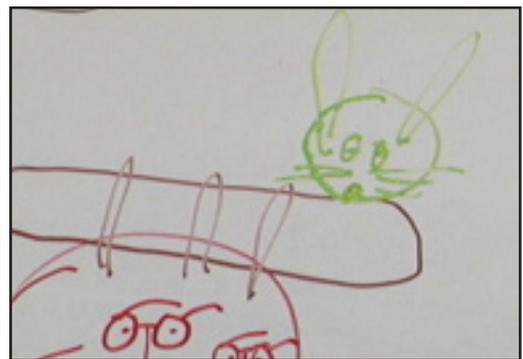
And Evil Mister Fred saw this and he said, "Whoa, they think they're smart? Those guys are dumber than a box of rocks.

Look at them. They're going to propel themselves right towards the black hole." And then he said, "But wait a minute. Those guys are Know-It-Alls. They know everything. They must know something I don't know. And by propelling it towards the black hole, maybe they're going to ricochet off or something." So Evil Mister Fred called the Acme Store of Everything and he ordered some bubble gum. And he put it on the nose of his rabbit. He says, "Okay, minions, start rowing." And the minions had oars, and they were rowing as fast as they could. He said, "We're going to ram the planet. We're going to turn it around the other way so that they'll go into the black hole, because obviously if they think they're going to go away from it by pointing that way, we'll reverse it on them."

So he did. He had the bunny come down and ram the thing. The bunny stuck his nose right against the bottle here and pushed as hard as he could with the minions rowing. And they turned the planet around. And the bottles with the soda and Mentos fired off, but the duct tape wasn't enough to hold it. And so now the bottles are pointed that way and zooming like crazy, and Evil Mister Fred and his death star are stuck on one of the bottles that's going crazy through space. And Evil Mister Fred and his planet went right into the black hole -- ka-boom -- and got sucked up. And the one with the Know-It-Alls started to spiral crazy because it's only got one bottle on it. It's going wzhoom, wzhoom, wzhoom, like that through space. And as it spiraled, it created an anti-black hole of its own and was able to escape. And they all lived happily ever, except Evil Mister Fred.



Giant soda bottles on planet.



Death star ramming the soda bottle.

## End of Lesson

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