



Teacher's Guide for:

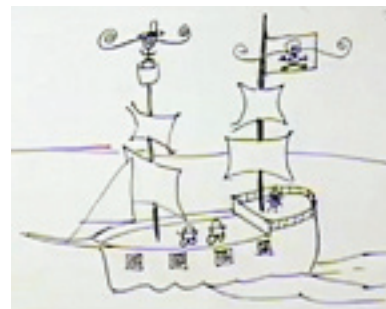
How Gases Change Size

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.

The Story: “*Beanstalk Island*”

(Numbers in the text are **time codes**, so you can refer back to the video.)

[00:01:18.14] Once upon a time Evil Mister Fred was traveling far, far out at sea. It seems that he'd been experimenting late one night and accidentally turned his mustache into a very sensitive antenna. And in the city areas, he picked up all the tv shows, the radio shows, everything under the sun, came in on his mustache and into his head, and it was driving him crazy. So he took off in his pirate ship to see if he could find a place where he could have peace of mind, and at least go out and try and get some treasure from other people.



Evil Mr. Fred's pirate ship

[00:01:45.09] In the meantime, Jack and Jill had learned from their Grandma that their great-great-great-great-great-Grampa Jack was the one who had planted the beanstalk and went and got all the riches from the giant. And he'd stored all those riches at Beanstalk Island. But nobody ever knew where Beanstalk Island was. And Jack and Jill had taken off in their handy-dandy rowboat to try and find Beanstalk Island.



Jack & Jill's rowboat

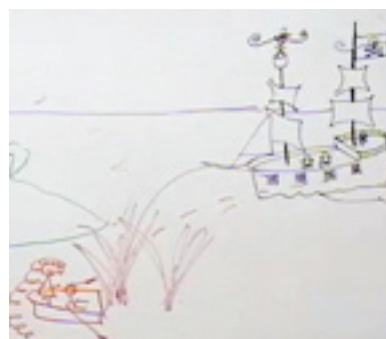
[00:02:20.05] And by chance, as they were out at sea, they saw a huge bank of fog. And under all that fog they saw some green. The green was beanstalks, growing out of something, green everywhere. And they looked, and here was an island, hidden in the fog. No wonder nobody ever found it.



Beanstalk Island in the fog

[00:02:51.08] And who would have guessed that at that very moment Evil Mister Fred arrived at the very same spot. And he saw Jack and Jill out there, and he also saw through the fog Beanstalk Island. Everybody knew that that was the island of the riches. And Evil Mister Fred said, “Yesss!! We found it, the famous island, with all the treasure. But Jack and Jill are there. I've got to get rid of them.”

[00:03:17.10] So Evil Mister Fred had his minions load up all the cannons and start shooting at Jack and Jill. They were trying to sink Jack and Jill's rowboat. And when Jack and Jill saw this, they said, “Whooh! Even if they are a bad shot, sooner or later they're gonna hit our rowboat and that'll be the end of us!”



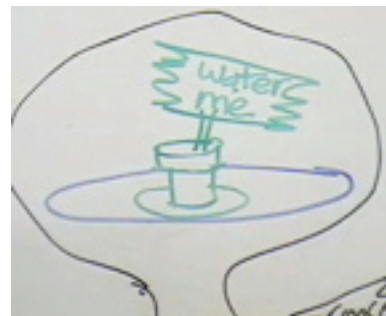
Minions shoot cannonballs

[00:03:42.11] So Jack and Jill dove into the water and started swimming for their lives. As soon as they entered, they looked down and what did they see? A sign under the water that says "Treasure," with an arrow. And the arrow pointed right at the opening of a cave underwater.



"Treasure" sign at cave entrance

[00:04:03.29] So Jack and Jill swam down into the cave. They only had to go a little ways when they popped up under the island in this hidden chamber. (We'll just draw the whole chamber here like this.) And the chamber had water in it. It looked like a small lake there. And when Jack and Jill popped up and they got their breath of air back, in the middle of the lake they saw a pot, like one would grow a plant in, with a little bit of ground around it. And the pot also had a sign. And the sign said, "Water me."

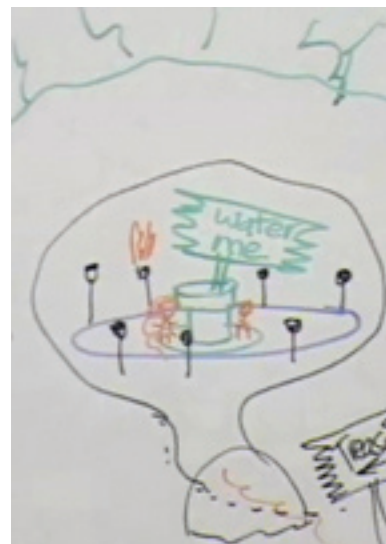


"Water Me" sign in pot

[00:04:59.23] There wasn't very much light in this room, but Jack and Jill saw that around the edges of the lake that was in there, there were torches. But they weren't lit. And so they pulled some matches out of their pockets that were in watertight containers, and they lit one of those torches.

[00:05:28.03] And they looked at this pot and they said, "Hmmm. I betcha our great-great-great-great-great-Grampa put this here. I wonder what this is all about."

[00:05:38.02] And as they were doing this, they noticed that the water level had come up a little bit. (Let's put them there, standing on this island.) The water was now up around their ankles, whereas before it was below the surface of the thing they were standing on. (Jill's hair came all the way out.)



Torches around lake

[00:06:01.11] And Evil Mister Fred was on the outside. He also wanted to find that treasure. He figured he's just gotten rid of Jack and Jill because they dove overboard and he never saw them again. So Evil Mister Fred got into his rowboat, rowed over to the island with some of his minions, parked the rowboat, and started running around looking for treasure. And all he found was bean plants.

[00:06:25.18] When he got near the top, he found a big "X" drawn on the ground. He says, "Ha, ha!! This must be the place where the treasure is hidden. So Evil Mister Fred had his minions start digging there, and they dug, and they dug, and they dug, while directly beneath them was Jack and Jill in the cavern, trying to figure out how to get water into the plant, to see what would happen.



Evil Mr. Fred finds "X" on ground

[00:06:52.25] If you were Jack and Jill, what would you do to get water up into the plant?

Imagination and Brainstorming Time

Ask your child(ren) how Jack and Jill could get water into the pot.

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.

End of Story

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

[00:26:20.09] Okay, you remember that when you had the candles under the jar, as the flame went out, the water started to go higher and higher in the jar. Jack and Jill started to realize the same thing. When they lit one torch, water started going up and up and up. So they quickly lit every torch in the whole place. And the water level went higher and higher and higher. And once the water level got up to the top of the pot, Jack and Jill were swimming in it, looking around, saying, "What's gonna happen now? And it overflowed into the dirt, and immediately something started to grow out of the dirt. And Jack and Jill said, "It's the beanstalk!"

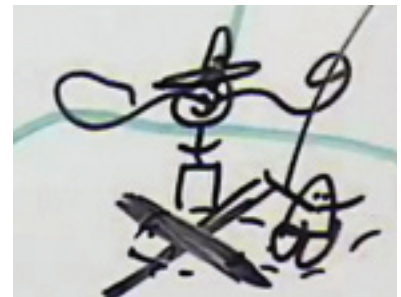
[00:27:06.20] And this enormous beanstalk just blew out of this pot, twenty feet wide, straight up into the air, hit the ceiling at about two hundred miles an hour, with such force that it burst the whole top of the island off. There was a huge exploding sound, rocks and debris, and beanstalks from the top were going everywhere.

[00:27:35.17] Do you remember who was up here? Poor Evil Mister Fred and his minions were up here trying to dig for treasure. And when that beanstalk hit the ceiling, Evil Mister Fred and his minions went flying -- ahhhhhh, ker-splooosh! Clear over the horizon.

[00:27:54.23] And Jack and Jill got carried away on the beanstalk itself. The leaves sprouted out and picked them up and carried them high into the sky. And then the beanstalk grew out other branches here and there, and they became heavier and heavier. And as it grew, leaves formed, and after the leaves formed, then the beans formed. The bean pods. But they weren't green. These bean pods were gold. And inside was gold coins and silver coins, and rubies and pearls, and all kinds of valuable stuff.



Beanstalk starts to sprout



Evil Mr. Fred & minions digging



Beanstalk bursts through, pods form

[00:28:35.20] And Jack and Jill, now that the beanstalk kept growing and tilted over, it ended up tilting right over where Evil Mister Fred's pirate ship was. Of course, he and his minions were gone. So Jack and Jill harvested all the gold, put it on Evil Mister Fred's pirate ship, and they took down his Jolly Roger flag and put up a flag of their own, and headed out back home again. And everybody lived happily ever after except Evil Mister Fred.



Jack & Jill take the pirate ship

Experiment #1: "Candle in a Jar"

[00:07:28.15]

Items needed:

- Large Roasting Pan
- 1-qt. Canning Jar
- Birthday Candles
- Matches
- Modeling Clay
- Water



We use ordinary birthday candles.

[00:07:32.17] We're going to be doing an experiment where we burn a candle in a jar. The jar will be upside-down, sitting in a puddle of water. The candle will be right inside it like this.



If the water goes up higher than one-fifth of the way, that's more than the amount of oxygen in the jar.

[00:07:43.11] As the candle burns, some textbooks say that the candle uses up the oxygen that's in the jar, and then the water goes up to take the place of the oxygen. Now the oxygen that's all around us is only about one part in five of the atmosphere. So if the water goes up about one-fifth the way, then we'd say, "Yup! That's probably right." If the water goes up higher, that's a problem. We'd have to figure out why it went up higher than there is oxygen in the air.

[00:08:15.21] To do this experiment, we need to get some candles under there and the jar sitting in water. Fortunately, this is very easy to do with things that you can find around your house or at the local grocery store. All you need is a one-quart canning jar, some clay, and some birthday candles. We usually buy birthday candles in big boxes, but you can get any variety of them.



Form the clay into a circle that fits the jar, and put a candle into it.

[00:08:40.05] We're going to form the clay into a circle about that big, just so it fits into the jar, and we're going to put some candles into the clay. So we'll just start with one candle like that.

Part One -- One Candle:

[00:08:58.28] And we would like the candle to be sitting in a fairly deep tub of water. You can use a baking pan of any sort, as long as it'll hold enough water to fill this jar up almost full. Now, we would like it to sit above the bottom of the pan, so we're going to rest it on another piece of clay. We'll just stick it in this pan, kind of squish it down a little bit, so it doesn't tip over too easy, and we'll put our candle on top of that so it looks pretty good. And that's the setup we're going to use, and in a minute we'll fill this with water, light the candle, and put the jar over it.

[00:09:45.06] Now, we just put a little food coloring in this water so it's easier for you to see. We'll light our birthday candle. *[Lights candle]* We want it to burn a little bit before we put our jar on, so that it's got a nice flame going.

[00:10:09.15] Now, when we put the jar on, if we put the jar over here and press down *[puts jar in water upside-down so the rim is resting on the bottom of the pan]*, no bubbles. *[Lifts jar out of water, then puts it in again at an angle, rocks it back and forth]* If we come in at an angle, we can make a bubble if we tilt it. *[Lifts jar out of water again.]*

[00:10:29.08] Now, we're going to put it on the candle and see if it acts the same way. *[Places jar over candle so the rim is resting on the bottom of the pan and the candle is inside]* Okay. No bubble. And we'll let it burn.

[00:10:44.02] So far it doesn't look like much of anything's happened, we just have a happy candle inside of a jar. *[Candle gradually goes out]*. Aww, the flame is going out. It used up its oxygen.

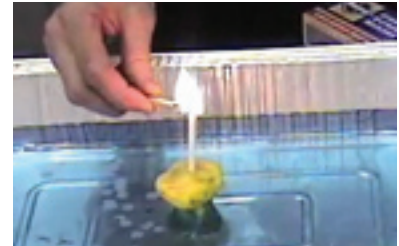
[00:11:07.04] *[Slightly lifts and tilts the jar, but not enough to lift it out of the water]* I don't know if you can see through the water level, but there's a tiny bit of water that's come up inside of this jar. Not very much, though. A very small amount. So as far as an experiment is concerned, we'd say, "Well, it used up the oxygen, but the water didn't come up one-fifth of the way, so something else might be going on."

Part Two -- Two Candles:

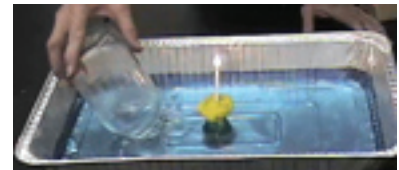
[00:11:38.24] *[Two birthday candles are stuck in the clay, which is sitting in the pan of water.]* We're going to wave the jar around a bit to get more air inside. *[Waves jar around, not near the candles]* And we'll light those guys *[lights candles]*. Do you think it's going to go higher with two, or the same amount?



Press clay into baking pan.



Light the candle.



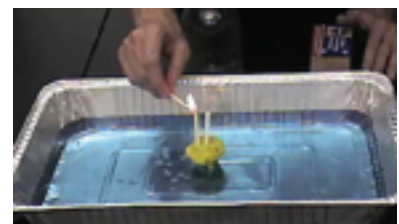
Tilt the jar at an angle to make a bubble.



Place jar over candle.



A tiny bit of water rises in the jar.



Light two candles.

[00:12:04.03] Here we go. *[Places jar over candles so rim rests on bottom of pan. Candles gradually go out.]* Now I can see the water in there. It is right about at that level *[points to water level on side of jar]*. If I put my finger on the surface you can see it better. So the water in the jar is up here. Hmm. Two candles made it go up higher. Looked pretty much to me like it went twice as high with two. *[Lifts jar off candles]*

Part Three -- Four Candles:

[00:12:52.25] *[Four lighted candles are sitting in the clay, in the pan of water.]* And always have something safe at hand like this whole pan of water in case something goes bad. Now we have four candles. It looked pretty much to me like it went twice as high with two. *[Places jar over candles]* Almost no bubbles. *[Candles go out, water starts rising quickly inside jar]* Boy, those sure went out a lot faster.

[00:13:14.16] Now, look at the level of the water. It's going up to about there very quickly, and the surface of the water is down right there at the tip of my finger. So it's about an inch and a half above the surface, and it's completely over the top of that clay. *[Lifts jar up; water makes gurgling sounds as it runs out of the jar.]* Glug, glug, glug, glug.

Part Four -- Eight Candles:

[00:13:41.22] *[Eight lighted candles are stuck in the clay, in the water.]* Now, let's do eight candles. There we go, eight candles. Move our jar around a little bit, make sure we've got fresh air inside. Here we go. *[Places jar over candles; candles go out almost immediately.]* Wow, those went out fast. *[Water rises quickly about halfway up inside the jar.]* So the water is up right to there, the surface is down here. That looks like the jar is almost half full. There's more than one-fifth, without any question.

Part Five -- Seventy-five Candles

Demonstration only -- DO NOT do this at home!

[00:14:28.29] *[Lights a group of 75 candles crowded together in a plastic cup.]* And you can tell that the more candles we get, the higher it goes. *[Places cup in water; flame is burning very high]* There we go, seventy-five candles. You may not want to try this at home. It smokes up the house quite a bit, and you have to be kind of careful when you're putting the jar over the top.



The water rises a little higher.



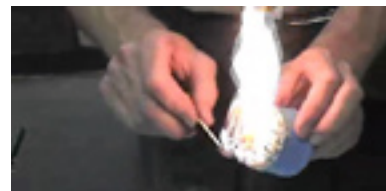
Four candles.



Water rises about 1 1/2 inches.



With eight candles, the water rises more than one-fifth of the way up.



75 candles -- DEMONSTRATION ONLY!

[00:14:54.20] Ready, get set, go. *[Brings jar in at an angle and lowers it over the candles. Flames go out immediately, water makes gurgling sound, jar fills with smoke above the water level.]* Whoah, look at all the bubbles that time! *[Water rises inside jar.]* Now you can see, the water is slowly going up, and up, and up. So far, it's right about there *[Indicates a spot about halfway up jar. Water continues to rise]*. Still going. Somehow that candle has made almost all the atmosphere in that jar disappear.

[00:15:39.12] Now, this is something that we want to try and figure out. So in the rest of the experiments, we'll take a look at this to see if we can find out why that water went so high.



Place jar carefully over candles.



With 75 candles, the water rises more than halfway up the jar.

Experiment #2: "Egg in a Jar"

[00:15:52.15]

Items needed:

- Glass Jar
- Hard-boiled egg, peeled
- Metal Tongs
- Hair Dryer
- Paper
- Match

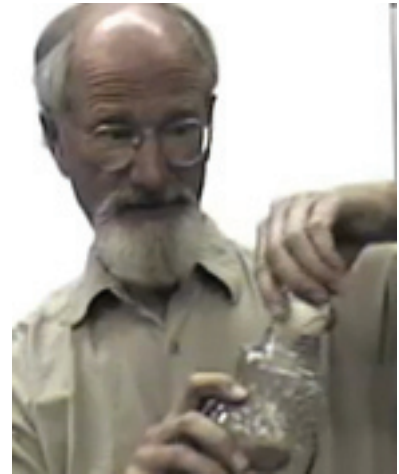


[00:15:55.10] Now, all you need for this experiment are some kitchen tongs, a hard-boiled egg with the shell removed -- you can draw a face on it if you like -- a match, a piece of paper, a jar that the egg almost fits into (the only ones I found at the grocery store are jars that they sell juice in), and a hair dryer.



[00:16:18.18] Okay, the air around us gets hot, and it gets cold. When it gets hot, it spreads out further, it expands and tends to rise. When it gets cold, it shrinks down and tends to fall down below. That's usually what helps make our winds go.

[00:16:35.08] Now we have an experiment here. We want to make some air expand or contract to help us out. In this case we have our friend here, Humpty *[holds up egg]*. Humpty is tired of sitting on top of his wall. He wants to go live inside of a jar. But the only jar he could afford had a door that was too small, and poor Humpty couldn't get inside. If you were Humpty, how would you get yourself into the jar? That's what we're going to find out.



Humpty can't get in the door.

Imagination and Brainstorming Time

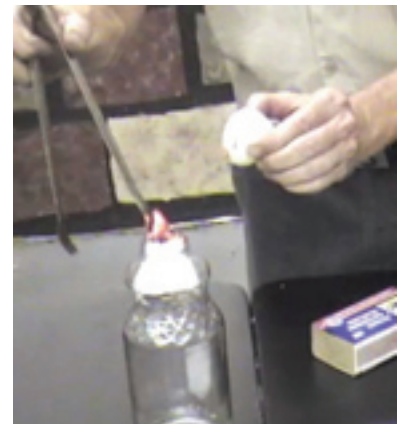
Ask your child(ren) how Humpty Dumpty could get into the jar.

After brainstorming, proceed with the experiments.

[00:17:20.00] If we consider that if we put a piece of paper in the jar that's on fire, *[Holds jar, places paper inside (NOT on fire)]* and then set Humpty on top of the door, what'll happen? Hmm, interesting. The paper's going to burn up the oxygen in the jar, it's going to heat up the air, the air's going to expand -- Humpty might not like this because he's going to be sitting on fire. He may dance a little bit. But then, the air should cool off, and we'll find out what's going to happen to Humpty.

[00:17:52.13] *[Paper is stuck halfway into bottle]* I'm going to use these tongs, and I'm going to light the paper on fire, push it down into the jar, and then set Humpty on the top of the jar quickly, and then we'll see what happens to Humpty.

[00:18:05.20] So we'll light our paper on fire, *[Strikes match, lights top of paper]* get Humpty with one hand *[picks up egg]*, and push our paper in *[pushes paper into jar with tongs. quickly places egg on top of opening]*, put Humpty on top. *[Egg vibrates up and down slightly]* Look at Humpty -- he's bouncing. Our paper's still burning -- *[Egg squeezes through opening and drops into jar]* thunk! He's in the jar. And he may or may not be a happy Humpty, but at least he's in there minding his own business. He thinks he's a hermit egg.



Use tongs to push burning paper into jar.



Quickly place egg on top of opening.

[00:18:47.07] Now, the paper burned just like we had a burning candle in the other case, and Humpty got sucked inside. When hot air cools, it creates suction, and that's what sucked Humpty down into the jar. You can try this yourself at home as long as your parents are there to help you with the burning stuff. And you should always have some water nearby in case something goes wrong.

[00:19:13.09] Now, let's suppose Humpty is dissatisfied. He's in his house, but he doesn't like it in there and he wants to get back out. How can Humpty get back out of his jar? Well, we could turn him upside-down, *[Turns jar upside-down]* and see if he'll fall out. *[Egg falls toward mouth of jar, but doesn't fall out]* But no, Humpty is too big. He's quite a lot bigger than that hole.

[00:19:36.27] First off, it's all kind of messy in there because he's got that burned piece of paper in there with him. So we should put in a little water and wash Humpty off. *[Dips jar into pan of water to get some water into the jar]* See if we can get some of that paper out of there. *[Shakes jar to make paper slosh toward mouth, uses fingers to pull paper out]* There it is, and get Humpty all clean. *[Swishes some more water into the jar and pours it out]* There we go, got a clean Humpty. There.

[00:20:04.17] *[Holds jar upside-down with egg at the bottom, slightly protruding through the opening]* Now, Humpty wants to leave, but he's stuck in the door. He can't get out of his house (you can see his face there).

Now we'll use our hair dryer and heat up Humpty's house. *[Turns on hair dryer, directs it at upper part of jar for about thirty seconds. Egg begins to squeeze through the opening, then drops through and falls to the table.]*

[00:21:05.11] So Humpty survived! He fell out of his house and landed on his feet, and he's happy again. So we can see that hot air can get him to go inside because when we lit the fire, the air got hot, Humpty bounced up and down, and a lot of the hot air escaped. As the air cooled, it sucked down Humpty Dumpty back inside the jar. Then when we wanted to get Humpty back out, we cooled off the jar in the water, got all the ashes off of him so he could make a nice seal on the lip, and warmed up the jar so the air expanded and pushed Humpty back out again.



Humpty's been sucked into the jar!



Now he can't get out.



Swish some water around inside to clean out the jar.



Heat up Humpty's house with the hair dryer.



Humpty squeezes out again.

Experiment #3: "Collapsing Soda Can"

[00:21:52.25]

Items needed:

- Empty Soda Can
- Metal Tongs
- Duct or Masking Tape
- Stove
- Large Roasting Pan
- Small Cup
- Water



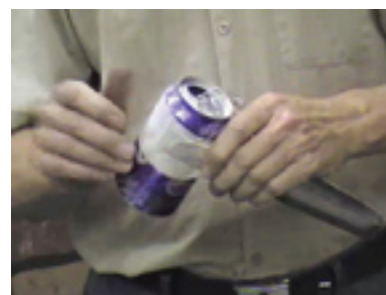
Empty soda can

[00:22:02.21] We're surrounded by a whole bunch of air. The air is mostly nitrogen, and there's some oxygen in there, a little bit of argon, a tiny, tiny, tiny bit of carbon dioxide, and a tiny bit of water vapor. And we want to take almost all of that out of this can in a very simple way and see what happens to the can.



Hold the can with tongs.

[00:22:22.26] We'd like to take all the air out with steam, which, luckily, is very easy to do. But what's not so easy to do is make the steam disappear instantly. And I'll show you a way that you can make the steam get a thousand times smaller in a very, very small part of a second. All you need is some kitchen tongs, your empty soda can with the top popped open, some tape of any sort (we're just going to use some masking tape), and something to measure out a little bit of water, like a cup.



Secure the tongs with masking tape.

[00:23:00.04] So, if you try to hold the can with the tongs yourself, they could probably slip off, so we're just going to tape it on there so that it's not so likely to slip off. If you have duct tape, masking tape -- I don't know if Scotch tape works that great. It tends to fall off under water. [Tapes tongs] And we're going to just get it on there so it's more likely to stay. There. Can on tongs.

[00:23:36.00] We'll put some water inside [takes a small amount of water in cup, pours it into can]. The amount of water you put in isn't critical. About that much shall do. Then you want to heat it up. If you have a gas stove at home, it's real easy. An electric stove will work, too. You just want to have the can against the stove when you're cooking it. [Turns on burner]



Pour a small amount of water into the can.

[00:23:58.18] For this guy, we'll just hold it over our stove [*Holding tongs, places can close to burner*]. We want to get it hot enough so that the water is boiling and there's lots of steam coming out. When it starts to steam, then we know that the steam is pushing out all of the nitrogen and the oxygen and the argon and carbon dioxide. So the only thing that will be left in the can, pretty much, is steam -- water vapor. For that amount of water, it'll probably take about a minute for it to get hot enough to go. [*Continues to hold can over burner for about a minute*]

[00:24:39.09] [*Steam is rising from opening in top of can*] Now we can see that there's a little bit of steam coming out. We want to make sure that there's lots of steam coming out. [*Waits a few seconds more*] Five, four, three, two, one. [*Quickly removes can from burner and turns it upside-down in the pan of water. Can crumples with a loud bang*] That worked.

[00:25:10.14] Now [*Lifts can out of water, and water runs out of it*]-- glug, glug, glug, glug, glug -- the can crushed itself. Why did it do that? You can see that it is a mere shadow of its former self. Now, when you take steam and let it turn back into water, it gets a thousand times smaller. When we had this end [*points to top of can*] under the water, that steam turned back into water so quickly that it created a vacuum inside. And all the pressure that's around it just crushed the can for us.

[00:25:48.12] This is related to our candles in our jar, too. Because whenever you burn a candle, it makes two things: Thing number one is carbon dioxide; Thing number two is water vapor -- and heat. But the carbon dioxide and the water vapor are the things that we're interested in. This can was filled with pure water vapor, and you can see that it created some suction and destroyed the can.



Hold can over burner until there's lots of steam coming out.



Quickly remove can from burner and turn it upside-down in the pan of water.



The can crushed itself!



When water vapor turned back into water, it created a vacuum that crushed the can.

Review of Experiments

(Do this part after completing the story)

[00:29:24.15] So we saw Jack and Jill were able to get the water into the pot and escape from the island. We've done three experiments so far. In the first one, we had candles in the jar, just like Jack and Jill inside of their cave. The candles burned up the oxygen and produced carbon dioxide and water vapor. The water vapor condensed rapidly and the hot air cooled off, and sucked the water upwards inside of your jar.

[00:29:56.09] In the second one, you had an egg in a jar with flame under it, and in this case, the flame burned and produced some hot air and gases which made the egg dance around and bounce on the top for a couple of seconds. And then after the flame died out, the egg settled down and sealed off the top. And then ka-boonk! The egg got sucked inside as both the water vapor and the hot air shrunk down.

[00:30:23.03] In the third one, we had a soda can that you heated up on the stove until steam was pouring out. And then when you turned it upside down and just touched the tip of it under water, all that steam condensed so fast, the can just went bang! -- and crushed itself by the air pressure that was all around it.

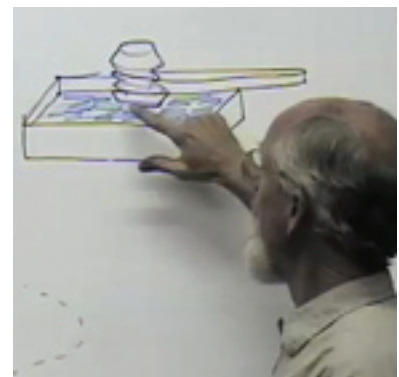
[00:30:42.28] So in these experiments you've learned a little bit about hot air, flames, and vacuum. So you can look on the internet and find out other experiments like this. And we hope you've all had a good time.



The torches in Jack & Jill's cave are like the candles in the jar. They produced heat, carbon dioxide and water vapor. When the gases cooled, they shrank, and the water vapor condensed to suck the water upwards inside the cave.



The burning paper inside Humpty's jar also created water vapor, along with hot air. When it cooled, the water vapor and air shrunk, and Humpty got sucked in.



The soda can was filled with hot steam that condensed so quickly when it hit the cold water, the pressure of the surrounding air crushed the can.