



Teacher's Guide for: **Cartesian Divers**

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
- Experiment: *Cartesian Divers* page 2
- Equipment List: *Cartesian Divers* page 3
- Story, Part 1: *Jack & Jill on the Moon* page 4
- Story, Ending. page 5

Video Transcript:

- Intro: page 6
- Story, Part 1 : *Jack & Jill on the Moon*. page 7
- Experiment: *Cartesian Divers* page 10
- Story Ending page 11

Title Page of Video

Cartesian Divers
A Rock-it Science Lesson
Filmed June, 2009

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

(c) 2012 Rock-it Science Educationally Useful Programs. All Rights Reserved

Intro Quick Recap: "Cartesian Divers"

- If you hold your breath and squeeze your cheeks, does the air always come out?
- If you sneeze with your eyes open, will your eyes pop out?
- Put a partly-filled plastic bottle on its side and squish it to show how the air compresses.
- Fill the bottle with water and try to squish it, to show that the water doesn't compress like the air.



Bottle filled with Air (at left) squishes more than Bottle filled with Water (at right).

Experiment Quick Recap: "Cartesian Divers"

- Each student gets a plastic pipette and cuts off the shaft so it's about 1" long.
- Thread two metal washers onto the shaft and glue them in place.
- Fill a 1.5-liter plastic bottle with water. Drop the pipette "creature" into it and try to make it float to the top is just barely showing above the water level.
- If necessary, wrap some wire around the shaft to make it heavier.
- Decorate the creature with permanent markers.
- Put the creature in the bottle, screw on the lid, and squeeze the bottle to make the creature sink to the bottom. Release it to make the creature rise to the top.



Creature sinks when you squeeze and rises when you let go.

Equipment List: "Cartesian Divers"

Items needed for Instructor:

- Plastic Water Bottle, 1.5-liter, with lid
- Water
- Scissors
- Salt, Table (if needed for sinkers), 1-lb container per class

Items needed for Students:

Consumables, per student:

- Plastic Water Bottle, 1.5 liter
- Pipette, 1 ml., with shaft cut to 1"
- Washers, Metal, #10, 2 each
- Cup, Clear Plastic, 12-oz
- Water
- Wire, Copper, 22 gauge, about 6"
- Magnet, 1/2" Disk

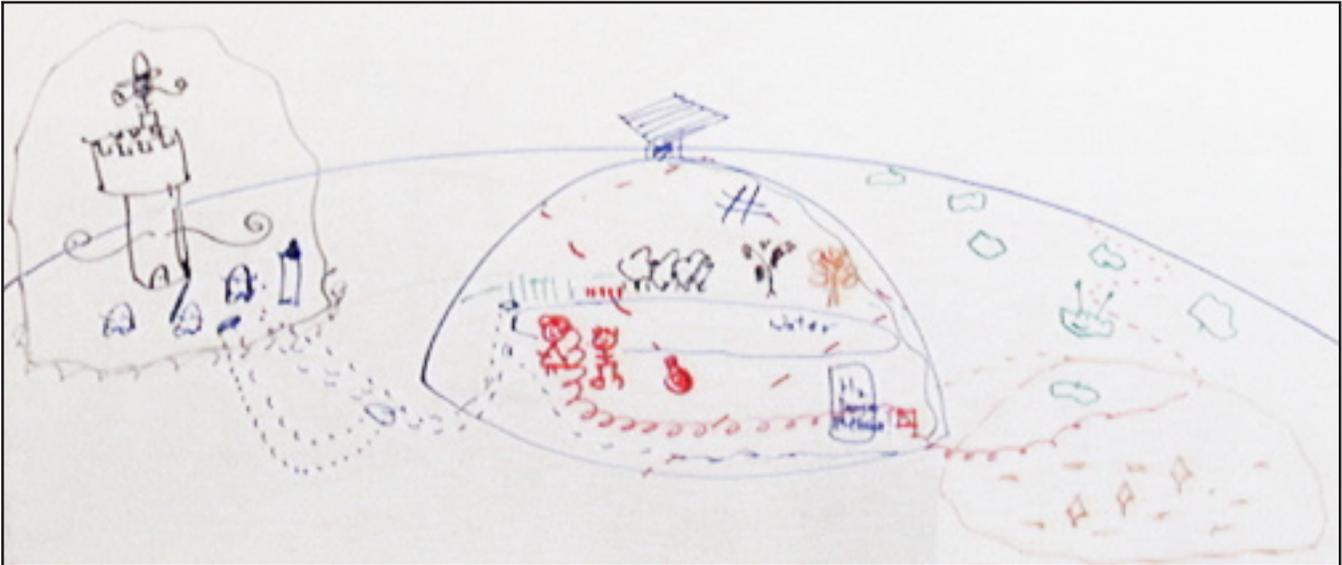
Other:

- Permanent Markers, Colored
- Glue Guns

Prep Work:

- Cut shaft off pipettes

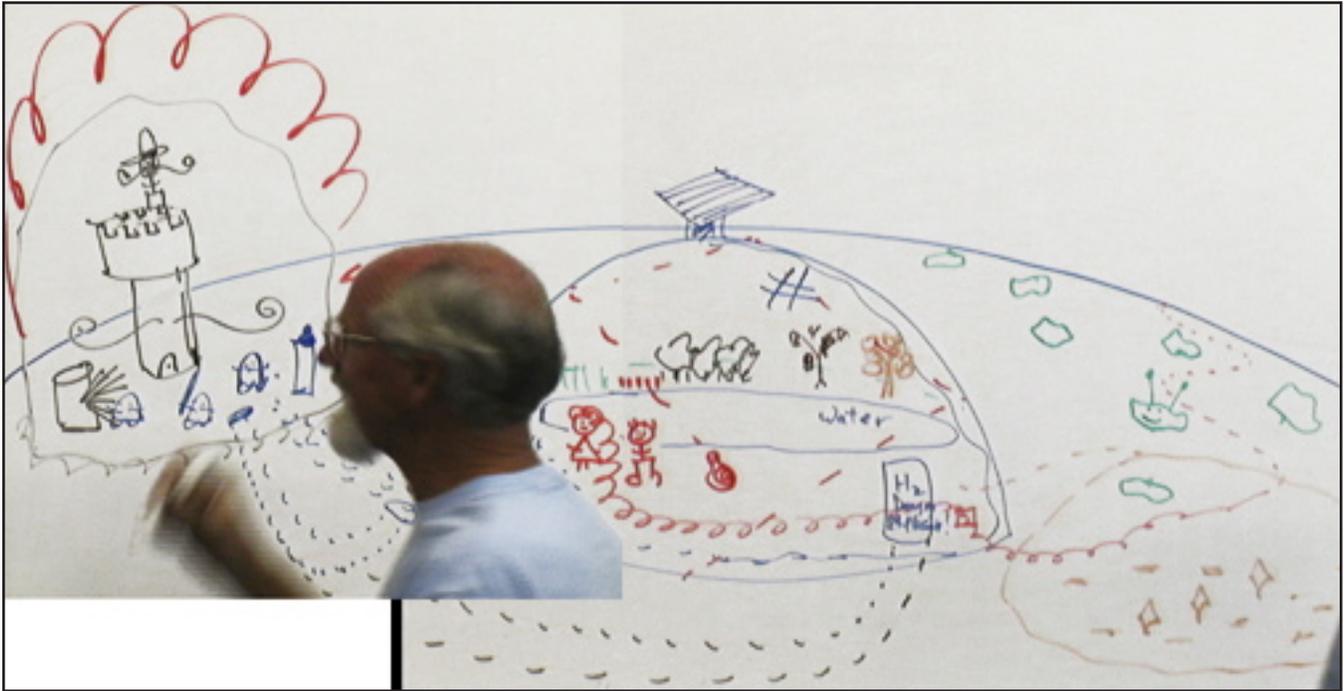
Story Recap: "Jack & Jill on the Moon"



Part 1:

- Since there were new students in this class, prior to the story, the Instructor explains who the characters are: Jack & Jill and their Kick-Mes, and Evil Mister Fred and his minions. Also how they both use the Acme Store of Everything (doorway on top of Mt. Everest, giant warehouse inside, elves with big ears who hear all requests and send anything to anyone through wormholes).
- Jack & Jill live on another planet in a glass dome.
- They have a lake that they use to manufacture hydrogen and oxygen. They breathe the oxygen and store the hydrogen in a tank.
- They also have a garden and solar panels for electricity.
- Evil Mister Fred builds a castle nearby and wants Jack and Jill's stuff.
- He calls the ASE and orders a giant garbage bag, puts it over his castle, covers the edges with dirt, and orders a tank of air to fill it up. After awhile, the air starts getting stale, so he decides to steal Jack & Jill's.
- Minions use baseball bats to dig a tunnel. First one comes up outside the dome, and the air starts to get sucked out of the garbage bag. Evil Mister Fred plugs the hole with minions, then has others dig a second tunnel, which comes up inside the dome.
- Minions steal a bunch of Jack & Jill's food and hook into their electrical system.
- Jack & Jill notice big rocks with antennas moving closer and closer outside the dome. These turn out to be aliens with the power to move things just by thinking.
- Jack starts a thought conversation with an alien, who shows him their underground chamber full of gold and gems. Evil Mister Fred also finds out and decides to get rid of Jack & Jill.
- Jack and Jill are kicking their Kick-Mes into the lake, where they bob up and down in the water. Meanwhile, it's getting harder to breathe because Evil Mister Fred is sucking out the air.

Story Quick Recap (cont.)



Ending:

- The minions dig another tunnel and steal Jack & Jill's tank of hydrogen.
- Evil Mister Fred wasn't paying attention, and the minions start hitting it with baseball bats and a big rock.
- They make a hole in the tank and the hydrogen starts to leak out.
- Evil Mister Fred pulls out a cigar and lights a match.
- The hydrogen ignites, and Evil Mister Fred, his castle, and his minions are all blown out into space.
- Jack and Jill plug up the tunnels.

Transcript: Intro:

If you hold your breath, can you squeeze your cheeks in? Does the air always come out when you squeeze your cheeks in? If you hold your breath hard enough and squeeze your cheeks in and don't let the breath out, will your eyes pop out of your head? No? You get extra points if your eyes pop out.

MythBusters tried an experiment. The myth was that if you sneeze really hard, your eyes will pop out of your head if you keep them open while you sneeze. Do you think that would happen? Wouldn't that be cool? You could be at the table eating dinner, and you sneeze with your eyes open, and your eyes pop out of your head. Your parents would say, "Whoa, what just happened?" And your little brother would say, "Oh, a meatball!" and eat your eye. *[Student: But then you'd be dead because . . .]* No, then you could see inside of his stomach.

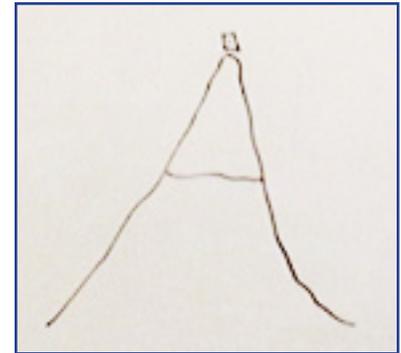
Well, they proved that your eyeballs won't pop out of your head, and it's partly because air is squishable. If you put air in a bottle and seal the top nice and tight, and then we could squish it . . . *[places a partly-filled water bottle on its side with the cap on and compresses it]*. See, it's squishy, squishy. Scientists say air is compressible, which is a neat thing. The water itself, though, water doesn't squish good. If you fill a bottle completely with water and squish it, it might flex a little bit. We'll put some water in this bottle. The bottle has some grooves on it, so the bottle will expand a little bit. There, now we have a bottle that's mostly full of water. Now let's see if it squishes as much as the air did. *[Attempts to squish bottle, which barely gives at all.]* So we're going to use the squishability of air and the non-squishability of water today in our experiment. But first, we need a crazy story.



Bottle filled with Air (at left) squishes more than Bottle filled with Water (at right).

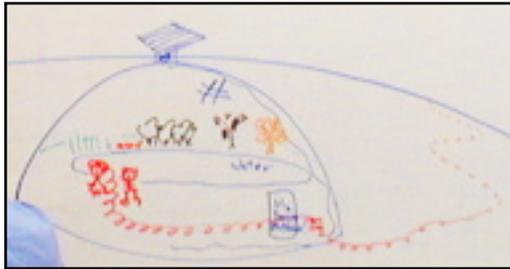
Story: "Jack & Jill on the Moon"

In our story we have the Evil Mister Fred and Jack and Jill. Evil Mister Fred is always trying to trap Jack and Jill in some sort of way. And he's trying to take over the world. And both of them have access to the Acme Store of Everything. The Acme Store of Everything lives on the top of Mount Everest, 29,000 feet high. It's just a door, floating directly above the top of it. If you walk around the door, you'll be able to see it on all sides, and it looks like a door from the front, from the side, and from the back. However, if you go and turn the doorknob, the door will swing open, revealing a huge warehouse full of all kinds of little elves. And they have really big ears. And if you say somewhere, "I want a pepperoni pizza with chocolate chips," all of a sudden, phew! -- it'll appear right in your hands, and be charged to your mother's credit card. And the Acme Store of Everything has, of course, everything for everybody. There's wormholes that lead out of it that go to everywhere on the planet. You'll find out about this as we tell the story.



Acme Store of Everything

Let's suppose that Jack and Jill have taken off and gone to a blue planet in space. It's blue because the dirt is blue. And there's no air there. So the people that visit there have to create someplace to live. And Jack and Jill have built a big glass dome.

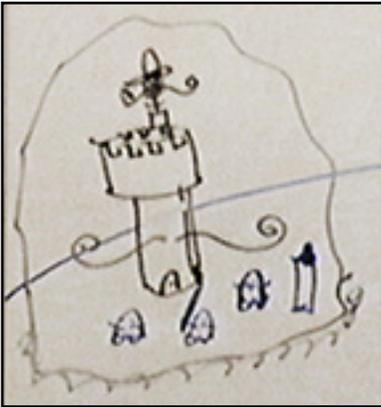


Jack and Jill's Dome with lake, garden, solar panel, and Hydrogen Tank.

Except there's no air. There's Jack, and there's Jill. And Jill has long hair, very long. They had to build a special doorway in the dome to let her hair out, because it grows infinitely fast and it's infinitely long. There it goes. And one thing you really need to have so you don't die is air. And to make air, Jack and Jill have a huge lake there full of water. And they turn the water into hydrogen gas and oxygen gas, and they can breathe the oxygen gas. And they put the hydrogen gas in big tanks and save it. H₂, Danger, Explosive, Exclamation Point!

Now Jack and Jill have oxygen to breathe, they have a place to stay, they can protect themselves from the sun, they put up some solar panels so that they have electricity and electric wires come down so they can cook food and have lights on and everything. They have fans. And they've grown food. Jack and Jill have a garden back there with corn growing. What else would you grow if you were living on some weird planet? They have carrots growing, peanuts growing, cashews, pears, pumpkins. And they're growing milkshakes on a chocolate milkshake tree. There's milkshakes growing there. And there's a pizza tree in the back. They have everything you could possibly want, plus they can go swimming and they have air to breathe.

Now, Evil Mister Fred heard about this, and he said, "Whoa, they're going to make a mint. There must be minerals there, all kinds of stuff. They're going to get rich, and I'm not going to have any." So Evil Mister Fred came to the same planet and build a castle. And he saw Jack and Jill's beautiful dome with all their stuff and he said, "Whoa, they've got good stuff, but I can do better. I don't need to spend all the time they spent." The castle's got a mustache. So Evil Mister Fred called the Acme Store of Everything and ordered a big garbage bag. And he put the garbage bag around his castle, and he covered the edges

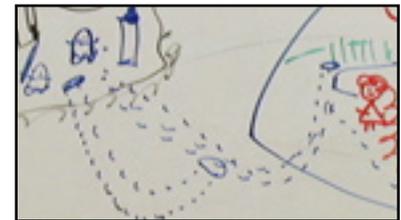


Evil Mister Fred's Castle,
with Garbage Bag around it.

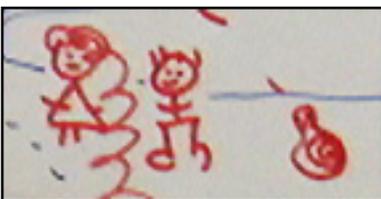
with dirt like that, and then he just needed air to fill it up. So he called the Acme Store of Everything and ordered a tank of air and filled it up.

Evil Mister Fred has minions with little mustaches. They do whatever he says, except they have no arms. They have to do everything with their mustaches. And so they have a tank of air here that they filled their thing up with. And then Evil Mister Fred started having a hard time breathing. The air was getting stale. He said, "Minions, we've got to solve this problem. There's an easy way to do that. Take your baseball bats -- (they always have baseball bats) -- and dig a hole in the ground, and pop up in Jack and Jill's place." So the minions said, "All right, boss." And they started banging on the ground so hard that they created a hole in the ground. And the first minion thought he was coming up in Jack

and Jill's place, but he came up in a swamp where there was no air. And it sucked the air out of the garbage bag -- shwoop! -- like that. And Evil Mister Fred said, "Stop!" And he plugged the hole with a bunch of minions, like corks. And then he had other minions dig again, and they popped up right by Jack and Jill's garden. And now they were able to steal Jack and Jill's air, Jack and Jill's food, and they also hooked into Jack and Jill's electrical system and took their electricity, too. So Evil Mister Fred had everything going and didn't have to pay for anything. He said, "Yeah, this is great! I'm all set."



Minions dug two Tunnels.

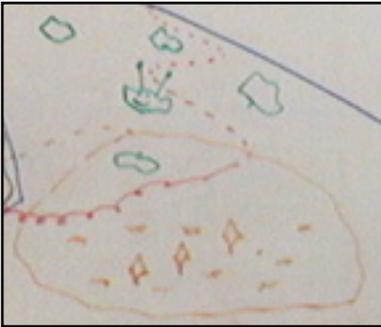


Jack & Jill with a Kick-Me

Now, Jack and Jill also have some friends with them. They're called Kick-Mes. The Kick-Mes are always sad -- there's a Kick-Me -- there's a target on his stomach. If you kick him on his target, then he's happy. And the harder you kick him, the happier he is. And Jack and Jill liked to kick them so they would bounce around inside -- boing, boing, boing, boing, like that. And they'd just laugh and giggle the whole time. If you accidentally kick a Kick-Me into something like a fire, he'll burn up

-- foofff! -- and it'll make smoke, and then the smoke will re-form, and out of the sky -- boingggg -- will be a Kick-Me. They're indestructible.

So Jack and Jill begin to realize that something is wrong in their place. The air is just not as much as there should be, the electricity keeps going down, and their food keeps disappearing. And the saw Evil Mister Fred over there laughing a lot. And they said, "Hmmm, I wonder what he's up to." Well, they didn't know, and after they'd been there for awhile, they also noticed that rocks were moving around on the planet's surface. They were big rocks, and they kept moving closer and closer. And sometimes the rocks had antennas. And they discovered that they weren't rocks at all. They were aliens. And the aliens had thought powers. They could move things just by thinking about it. And Jack was out there one day, staring out the window, and there was a rock. And he was staring at the rock, and as he stared at it, its antennas went up and it smiled at him. And Jack said, "Whoa, that's really cool!" And he started thinking to the rock, and the rock started thinking back, and they were having a think conversation. And the rock said, "Did you know we have an underground chamber with all kinds of stuff?" And Jack said,



Rock-like aliens and their Underground Treasure Chamber

“No, really? How do you get there?” And the alien said, “Oh, special powers. If you come with me, I’ll show it to you.” So Jack told Jill about this, and Jill said, “Well, I’m going to stay inside because I think that Evil Mister Fred is doing something. Why don’t you go check it out.”

So Jack went out there and sure enough, there was an underground chamber that was full of diamonds and rubies and pearls, all kinds of gold and treasure of every sort. And he said, “Whoa -- that’s great! If Evil Mister Fred finds out about that, you’ll be in deep trouble. He’ll just take over the whole planet, and who knows what he’s going to do?” And

Evil Mister Fred, of course, eventually did find out about the treasure, and he decided he was going to get rid of Jack and Jill. And Jack and Jill had been kicking their Kick-Mes into the water, and the Kick-Mes floated up and down in the water. And Evil Mister Fred was busy sucking the air out of Jack and Jill’s dome. And Jack and Jill were having a harder and harder time breathing. And they said, “Oh, no.” And Evil Mister Fred was going, “Mwah, hah, hah, hah!” If you were Jack and Jill, and you knew Evil Mister Fred was doing something evil, 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: “Cartesian Divers”

[The beginning of the experiment is missing from the video, but the process is repeated later with the students’ bottles. The Instructor brings out a “creature” made from a plastic pipette with the long end cut off about an inch below the bulb. Two metal washers are glued onto the shaft to stabilize it. Then the Instructor fills a 1-liter plastic bottle with water and places the creature inside so it just floats at the very top.] See him in there -- just the tip of his head is floating. *[When the Instructor squeezes the bottle slightly, the creature drops to the bottom. When he releases it, the creature rises back to the top.]* There’s actually air in the creature, and when he goes down the water pushes on the air and squishes it. See, do you know what I’m doing to make him go up and down? *[Student: Pushing on it!]* *[Instructor lets the student try it.]* Of course, you don’t tell your parents that. When you take yours back home, pretend like it’s a trick and do the abracadabra thing and make them gasp.

Okay, so we’re going to give you each a creature and -- do you want to chop them yourself? It’s more fun to chop them. And then, your creature needs to have a face, or any other creature things. So you’re going to use





Gluing the Washers on



Copper Wire wrapped around.



Using a Disk Magnet.

permanent markers and you can draw on it. Decorate it any way you like. When you're done decorating, come over and take two washers and your creature and we'll glue them up. *[Students decorate their creatures, then glue the washers on. They also put a large dab of glue on the end of the shaft to seal it off. For those who need help, the Instructor does the gluing for them. Then the students put their creatures in the bottle of water and try to get it to float so that just the very tip is showing above the water. The level needs to be fairly exact. If the creature floats too high, the children's hands won't be strong enough to compress the bottle sufficiently.]*

If the creature floats too high, the Instructor wraps some copper wire around the shaft to make it a little heavier, testing it in a cup of water, and adding or removing wire until the creature rises very slowly and floats just above the surface. For one student's creature, which was staying at the bottom, the Instructor added a large quantity of salt to the water so the creature would float.]

Now, everybody hold up your bottle, pretend like your parents are watching, hold your hand over the top, and say "Abracadabra" and then squeeze, and see if it goes down. Now, you can take your pens and draw on the bottle. Put your name on it somewhere on the outside so you can tell which one is yours.

[Then the Instructor gives each a student a half-inch disk magnet so they can also make the creature move up and down without squeezing the bottle.]



Sealing up the Opening with Glue.

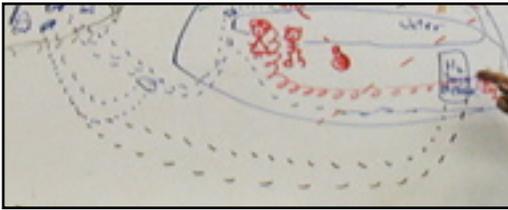


If a creature stays on the bottom, you can help it float by adding salt to make the water denser.

End of Story

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

So you remember Jack and Jill are in their big glass dome, and they've got food, they've got water, they've got a tank of hydrogen, they've got electricity. Everything is cool. Now Evil Mister Fred is stealing all their stuff, and he's sucking the air out of their building. And one of the minions said to Evil Mister Fred, "Hey! Evil Mister Fred! There's a tank over there. It says Danger, H₂, Explosive." And Evil Mister Fred said, "Oh, those two are goody-two-shoes. They don't have anything that'll blow up." And the minion said, "Oh, let's steal it, boss. Come on, come on, can we steal it? Can we steal it?" And Evil Mister Fred said, "Okay, all right, already." So the minions dug another tunnel right under the tank of hydrogen gas. And they pulled it down just like a gopher pulling a carrot plant under the ground. And Jack and Jill saw it disappear. They said, "What is going on?! The tank just went under the ground all by itself." And the minions carried it underground over to their own place. And now they had it, Evil Mister Fred was busy doing other stuff, and they started banging on the tank with their baseball bats. And they're going, "Oh, boy, oh, boy!" Crash, crash, making a lot of noise and



Minions dig a Tunnel under the Hydrogen Tank.



Minion punches Hole in Tank

stuff. And Evil Mister Fred, said, "Would you just stop that? What are you guys doing over there?" And one of the minions grabbed a big old rock, and he threw it at the tank -- psheewww! And he made a hole in the tank. So now, here it is, it's leaking out gas, and Evil Mister Fred is standing on top of his castle saying, "Yeah, I'm good. That's going to be the end of Jack and Jill." And he pulled out a cigar, and he says, "I'm going to celebrate!" And he went to light his cigar with a match.

And as soon as he did -- Kaboom!!! It was like a huge explosion, and Evil Mister Fred and his minions and his castle took off into space and disappeared. And Jack and Jill said, "Whoa! I don't know what that was, but there's just a big hole in the ground where the Evil Mister Fred used to be." And they said, "Oh, well." And then they discovered all those tunnels and what he was doing, plugged them all back up, and Jack and Jill lived happily ever after. And Evil Mister Fred didn't, did he?



Big Explosion.

End of Lesson

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