



Teacher's Guide for:  
**Water Bottle Rockets**

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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## Title Page of Video

Water Bottle Rockets  
A Rock-it Science Lesson  
Filmed November, 2009

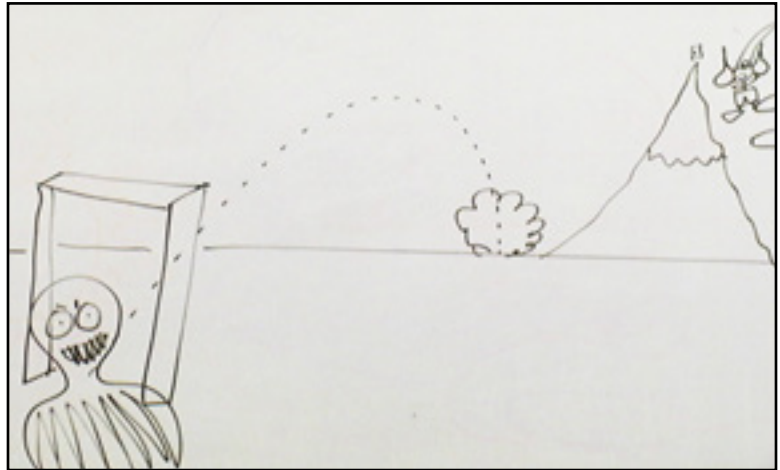
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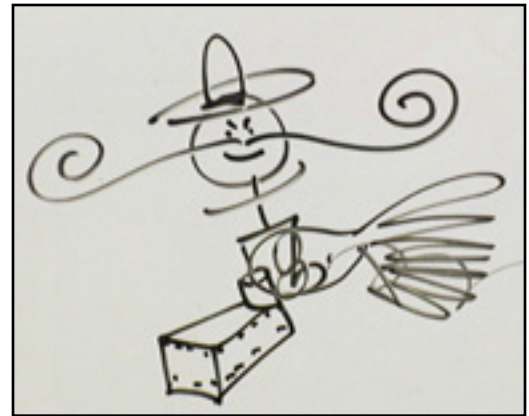
## Intro Quick Recap: *Newton's Laws of Motion*

- There was a portable doorway out in the middle of nowhere. It was guarded by a mean octopus.
- Anyone who came by would want to go through the doorway, but the octopus is sitting right in the middle.
- Evil Mister Fred came by and wanted to go through, but the octopus wouldn't let him.
- He tried to kick the octopus, so the octopus bit off his foot.



Octopus in doorway and elf at Acme Store of Everything

- Evil Mister Fred called the Acme Store of Everything and ordered a heavy steel foot.
- The Acme Store of Everything is a floating door at the top of Mount Everest with nothing around it. When you open it, there's a huge warehouse with lots of elves with big ears. They can hear whenever anyone asks for something anywhere in the world. The pull it off the shelf and drop it into a wormhole, and it's delivered.
- Evil Mister Fred kicked the octopus with the steel foot as hard as he could, and the octopus flew through the doorway, over the horizon, and crashed on the ground.
- The octopus got really mad, came running back, and bit Evil Mister Fred's other leg and hung on.
- This is Newton's three Laws of Motion.
- First Law is: If something's at rest, it remains at rest unless you do something to it, like the octopus in the doorway.
- Second Law is: When you kick something, the harder you kick it, the higher it goes. Force equals Mass times Acceleration.
- Third Law is: For every action, there's an equal and opposite reaction. The octopus got mad and came back and bit Evil Mister Fred.



Evil Mister Fred with steel foot, and octopus biting his other foot.

## Experiment Quick Recap: "Water Bottle Rockets"

- Demonstrate how to put a cork in the plastic bottle and use the bicycle pump to force air into it. Instructor holds cork rather than using launch pad. Pump until the bottle flies off.
- Explain how to insert the cork into the slot on the launch pad and how to tilt the launch pad at different angles.
- First students will use only air in the bottles, and later they'll use water.
- After shooting the bottles, leave them on the ground until Instructor calls "Cease Fire." Then they can gather up the bottles.
- After the Instructor says, "Resume Firing," students can resume shooting.
- Students work in teams of two.
- After returning inside, ask students which water level was most effective and which launch angle was best.



Demonstrating the launch pad.

## Equipment List: "Water Bottle Rockets"

### Items needed for Instructor:

- Garden Hose
- Large Plastic Tub for Water
- Rolling Cart

### Items needed for Students:

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

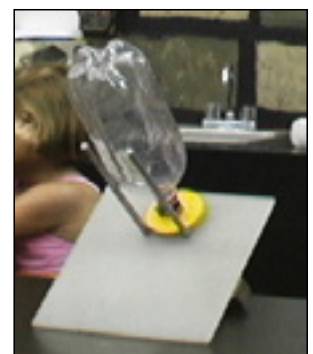
- Water

#### Other:

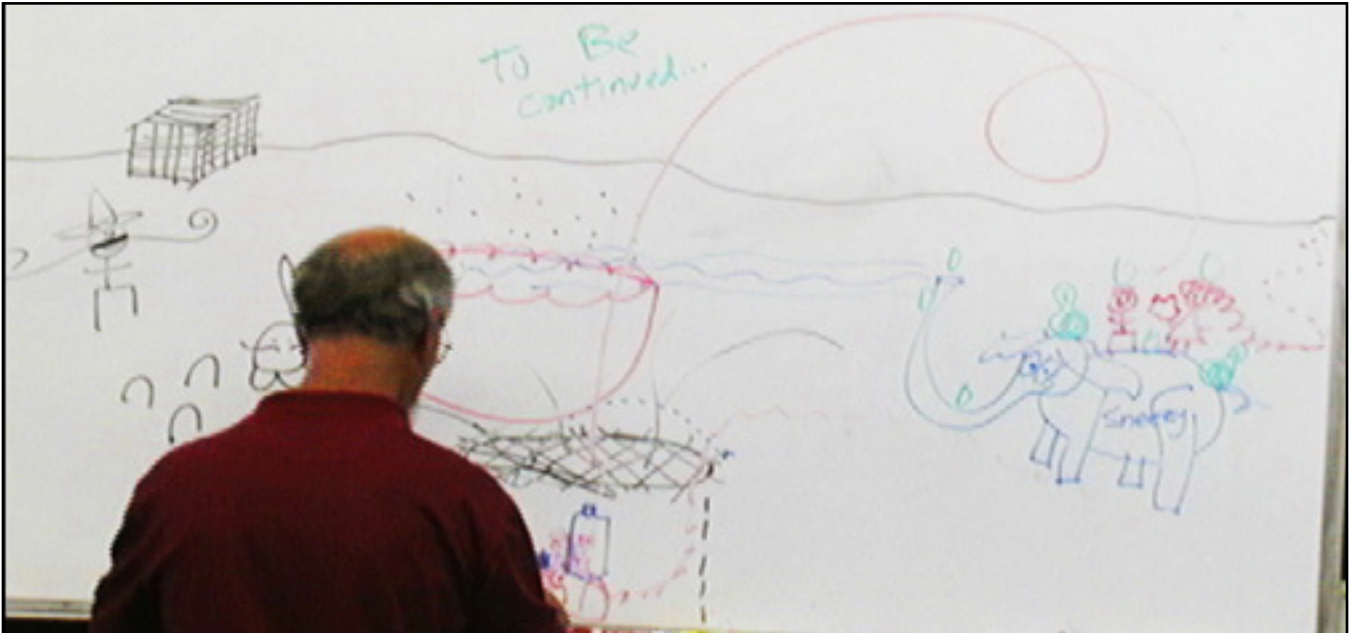
- Bicycle Pump with plastic tubing and plug
- Launch pad
- 2-Liter Plastic Bottles

### Prep Work:

- Inspect bicycle pumps, hoses, etc.
- Construct tubing & cork assemblies
- Construct launch pads  
(see Prep video for instructions)



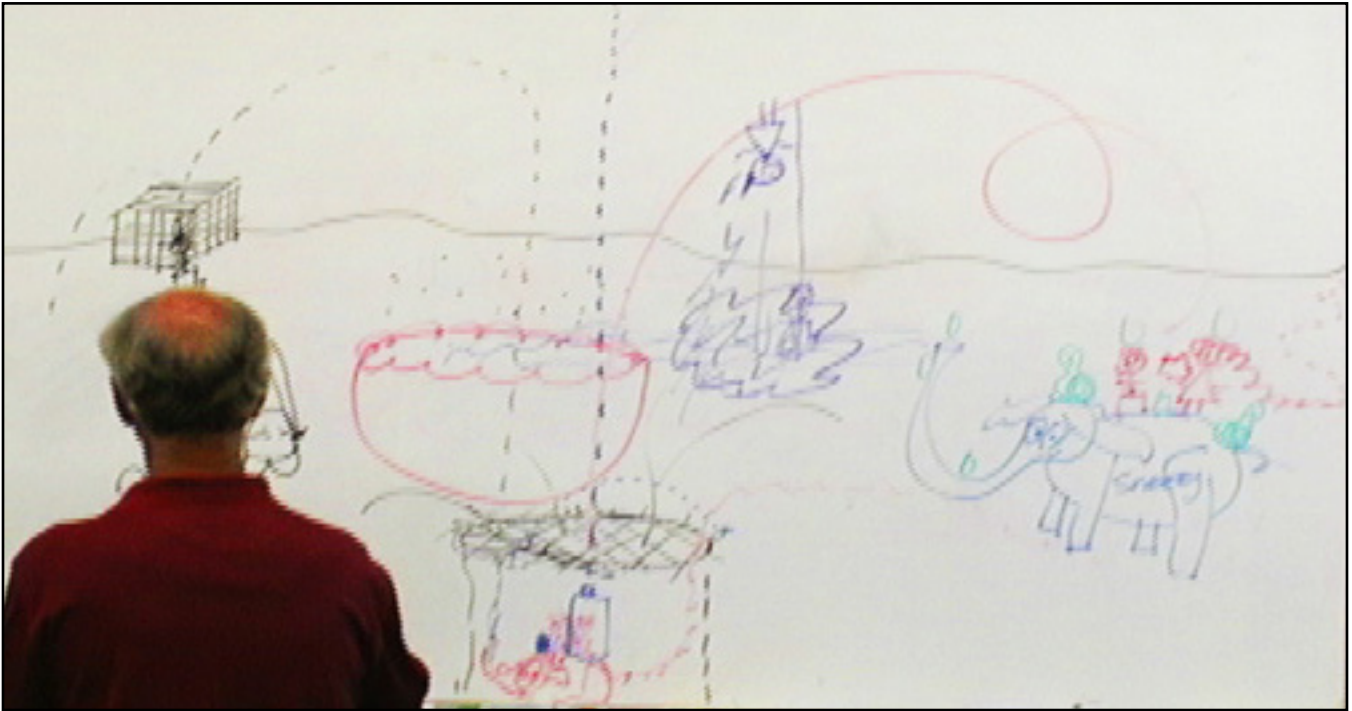
## Story Recap: "Jack and Jill and the Stinky Flower"



### Part 1:

- Evil Mister Fred happens to be in Africa, and his minions are driving him crazy.
- He finds a giant flower that smells really, really bad. He has to put duct tape on his nose.
- He tells the minions to dig a hole with their baseball bats, and they dig a pit twenty feet wide and a hundred feet deep. Then he has them cover it with sticks and leaves to make a trap.
- He called Jack and Jill and pretended to be Livingstone, who was lost in Africa.
- Jack and Jill came to Africa to rescue him. They rode on an elephant named Sneezy because he has allergies. They also brought a bunch of Kick-Mes.
- When they got to Africa, they heard about the stinky flower and decided to go there, even though Sneezy didn't want to.
- Jill ripped off a piece of the flower just before Sneezy smelled it and sneezed so hard he flipped into Evil Mister Fred's trap.
- Jack tried to climb out on Jill's hair, but it was slippery and not attached to anything.
- Jill wrote a message on a Kick-Me and had Sneezy sneeze him out of the hole, but he barely made it past the rim.
- Evil Mister Fred called the Acme Store of Everything and ordered a big cage.
- He told Jack and Jill he was going to put them in the cage, take them to the North Pole, and leave them there in the freezing cold.

## Story Recap (cont.):



### Ending:

- Jill called the Acme Store of Everything and ordered a rabbit with big ears. She climbed on top of the minion and put the rabbit with its ears against the minion's head.
- The rabbit could hear Jack faintly inside the minion, and they moved closer to one ear, and that turned out to be the one Jack was in.
- Jill told Jack to go to the minion's brain. Jack cut a hole in the cochlea and entered a big empty cavern with some lights and sparks in it, and saw the teeny little brain.
- Jill told Jack to squeeze the brain, and when he did, the minion yelled and raised one foot.
- When Jack squeezed the other side of the brain, the minion raised the other foot. By alternately squeezing each side of the brain, Jack could make the minion walk.
- The minion ended up walking back toward Evil Mister Fred's castle and stepped on it and on Evil Mister Fred.
- Jack and Jill kept the giant minion and used it to help them build cities and stuff.

## Transcript: Intro

We're going to do some experiments that relate to water and air pressure and things that fly through the air.

This is the story before the story. This is the science content, the serious science stuff. Once upon a time, there was a portable doorway. You could pick it up and move it anywhere you wanted to go. It had no walls, just a doorway. And the doorway was carried around by an octopus. It's a mean octopus. The octopus would put his doorway out in the middle of nowhere and sit in the middle of it and wait for people to come along. Of course, people would eventually come along, and for some reason, when a person sees a doorway there, they want to walk through it. But the octopus is sitting right in the middle. And he didn't have to wait long. After a few minutes, somebody did come by.

Evil Mister Fred came along and saw the octopus sitting in the doorway. He said, "Hey! Octopus! Get out of that doorway. I want to walk through there." And the octopus said, "Make me." And Evil Mister Fred said, "Fe, fi, fo, fum, if you don't get out of there, I'll huff and I'll puff and I'll blow you away." And the octopus just kind of went, "Eh." And so Evil Mister Fred backed up, ran forward, and tried to kick the octopus. And the octopus was ready for this. People have tried this before. So he bit off his foot. Evil Mister Fred's doing the ooh-ahh-ooh-ahh dance, "Ahh, ahh, ahh, that hurts!" And he couldn't walk very well because he only had one foot.

So he called the Acme Store of Everything. And the Acme Store of Everything is in existence on top of Mount Everest. It's just a door that's floating in midair. If you were to walk around the door, it looks like a door from the front, and from the side, and from the back. But if you grab the doorknob and twist it and pull, the door opens up and there's this enormous warehouse inside. And the warehouse is full of little elves running around, and they have really big ears. And when the elves are in there, they can hear anybody on the entire planet. So when Evil Mister Fred said, "Hey, Acme Store of Everything, I need a new foot! And I need a really big strong one," well, the elves went right over to the shelves, grabbed this big steel bionic foot, and they ran over to the nearest wormhole, which is a distortion in the space-time continuum, and they threw it down into the hole. And it popped out right onto Evil Mister Fred's leg. So now he's got a steel foot, like that.

And Evil Mister Fred said, "Ohh, now we're set. Okay now, octopus, better move out of that doorway." And the octopus said, "Hah! Not by the hair of my chinny-chin-chin!" And Evil Mister Fred said, "Okay."



Evil Mister Fred and the octopus.



Acme Store of Everything



Evil Mister Fred's steel foot.

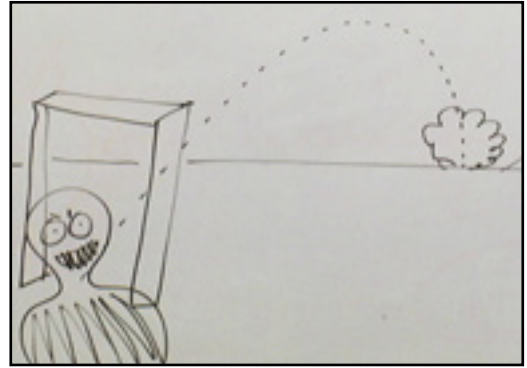
And he backed up, ran forward, bamm! -- and he kicked the octopus as hard as he could. This time the octopus wasn't fast enough, and the octopus flew through the doorway, over the horizon, and foom! And the octopus didn't like this, and he got really mad and came running back. [*Student: How did he run?*] The octopus runs like a wheel, he spins on all eight legs. He came spinning back, and he bit Evil Mister Fred on the other leg and just hung on.

Now, that's science. You've just learned Isaac Newton's three Laws of Motion. First Law of Motion is: If something's at rest, it'll stay at rest. So if the octopus was sitting in the doorway, he'll keep sitting there unless you do something to him, like kick him. So things will stay at rest unless you do something to them. That's Newton's First Law of Motion.

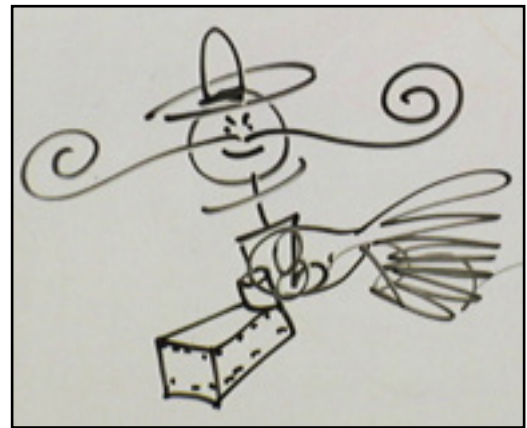
Newton's Second Law of Motion is: When you kick something, the harder you kick it, the higher it goes. And Newton wrote it in a mathematics form, too. He said Force equals Mass times Acceleration ( $F=ma$ ). If you like math, that's the way he did it.

And the Third rule is: For every action, there's an equal and opposite reaction. Because the octopus got mad and came back and bit Evil Mister Fred. That was his reaction.

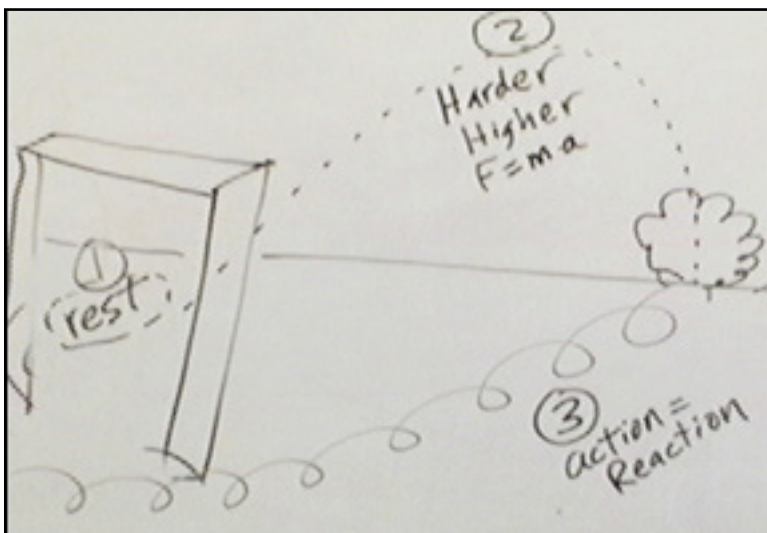
Now, those are the three Laws of Motion. We're going to use them today in our experiments. We're going to try to make something zoom away by doing something to it.



Octopus was kicked over the horizon.



Octopus hanging onto the other foot.



Octopus hanging onto the other foot.

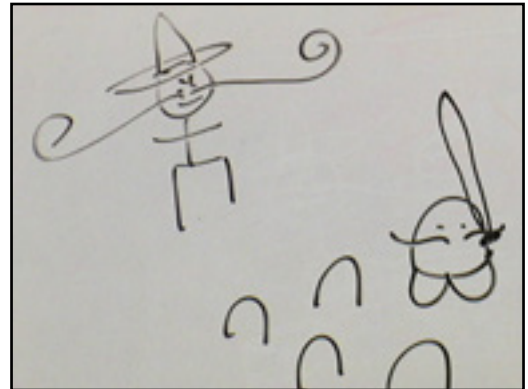
## Story: "Jack and Jill and the Stinky Flower"

Now we can do the real story. Once upon a time, Evil Mister Fred was being driven crazy by his minions. Minions are little guys with big feet, and they have no arms. They've got little mustaches, but their mustaches are very strong, and their mustaches can grab things and hang onto them. And minions always carry baseball bats wherever they go. If you give them swords, they chop each other to pieces, and then Evil Mister Fred has to tape them back together with duct tape. If you give them spears, they stab each other, and then he has to pull out the spears and plug up the holes with corks. Any weapon you give them, they'll hurt each other.

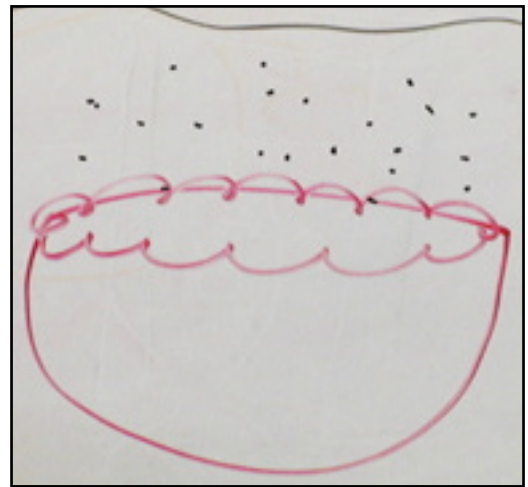
So there are minions all over the place. His minions were arguing with each other and fighting and running around and driving Evil Mister Fred crazy. They're supposed to be a highly organized, deadly army that he's going to use to take over the world. But it's more like a herd of cats. And Evil Mister Fred happens to be in Africa -- deepest, darkest Africa. And he smelled something while he was wandering around -- something that smelled really, really bad. It smelled like ten-day-old dead fish. It smelled like sweat socks that a whole team had used for day after day after day. It smelled like sewage. All in one. But it was packaged in the world's most beautiful huge flower. Big giant flower full of stinky, stinky smell. It's so stinky that flies came from all over Africa just to visit it. There are flies everywhere, flying around.

When Evil Mister Fred got there, he had to put duct tape on his nose because it smelled so bad. And his minions said, "Boss, it stinks! I'm gonna throw up!" And Evil Mister Fred said, "If you throw up on my shoes, you'll be in trouble." And in order to keep his minions busy, he said, "Okay, minions, what I want you to do is dig a deep, deep hole by the stinky flower." And the minions said, "Boss, we can't dig a hole. You won't let us have shovels." And Evil Mister Fred said, "Just dig a hole. Bang on the ground with your baseball bats. I don't care. Make a deep hole."

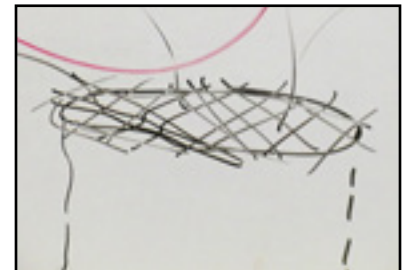
And the minions started fighting each other, trying to decide how they're going to do this. And they created a huge amount of commotion, and dirt was flying everywhere, and before you knew it, there was a hole twenty feet wide and a hundred feet deep. Minions were flying out everywhere, they were all fighting with each other. And Evil Mister Fred couldn't believe his eyes. "They actually dug a hole! It's a really big hole!" So he says, "Okay, minions, now cover it up." And the minions said, "Awww, we just dug it. We don't want to cover it up." And Evil Mister Fred said, "No, cover it up with giant leaves."



Evil Mister Fred and his minions.



The giant stinky flower and flies.



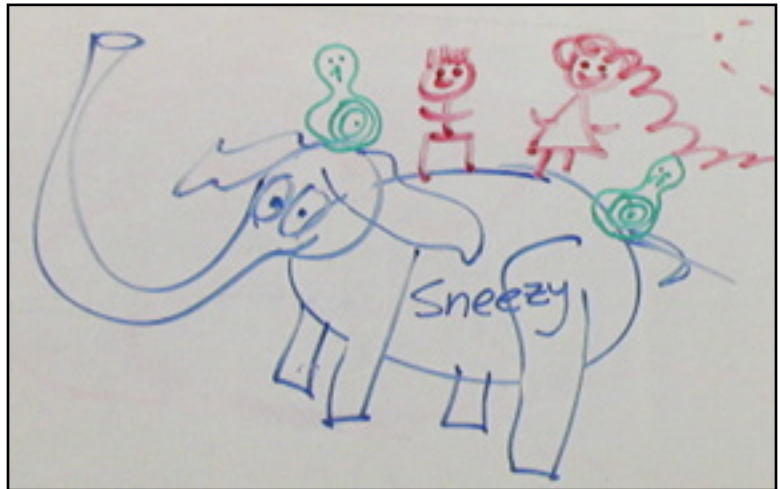
Hole covered with leaves & sticks.



So they went through the jungle and they found giant leaves and they laid them across the top of the hole. And sticks. And snakes. And they covered up the top of the hole with this flimsy cover. Now it's a trap. And Evil Mister Fred said, "Mwah-ha-ha! I like this! We've got to use this trap." So he got on his cell phone and he called Jack and Jill. He pretended like he was a famous guy, like Livingstone. He says, "Hi! I'm Mr. Livingstone. I'm lost in deepest, darkest Africa. Come and find me and save me." Click. He hung up. And Jack and Jill said, "Oh boy, we've got a job to do. We've got to go find Livingstone."

So Jack and Jill took off and went to Africa. And they hired a transportation service so that they could get around where there weren't any roads. There. They found an elephant. His name is Sneezy, and he's got allergies. And Jack and Jill are riding Sneezy in search of Livingstone. And they brought along with them a whole bunch of their friends, too. Their friends are called Kick-Mes. And Jill's hair is infinitely long.

And the Kick-Mes are always sad unless you kick them. They have a target on their stomach where you're supposed to kick them. And they're indestructible. If you kick a Kick-Me into an airplane propeller, he'll get turned into Kick-Me potato chips. And then they'll all form back together to make a Kick-Me again. If you kick him into a fire, he'll burn up. And then the smoke will all come back together and he'll be a Kick-Me again. And Jack and Jill have a whole bunch of Kick-Mes they brought along.



Jack & Jill and their Kick-Mes riding on Sneezy.

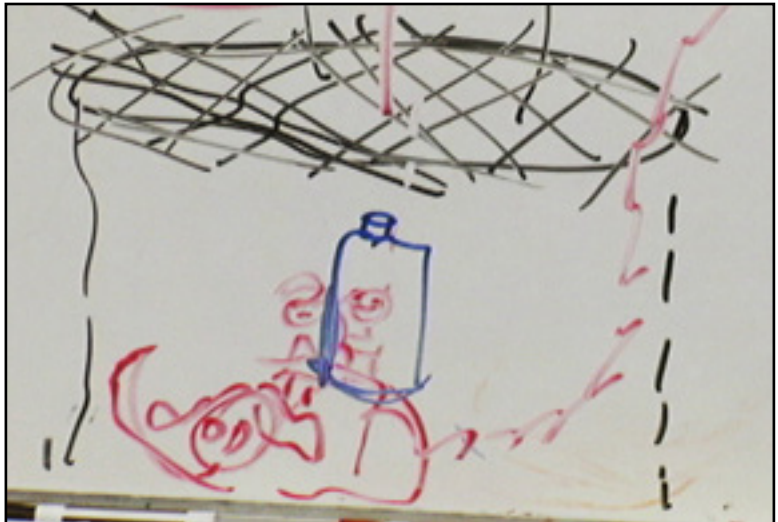
And when Jack and Jill got to Africa, they were in search of Livingstone, but they also heard that there was the world's biggest, stinkiest flower there. They said, "Oh, we've got to go see that!" And Sneezy says, "No, we don't! We don't have to go see that. I'm allergic to flowers. We'll stay away from that." Jack and Jill said, "Oh, we'll just see." Well, it didn't take them long, because the smell of the flower was so strong the wind carried it along, and Sneezy could smell it. He said, "Whatever you do, don't go that way!" And Jack and Jill said, "Okay, we're going that way!"

And then they got to the flower. And when they got there, Sneezy says, "Oh, please, don't make me get any closer!" And Jill said, "Just a little bit. I want a piece of it." So Sneezy had to hold his breath, and he came up and Jill ripped off a piece of the flower, and she was holding it in her hand. And then Sneezy had to breathe. He went, "Ahhhhhhh-ehhhhhh!" And he didn't know whether to throw up or sneeze. But he sneezed first. And he went, "Ahhhhhhhhh-chooooo!" He sneezed so hard, he did a double back flip and ker-plop -- right into Evil Mister Fred's trap. Ahhhhhh-splat! A hundred feet deep.

So Sneezy's way down in the bottom of the hole, and there are Kick-Mes down there, Jack and Jill are down there, everybody's down in the hole. And Jack and Jill said, "Uh-oh. How are we going to get out of here? This thing's a hundred feet deep!" And Jill said, "Well, we'll just climb up my hair." And Jack said, "Okay." So he tried to climb up Jill's hair, but it's all slippery and it wasn't attached to anything.

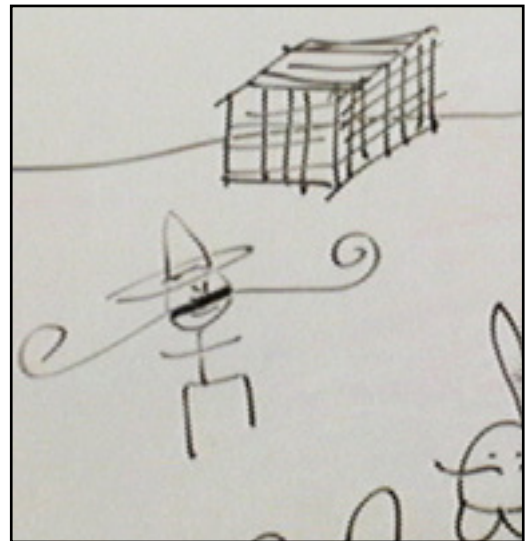
He said, "Oh, man." And they looked around, and Jack had in his backpack some water. And Jill said, "I've got an idea how we can get out of here. We'll send a message. A message in a bottle!" But Jack said, "We don't have an ocean to throw it into." Jill said, "That's okay."

She grabbed one of the Kick-Mes and wrote a message on his stomach: "Help! Save us. We're trapped in a deep pit out here in Africa," and stuffed it in the elephant's trunk. Then she waved the flower by the elephant, and the elephant went, "Ah-ah-ah-choooo!" -- and shot the Kick-Me out. And he just barely made it out of the hole. And Jack and Jill said, "Uh-oh. That's not going to work very well."



Jack & Jill and Sneazy in the hole with Jack's water bottle.

Now, Evil Mister Fred said, "Whoa! I don't believe it. This is great! I caught Jack and Jill and some dumb elephant." So he called the Acme Store of Everything and he ordered a great big cage. And Evil Mister Fred ran over to the hole, looked down and said, "You guys stay right there. I'm going to go get a big old cage and I, being such a nice guy, am going to help you out of this hole, and then I'm going to put you in the cage. And then I'm going to take you to the North Pole, set you on some ice where it's forty degrees below zero, the wind is blowing, there's nothing to eat, and there's no shelter. I'm going to leave you there for the rest of your short, worthless little lives. Mwah-ha-ha!" And he ran off to get the cage. Now, if you were Jack and Jill, and you're trapped in the bottom of a deep, deep hole, what would you do?



Evil Mister Fred's cage.

## 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: "Water Bottle Rockets"

We're going to do an experiment. The experiment involves a bicycle pump and a cork and a bottle. And if you put the cork in the bottle and then you pump the pump, the pressure goes in the bottle. *[Pumps air into the plastic bottle with the bicycle pump until it pops off and flies through the air.]* The objective is to make the bottle go as far as you can. And there's going to be some stations set up out there so you don't have to hold the cork. There's plastic things, and you put the cork on there. If you put the cork on the bottle first, it's easier. Then you can set it like that. And this is kind of neat, because you can make it so it points almost straight up. Or you can slide this forward and you can make it tilt at an angle. And you can go pumpy, pumpy, pumpy, pumpy, and pshhhhhhhh! -- away goes the bottle!

The way we're going to do it is, there'll be some stations about ten feet apart, and you'll be taking turns pumping and shooting bottles off. And now, after you shoot your bottle off, we're going to make you a criminal. Because you're going to leave the bottle laying there on the parking lot. That's littering. And the police could come and put handcuffs on you and take you away for littering the parking lot. And after we use up all the bottles, I'll say, "Cease fire!!" And if you've got a bottle you've been pumping up and pumping up and it's just ready to go, you don't get to pump anymore. You have to go up to it and loosen it, and it'll go pshhhhh -- and set it on the ground. And after all the bottles are on the ground, then we'll say, "Go get the bottles!" And you'll all run out there and grab as many bottles as you can and bring them back. And you'll un-criminalize yourselves because you'll pick up the bottles. And then when all the bottles are back and everybody's behind the firing line, we'll say, "Resume firing!" and then you shoot bottles.

At first, you're just going to have air in your bottles, and then, after we fill up the buckets, we'll say, "It's water time!" And then you can add water to the bottles and see if that makes any difference. So in this case of Newton's Law, the action is water or air squirting out that way. The reaction is the bottle going that way. So you need to choose someone to work with. You're going to choose a partner.

*[Students partner up and go outside, where the launching stations are set up. They mount plastic soda bottles on the*



Bottle, bicycle pump, and launch pad with rubber cork in place.



Bottle mounted on cork and launch pad set at an angle.

*launchers and pump them full of air until they launch. Later, they get to submerge the bottle in a tub of water in order to get some water inside the bottle. They then pump it up and fire it, trying different amounts of water and different launch angles to see what works best.]*



Launching bottles first with just air (above), then with air and water (below).



[Back inside the classroom] When you were shooting the bottles, did they go furthest when they had just air in them? [Students: Water and air.] For those who think water made it go further, did it go furthest with that amount of water in it? [Indicates various water levels.] Did it go furthest with that amount of water in it? Did it go furthest with that amount of water? Did it go furthest with that amount of water? Did it go furthest with that amount of water? Did it go furthest if it was tilted straight up? [Students: No.] Did it go furthest if it was tilted flatways? [Students: No.] Did it go furthest if it was tilted halfway between straight up and flatways? [Students: Yes.]

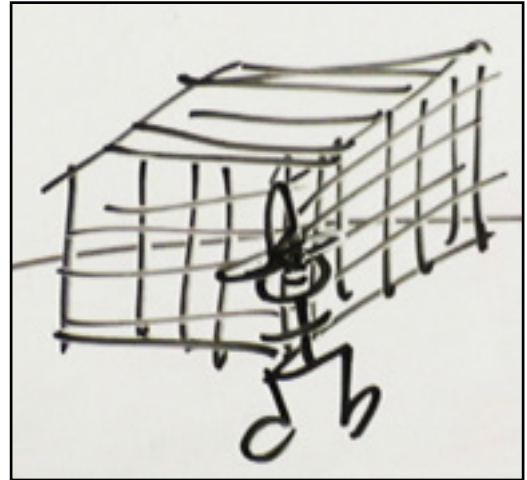
## End of Story

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

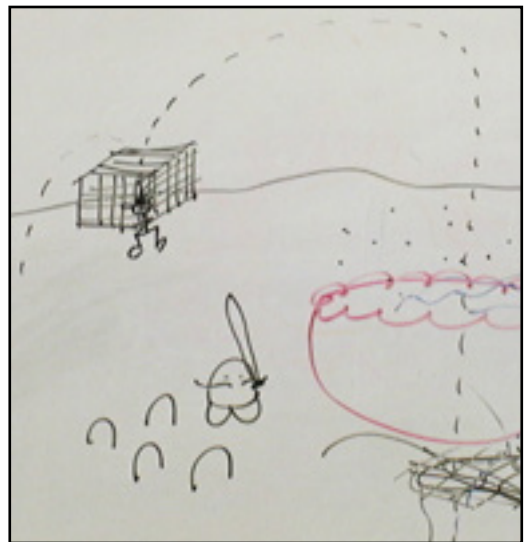
Now, where were Jack and Jill when we left them? [Student: In the hole.] Down at the bottom of the hole. What did they have with them? [Students: A water bottle. A giant elephant.] Water bottle, elephant. And some Kick-Mes. And Evil Mister Fred is running back, and he's got the cage on top of his head. It's easier to carry that way. So here he is, running back to catch Jack and Jill.

And Jack and Jill said, "Well, we've got to make those Kick-Mes go further -- quickly!" So Jill took one of the Kick-Mes, put in just about one-third full of water, stuffed him in the elephant's trunk, waved the leaf by the elephant's face, and the elephant sneezed. "Ahhh-boom!" And the Kick-Me shot way up into the air and bounced off the cage -- boing! -- like that. And Evil Mister Fred said, "Huh! They're trying to send a message. Well, they'll never get here in time. Ha, ha, ha!" And as he was running forward, Jack and Jill said, "We'd better do something quick, and something dramatic."

So they said, "Sneezy, do a headstand." So Sneezy stood on his head. And Jack and Jill hung onto his ears. And the Kick-Mes stuck all over Sneezy. Then they waved the leaf by Sneezy's face. And Sneezy says, "Oh, no! Ahh-ahh-ahhchoooooo!!!" And Sneezy sneezed the biggest sneeze ever heard on the earth. And Sneezy and Jack and Jill shot up into the air one hundred thousand feet. It was so high in the air that when Jack and Jill looked up, all they saw was black. The blue was gone. They could see little stars out there. They looked down and they could see the curvature of the earth and little squares and things where the farmers were growing their crops. And they looked at each other and they said, "Oops!"



Evil Mister Fred with the cage on his head.



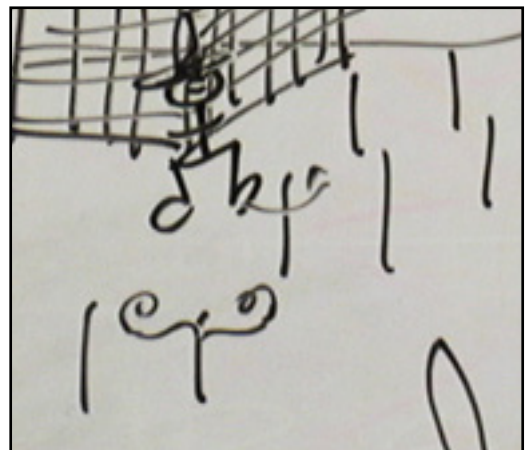
The Kick-Me bounced off the cage.

And then they started to fall -- "Ahhhhhhhhh!" And Jill said, "Well, as long as I'm falling, I might as well have a little fun!" So she was doing some somersaults, and spinning around. And Jack said, "Well, we've got one chance. Start growing your hair really fast!" So Jill started growing her hair infinitely fast. And she made it fall faster than them, until there was a nice pad of hair on the ground. And Jill came down head first, and her hair's going down like this, and ka-boosh! Nice soft landing in the hair. And Jack came down -- "Yaaa!" -- sploosh! He bounced off, perfectly fine. And Evil Mister Fred said, "Ha! They'll never get away."

And Evil Mister Fred forgot that there was something else up in the sky. And as he was running forward with the cage on his head, he saw a big shadow around him. He said, "What an odd shadow." And it just occurred to him -- the shadow has a long snakey thing coming out of it. And about that time, Sneezy hit the top of Evil Mister Fred's cage -- ka-boom! And it cut Evil Mister Fred into french fries. Sneezy bounced off and went running away. Then you have all these french fried pieces of Evil Mister Fred, each one having a mustache, running around making squeaky sounds. And then it started raining Kick-Mes. And everybody lived happily ever after, except Evil Mister Fred.



Jack & Jill landed on a pile of Jill's hair.



Evil Mister Fred turned into french fries.

## Home Experiment:

Now, if you want to do this at home, you have to find a parent that hasn't been to the class, or some other unsuspecting adult. And you get a bicycle pump. And bicycle pumps, when you buy them, come with a needle that you use to fill up soccer balls and basketballs. And you go down to a science store [and buy a rubber cork]. And you put the cork on the needle.

Now you can pump air. And you can put a bottle on it, but you don't have a launch stand. So sad.

So you take one of your parents outside and you have them sit on the ground. And you have them hold the cork in their hands. Make sure there's a lot of water in it. And you say, "This is all for science! You'll love this! This'll work great!" And you go pumpy, pumpy, pumpy, pumpy, pumpy, pumpy, pumpy. And they say, "Are you sure this is okay?" And you say, "Oh, it's fine! Don't worry about a thing." Pumpy, pumpy, pumpy, pumpy, pumpy, pumpy -- booozzhhh! -- and they're covered with water. Science can be fun, as long as you have somebody that doesn't know what you're doing.



Insert the needle through the small hole in the rubber cork.



Have your parent hold the cork while you pump.

### *End of Lesson*

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