



Teacher's Guide for:

Water Powered Rocket Cars

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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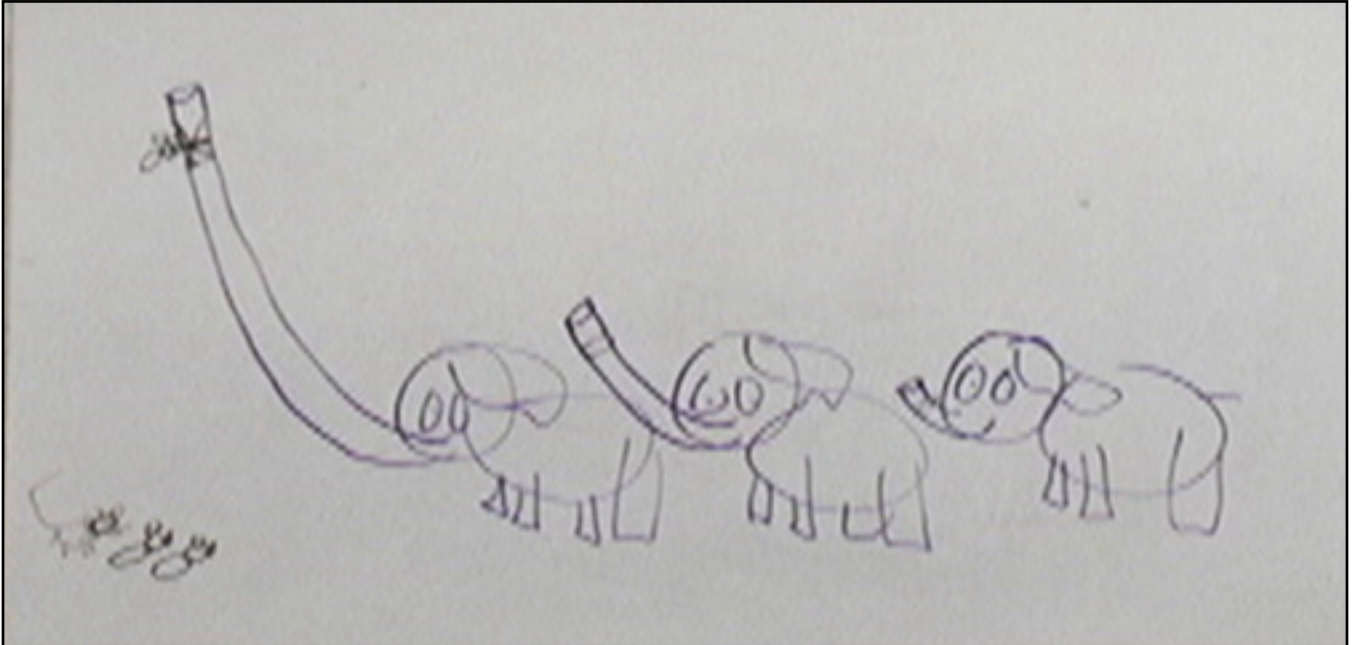
Water Powered Rocket Cars
A Rock-it Science Lesson
Filmed June, 2012

Rock-it Science

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Intro Quick Recap:



- You have three elephants. They each have different size noses: one short, one medium, one very long.
- A mouse is coming. When the elephants see it, they scream in terror through their noses.
- They blow with such power that they could blow themselves backwards.
- The mouse has two buddies, and they each climb onto an elephant and squeeze its trunk closed. Then they let go of it all of a sudden.
- Which elephant will shoot backwards the fastest?
- Have the students vote, and record the numbers on the whiteboard.

Experiment Quick Recap: "Water Powered Rocket Cars"

Part One: Demo -- How to assemble the rocket car

- Instructor demonstrates how to assemble and shoot the rocket car.
- Show the bicycle pump with a cork attached to the end of the tube.
- Start with a plastic bottle that has a short length of plumbing pipe attached.
- Show students how to add two more pieces of pipe.
- Show how to attach the wheels using a rubber band.
- Show how to insert the cork into the pipe, pump air into the bottle, and launch it.
- Tell students that when they go outside, they'll find tubs of water, cups, and funnels so they can add water to their bottle.
- Caution students about running out to retrieve their bottles. They need to watch out for other students who are shooting theirs.



Bottle with all three pipes attached.

Part Two: Students assemble and shoot their rocket cars

- Students work in teams of two. Each team gets a pump and a bottle with a short pipe on it.
- First they shoot the bottle with just air in it, then they add water.
- After awhile, the Instructor passes out a medium-length pipe to each team, and they attach it to the end of their short pipe and continue shooting.
- Finally, the Instructor passes out the long pipes, and the students see which length of pipe makes the bottle go the farthest.



Water blasts out the back as the bottle zooms forward.

Equipment List: "Water Powered Rocket Cars"

Items needed for Instructor:

- Large plastic tubs for water, two or more, depending on number of students.
- Plastic funnels, four per tub.
- Cups, plastic, 16-oz., four per tub.

Items needed for Students:

Consumables:

- Water

Other (per 2 students):

- Bicycle pump with vinyl tubing extension and #4 rubber stopper (see Prep box at right)
- 2-liter plastic bottle with 6" PVC pipe and 1/2" plumbing fitting attached (see Prep box at right)
- Wheel assembly with large rubber band (see Prep box at right)
- 12" PVC pipe with 1/2" plumbing fitting attached
- 24" PVC pipe with 1/2" plumbing fitting attached

Items needed for Wheel Assembly Prep

(See page 5 for instructions):

- Two sets of plastic pulleys with metal brackets
- Electrical tape
- Crazy Glue

Items needed for Cap Assembly Prep

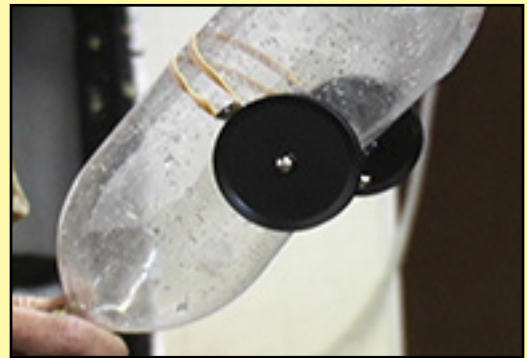
(See page 6 for instructions):

- 1/2" PVC pipe, 6" long
- Balloon
- Rubbing Alcohol
- Bottle cap with 7/8" hole in top
- 1/2" PVC plumbing fitting

Prep Work: Also see this lesson's Prep video at <http://rockitscience.com/water-poweredcarsvideo/>

For instructions regarding the bicycle pump, see the Prep video at <http://rockitscience.com/waterbottlerocketsvideo/>

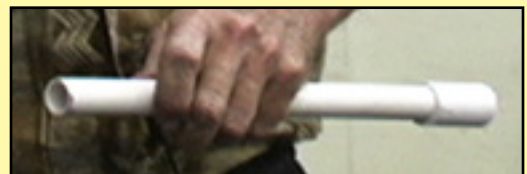
- Build the wheel assemblies (p.5):



- Attach a short pipe to each bottle, using a cutoff balloon as a seal, then attach the cap (p.6).



- Slide a 1/2" plumbing fitting onto one end of each piece of PVC pipe, including the one attached to the bottle.



Equipment Prep: Wheel Assembly

***Please Note:** This is how we did it, but you don't need to make your wheels this way. Just nail some jar lids to a stick. Any lightweight wheels will do.



1. Remove plastic wheels from pulley bracket by removing screws. Use only large wheels.



2. Twist and bend hooks to remove them from ends of pulley bracket. Then bend bracket as shown.



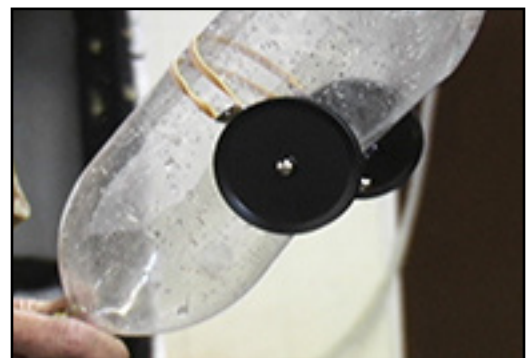
3. Combine two brackets and join them at the center with a screw.



4. Put Crazy Glue on screw before screwing on wheels, to keep it from shaking apart.



5. Finished wheel assembly, with screw in center and electrical tape wrapped around the overlapping of the brackets.



6. Hook a large rubber band around the ends of the bracket to attach wheels to bottle.

Equipment Prep: Pipe and Cap Assembly



1. Stretch the neck of a balloon over the end of the 6" PVC pipe and cut off the balloon.



2. Make $7/8$ " hole in bottle cap so it can slide over the pipe.*



3. Spray rubbing alcohol on the balloon.



4. Insert end of pipe in neck of bottle so the threads cover the balloon. Then screw the cap on.



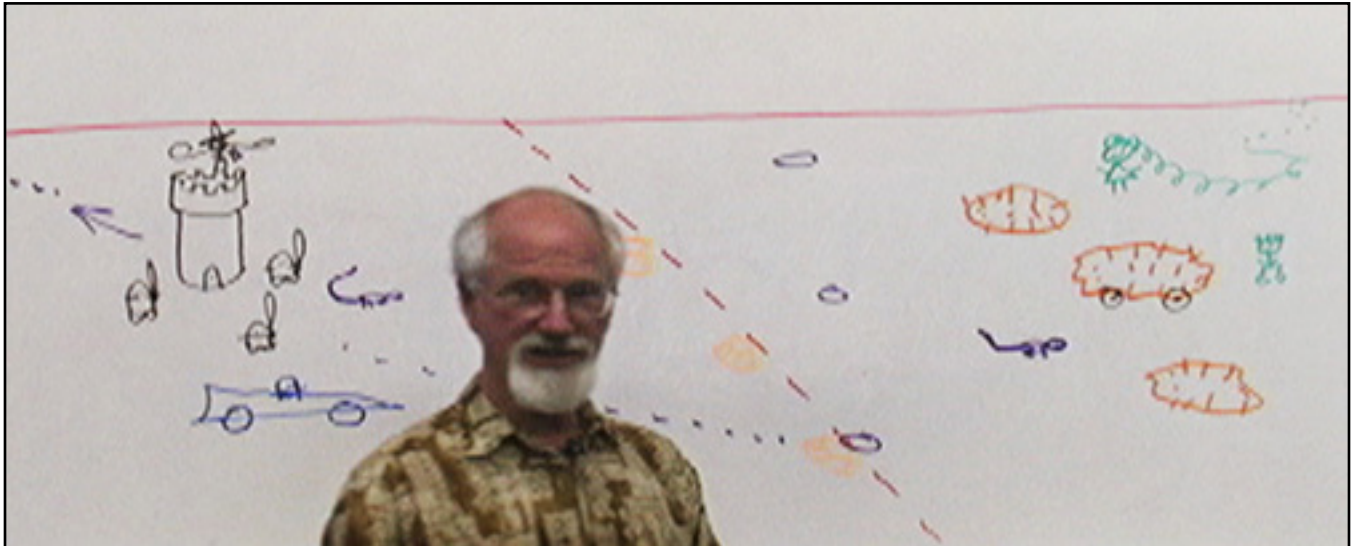
5. Slide a $1/2$ " pipe fitting onto the other end of the pipe so you can insert the cork.

*Please Note:

It's difficult to drill the hole in the bottle cap, and we only do it this way because we need to be able to disconnect the bottles and use them later for other experiments.

The easier way is to just put some Gorilla Glue on the pipe before you insert it into the bottle. This will attach it permanently, and you don't need to use the balloon or the bottle cap.

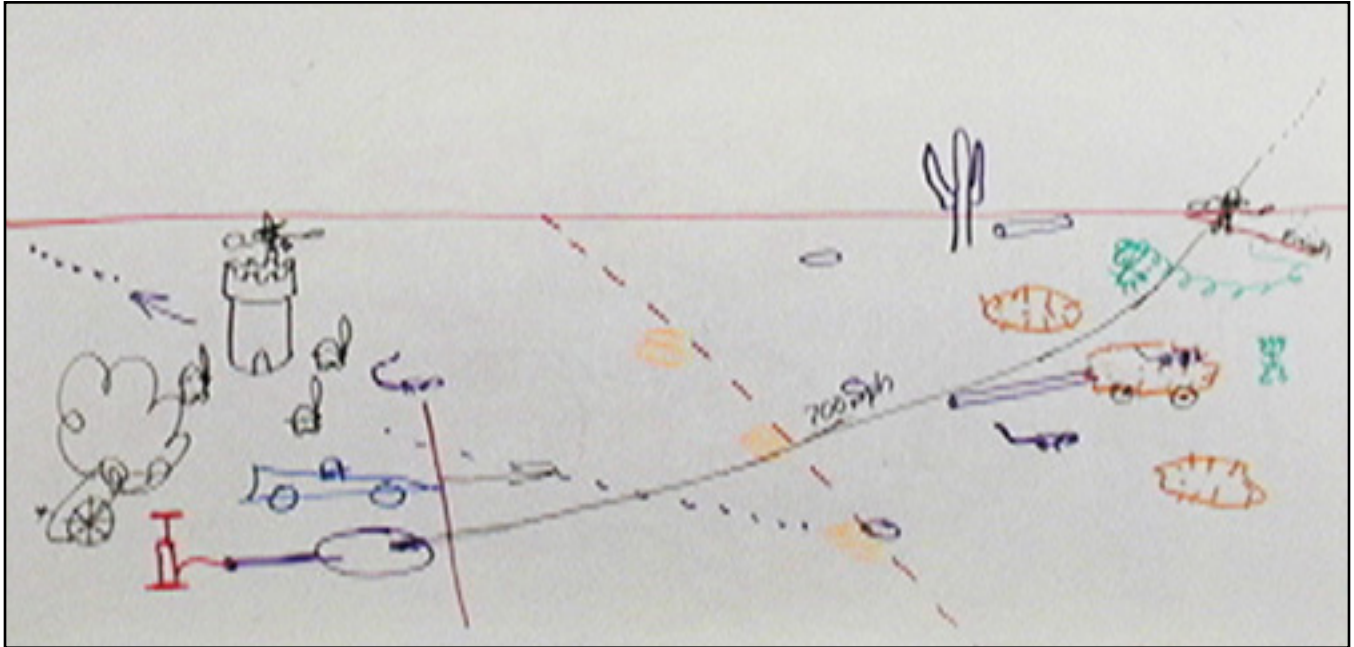
Story Recap: "Puffer Fish in the Desert"



Part 1:

- There was a desert made of strawberry cake with a line drawn through the center of it.
- On one side was Evil Mister Fred, his castle, and his minions.
- On the other side were Jack and Jill and some desert puffer fish they were studying. They discovered that the puffer fish liked to eat lizards and strawberry cake (the ground).
- Evil Mister Fred built some battery-operated robotic lizards to fool the puffer fish so they'd eat the fake lizards. He uses a remote control to direct them to where the puffer fish are. When the puffer fish eat the fake lizards, the chemicals in the batteries make them get sick.
- Jack and Jill are digging around to find other things that the puffer fish might like to eat -- ants, cockroaches, crickets. But they would only eat lizards.
- While digging, Jack and Jill discovered a pot of gold that had been buried under the dividing line when leprechauns lived there thousands of years ago.
- When they started talking about the gold, Evil Mister Fred overheard them. He sent his minions to find it, but Jack and Jill had already covered it up.
- Evil Mister Fred thought of a way to get Jack and Jill to dig up the gold and give it to him.
- He built a radio-controlled racecar, put a minion in it, and made it drive around where Jack and Jill would see it. He challenged them to a race.
- Jack and Jill said they could beat Evil Mister Fred's car even if they just used dirt and sticks.
- They made a bet to race for a pot of gold.
- Since Jack and Jill said they could make a racecar out of whatever was lying around, they found some old tires in the desert and attached them to a puffer fish. But they needed a way to make it go really fast.

Story Recap (cont.): "Puffer Fish in the Desert"

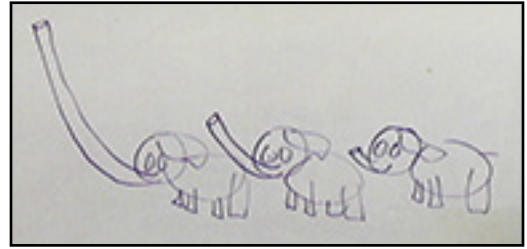


Ending:

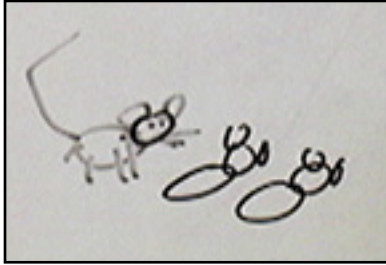
- Jack and Jill put wheels on a puffer fish and put a lizard on top to steer.
- They found a dead cactus and used one of its hollow branches as a pipe. They attached it to the puffer fish, like the pipes on the bottles in the experiment.
- They used a bicycle pump to pump the puffer fish full of air.
- Evil Mister Fred went to the Finish line to make sure he could judge the race.
- He set up a remote-controlled cannon at the Starting line and fired it to start the race.
- The puffer fish was puffed up really large, and it was very light, so it took off a lot faster than the race car -- about seven hundred miles per hour.
- The lizard wasn't very good at steering, so when it got to the Finish line, the puffer fish hit Evil Mister Fred right in the face. He went flying through the air with a puffer fish stuck on his face.

Transcript: Intro

Imagine you've got three elephants. Here's elephant number one. Here's elephant number two. *[Student: Where's his nose?]* He doesn't have a nose. A no-nose elephant. And here's elephant number three. And they have no noses. And let's suppose that this elephant has a nose that size. And this elephant has a nose this size. And this elephant has a nose that size.



Three elephants with different sized trunks.



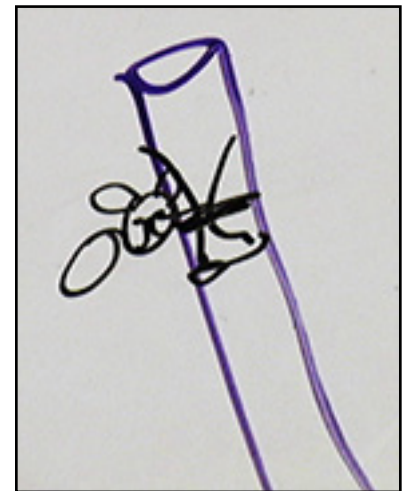
Three mice.

And over here, approaching the elephants, is a mouse. And the elephants don't know the mouse is coming yet. And then, as soon as they see the mouse, they scream in terror through their nose *[makes a noise like an elephant]*.

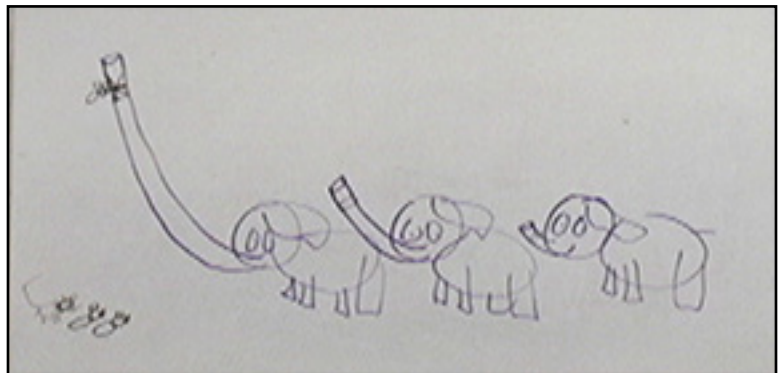
And they do it with such power that they could blow themselves backwards. Jet-powered elephants.

And the mouse doesn't help, because the mouse has two more buddies. And they jump up on the elephants and squeeze the ends of their trunks closed. These mice are playing games. They squeeze the trunk closed, and then they let go of it all of a sudden. Squeeze. Squeeze.

Which elephant do you think will shoot backwards the fastest? *[Students: The big one!]* The big one. How many vote for the big one? How many people vote for the middle one? How many people vote for the little one? *[Instructor records the votes on the whiteboard.]* Okay, so almost everybody, a bunch of people, voted for the one with the long trunk. Well, we've got to find out, right? We can't just let this kind of a question go. And we're going to do that in our experiment. But first, we need a crazy story.

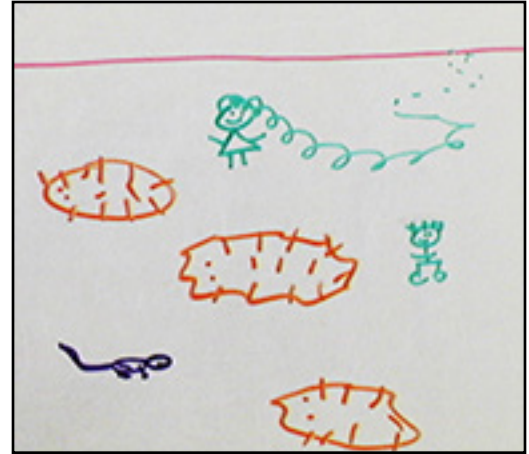
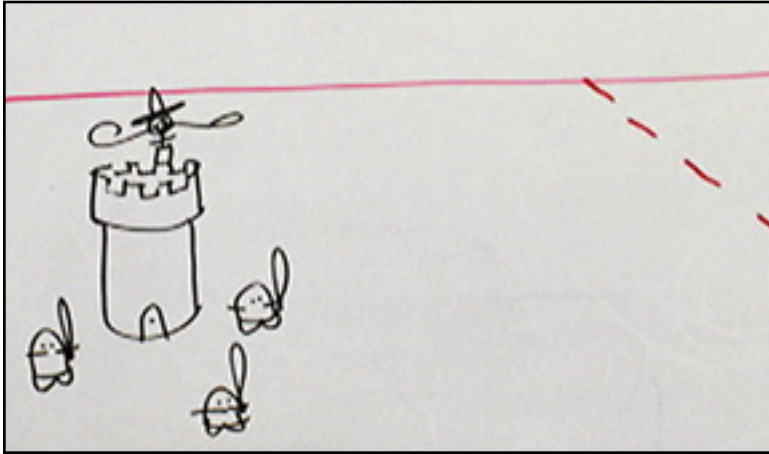


Mouse squeezing trunk.



Mouse on elephant's trunk.

Story: "Puffer Fish in the Desert"



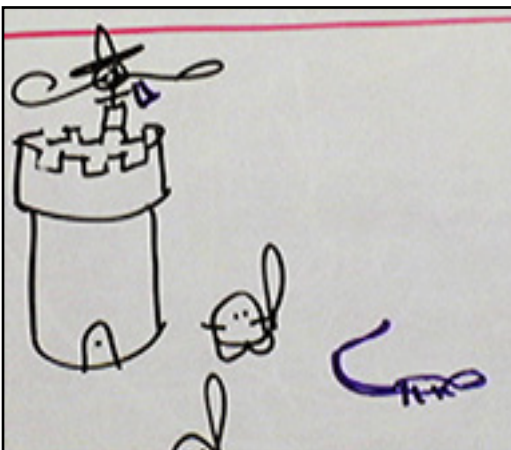
Evil Mister Fred on one side of the line, puffer fish on the other side.

Once upon a time, there was a desert made out of strawberry cake. It was a dessert desert. And there was a line somebody drew down the middle of it. There. On one side was The Evil Mister Fred and his castle. His castle is made out of dirt. There's some minions.

Over on the other side, Jack and Jill are raising desert puffer fish. But they're un-puffed. There's a puffer fish. And puffer fish are spikey. They're kind of like the sea's version of a porcupine. And these puffer fish eat lizards. And they lay on this ground and they cover themselves with sand so you can hardly see they're there. And they wait for a lizard to come by. When a lizard comes by, the puffer fish goes [*makes a sucking sound*], and sucks them in. Just boom! -- lizard disappears.

So if you had a lizard coming by here, he would be unsuspecting. Lizard's coming along, walking along minding his own business. Next thing you know, boom! -- he's in a puffer fish's stomach.

And Jack and Jill have been examining these puffer fish because they'd never heard of desert puffer fish before. And they're out there watching to see what the puffer fish eat and what they do for fun. Puffer fish like strawberry cake. They eat the ground that's made out of strawberry cake. Now there's Jill. Let's put Jack out here, too.



And Evil Mister Fred wants to steal some puffer fish, or at least cause Jack and Jill problems. So Evil Mister Fred has been making some robotic lizards over here. He's got a remote control, and he's got some lizards. And he wants to see if he can make the puffer fish have indigestion. So runs his lizards over there, and the puffer fish eat them. And there's batteries in the robots. Ever eat a battery? Oh, it'd make you really, really sick. You might even die. And he's running these lizards over there, causing problems for Jack and Jill.

Evil Mister Fred with remote control and lizard.

And both of them don't know that right under this line there's buried treasure. Some leprechauns used to live here thousands of years ago, and they left pots of gold under the ground. There used to be a rainbow that was always here. The rainbow's gone now. Only the gold is left.

And Jack and Jill are trying to find what sort of food the puffer fish eat. So they bring all sorts of things. They brought some ants to them, they brought some cockroaches to them, they brought some crickets to them, to see what they would eat. They even brought them a teddy bear. But they only ate lizards.

While investigating for food, Jack and Jill had to dig holes here and there. They went out and they dug holes. And Jill just happened to dig a hole right where one of the gold treasures was. And she says, "Whoa! Treasure!" And Jack ran over there and said, "Oooh! Solid gold coins! This is great!"

Well, whenever you say the word "gold," and Evil Mister Fred is within a thousand miles, he'll hear it. And he heard Jack say, "Oooh, gold!" His ears perked up and he said, "What was that? Did somebody just say gold? Huh! Minions, go find it!"



Holes and pots of gold.

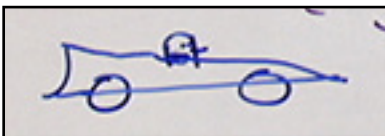


Minions run in different directions.

So the minions all started running that way. And Evil Mister Fred said, "Nooo! Minions, go the other way!" So they turned around backwards and started running that way some more. And he says, "Arrrrghh!" And the minions finally did go this way.

And Jack and Jill by that time had covered up the ground so the gold was still hidden. And they said, "Hi, minions! What's up?" The minions said, "Got any gold?" And Jack and Jill said, "Nope! No gold here." The minions said, "Okay," and ran away.

Now, Evil Mister Fred knows that Jack and Jill found gold, because he saw the minions run over there, he saw Jack and Jill trick his minions, and he said, "Ahhh, I'm going to get that gold. But I've got to trick them first. Because, you know, I could just take it, but that would be too easy."



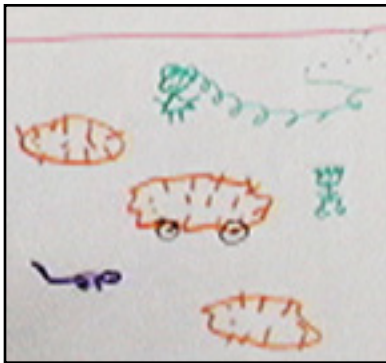
Race car with minion inside.

So he thought, "What would be a good way to get all of Jack and Jill's gold and make them dig it up and hand it to Evil Mister Fred?" That way he doesn't have to do any work. So he says, "Ahhh, I'm brilliant. I'm smart. And I'm clever. I know what I'll do." So he called the Acme Store of Everything, and he ordered a racecar. There. Racecar. Really fancy

race car. And he put some minions in there. He gave them race car helmets. There. But it's a radio-controlled race car, so the minions don't get to drive. And he drove it around.

And Jack and Jill said, "Uh, Evil Mister Fred, why do you have a race car?" And he says, "Oh, because I'm really good at racing." And Jack and Jill said, "Oh, yeah?" And Evil Mister Fred said, "Yeah, and I can beat you. I don't care what you use for a race car. I'll beat you."

And Jack and Jill said, "Well, I don't know about that. We can make a race car out of dirt and sticks that'll beat your race car." And Evil Mister Fred said, "Well, all right. Put your money where your mouth is." And Jack and Jill said, "Well, what do you want to bet?" And Evil Mister Fred said, "Uh, let me think. How about a big pile of pure gold?" And Jack and Jill said, "You're on!"



Tires on puffer fish.

So now Jack and Jill have to make a race car. And they're out there, and they already told him they were going to make it out of stuff that was just laying around. So they said, "We're going to make a race car out of puffer fish." So they found some old tires in the desert, and they fastened some tires to a puffer fish. There. Now, if you were Jack and Jill, and you wanted to make a puffer fish go really fast, how would you do it?

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 Powered Rocket Cars"

Part One: Demonstration



Cork from bicycle pump attached to pipe.

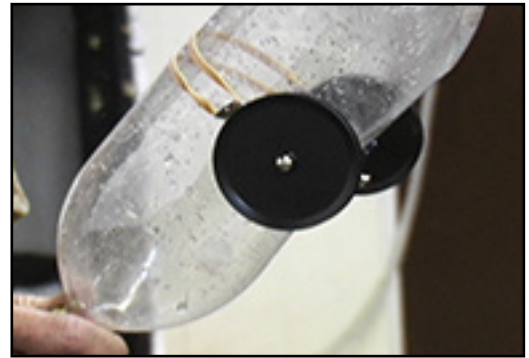
But it's not a rocket yet, at least not a car rocket, because no wheels. Right? Got to have wheels. Wheels. We can put a rubber band over the top. Now it's got wheels.

So we can take it over here in the aisleway, and we could pump it up. *[Instructor attaches bottle to bicycle pump and pumps it until the bottle flies off.]* And it goes. Now, it didn't go very far. It only went about ten feet. We want it to go further.

We have a bicycle pump. So we'll unwind it. And it's got that good cork on there. Luckily for us, the cork fits into the kind of fittings that they use for plumbing fittings, half-inch plumbing fittings at the store. And we have some thin-walled plumbing pipe to put the cork on. You've got it on there. And it could eventually pop off.

If you put one of those plumbing fittings in a bottle, and it's just held on with a piece of pipe, and a piece of balloon, you could put it on like that. And you've got a bottle that you could go pump-a-pump-a-pump-a-pump-a, and they'll take off.

But it's not a rocket yet, at least not a



Wheels attached with rubber band.



Pumping air into the bottle.

Now, when we go outside, you're going to find that there's funnels out there, and cups, and tubs of water, for whatever you might want to do with them. And you'll see that you're going to be using it first just like this. You'll first use it just the way it is.

The second time (or third or fourth, whatever time), we'll eventually give you this size of pipe *[holds up a one-foot pipe]*, and you put that on it and try shooting it off that way.



Second pipe added to the bottle.

And then, later, we'll give you that pipe [*holds up two-foot pipe*]. And you go like that, and now you've got an elephant with a really long trunk. Okay? So it'll take some practice, and somehow you've got to get water in there, if you want to try it with water in there.



Third pipe attached.

When these shoot off, they go pretty fast. If yours shoots off and you run out to get it, somebody else's might be shooting off right behind you. So after yours shoots off, before you run out to get it, look around. If you see somebody with an evil look on their face, pumping really fast, you might want to wait until after theirs goes off before you go get yours. And when you're coming back, also look at their faces. If you see them kind of nudge theirs a little bit and point it at you, no, you don't want to get hit by it. Because it's got some sharp metal edges, and it might just slice right through your ankle, and red ink will leak out. So watch where you're going while you're out there. You're going to work in groups of two, so find a victim to work with.

Part Two: Shoot Rocket Cars

[Outside, pairs of students line up with their bicycle pumps and take turns shooting off their rocket cars. They use cups and funnels to pour water into their bottles in whatever amount they want. After awhile, the Instructor gives each team a one-foot pipe to add to their existing one, and they shoot some more. Then they add a two-foot pipe and continue shooting. Then they come back into the classroom.]



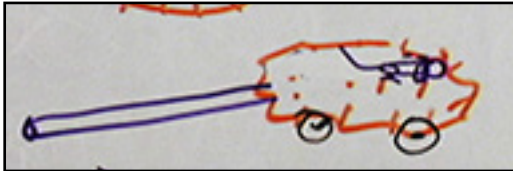
Students work in pairs to launch rocket cars.

Did the bottles go furthest when they were full clear to the top with water? [*Students: No.*] About there? [*Instructor indicates various levels.*] About there? About there? About there? Okay, about there. [*Indicates about half-full.*] Did they go when they had just the stubby pipe? [*Students: No.*] When they had the medium pipe? [*Students: Yes. No.*] Or when they had the tall pipe? [*Students: No. Yes.*] I saw one that looked like this that went way beyond the first row of cars. But we wanted to know which one went the furthest, and the long pipe went the furthest of all of them. Did it make a difference how hard you put the cork in? [*Students: Yes!*]

End of Story

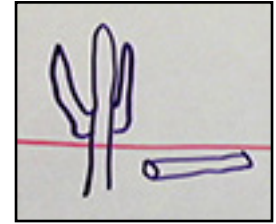
*** DO NOT * present this part of the lesson until after the experiments!**

So Evil Mister Fred brought a race car to the desert, and he challenged Jack and Jill to a race. And Jack and Jill said, "What are we going to do? We've got to make something." So they got these puffer fish, and they put wheels on them. And they put a lizard on top to steer. There, there's a lizard. He can steer the puffer fish.

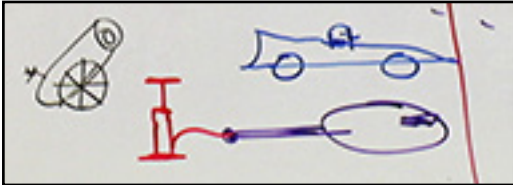


Puffer fish with tube and lizard.

Now, let's make our puffer fish like your race cars. Have you ever seen a cactus that looks kind of like that out in the desert? Well, when they die, they leave hollow tube-shaped things lying around. Let's stick one in the puffer fish's mouth. There.



Cactus with branch.



Puffer fish with bicycle pump and cannon.

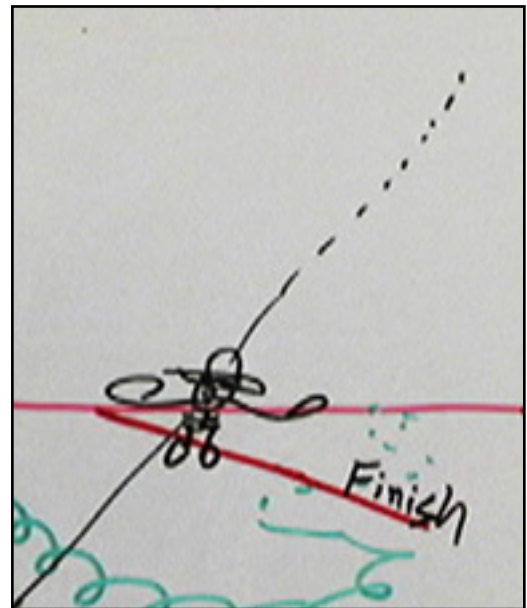
So they can take their puffer fish out here and position him next to Evil Mister Fred's race car. There, like that. Then all they've got to do is puff up the puffer fish. So they need some air. They got a bicycle pump. Of course, there's always bicycle pumps lying around in the desert. And here's the Start line, right here.

And Evil Mister Fred saw that the Finish line was going to be up here. So Evil Mister Fred went out there to make sure that he would judge the Finish line. So he's standing right here watching the race.

And you need some way to start a race. You can't just yell, "Start!" That's not an official way to start a race. You've got to have a loud bang, right? So Evil Mister Fred got a remote-control cannon with a fuse on it, like that. And so he yelled from way far away, "Ready! Get set! Goooo!" And the cannon went ka-boom! And the race car took off -- bazhoom! And the puffer fish went bazhoom!

Well, the puffer fish is really light, and it was puffed up super big. And when it took off, it just went bazzoooooo, about seven hundred miles an hour. There. Kind of out of control. The lizard wasn't that good at steering the puffer fish. And the giant puffer fish went zhooooom between some other puffer fish, right next to Jill, almost caught her hair, and boom! -- hit Evil Mister Fred right in the face. It got across the finish line first.

So Jack and Jill said, "Yayyy! We won!" And then they looked, and now Evil Mister Fred was flying through the air with a puffer fish stuck on him. And they all lived happily ever after, except Evil Mister Fred.



Evil Mister Fred at the Finish line.

End of Lesson

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