Teacher's Guide for:

Blue Bottle

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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Blue Bottle
A Rock-it Science Lesson
Filmed December, 2009

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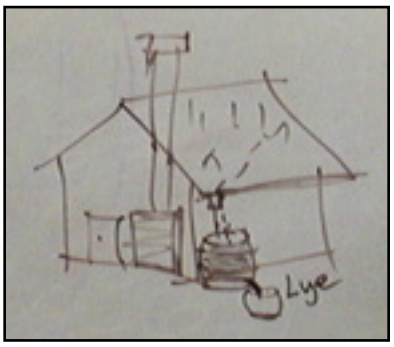
Intro Quick Recap:

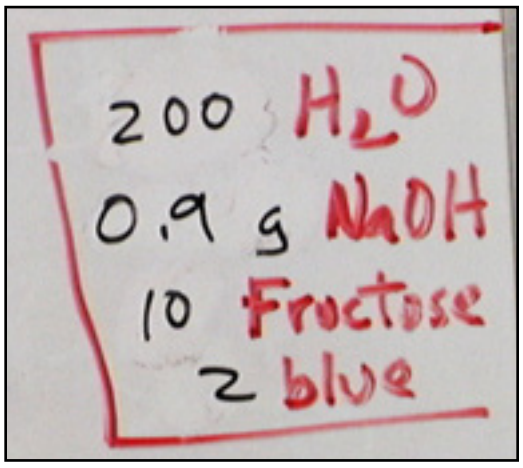


Rain barrel and lye pot.

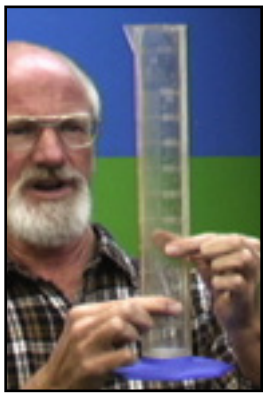
- In olden days, if you lived in a cabin, you had a rain barrel under the gutter, with a clay pot at the bottom.
- Ashes from the fireplace would be dumped into the rain barrel.
- When it rained, the rain would drain through the barrel of ash and come out the bottom into the clay pot.
- The liquid in the pot is called "Lye." It's mostly potassium and sodium hydroxide.
- If you stuck your hand into the pot, the skin would fall off.
- They use lye to make soap by heating it and mixing in animal fat. A solution similar to lye is used in depilatories.
- In the experiment, we'll use a powder called Red Devil Lye.
- If you spill it on the table, you can sweep it up. But it develops a lot of static electricity and tends to cling to things.
- If there's moisture in the air, it gets absorbed by the lye and forms droplets around itself. It might look as if someone just spilled water on the table, but if you try to wipe it away with your bare hand, you'll get blisters on your skin.
- If you do get it on your skin, you have a few seconds to put it in water and wash it all off. But lye soaks through the top layer of skin, so it helps to put vinegar on it to kill it off.
- Today you'll learn how to weigh lye, how to dilute it, what happens when you dilute it, and we'll do an experiment with it.
- You'll wear gloves and goggles so you won't get it on your skin.

Experiment Quick Recap: *"Blue Bottle"*

- Students put on goggles and rubber gloves.
- Instructor explains the steps for the entire experiment before students begin:
  - The ingredients for the lye mixture are written on the whiteboard: 200 milliliters of water, .9 grams of sodium hydroxide (lye powder), 10 grams of corn syrup, and at least 2 drops of methylene blue.
  - Students work in pairs and will mix a double portion of the ingredients.
  - Start with a half-liter bottle of water. Use a graduated cylinder to measure out 400 milliliters. Pour the remaining 100 milliliters of water into a plastic cup, then pour the 400 milliliters from the cylinder back into the empty bottle. It doesn't have to be exact.



Amounts for lye mixture.


Graduated cylinder.

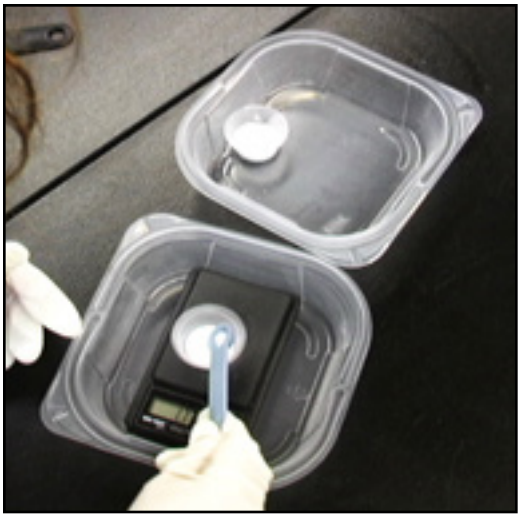
- Give each group a plastic tray with high sides. Place a digital balance in the tray. Put a 3/4 oz plastic souffle cup on the balance and set it to zero.
- Instructor sets out several plastic trays with a souffle cup in each one, and some sodium hydroxide in the cup. Students will use a measuring spoon to transfer 1.8 grams of lye into the souffle cup on their balance.
- Pick up the souffle cup from the balance and slowly pour the lye into the bottle of water.
- Once the lye is dissolved in the water, it's fairly harmless, like bleachy soap.
- Once the lye is in the water, it will get hot. Put the cap on and swirl it around.
- Get another souffle cup and measure out 20 grams of corn syrup on the balance. It doesn't have to be exact.
- Pour the corn syrup into the bottle of water.
- Then add about 8 drops of methylene blue. It doesn't have to be exact, but if you use less than 2 drops it won't work.
- Put the cap on and shake it well. Then set it down and leave it alone for about sixty seconds.
- Place the bottle in an ice chest filled with hot water and watch it to see what happens. Wait at least two minutes (the blue water should turn clear).


Digital balance.

- Get a second bottle, dump the water out of it, and pour in half of the mixture from the first bottle. Do NOT shake them. They should both still be clear.

Experiment Quick Recap (cont.):

- Put the second bottle in the other ice chest, which is filled with ice, and wait for a couple of minutes.
- Instructor explains that this is sometimes called a clock reaction, and it depends on the temperature.
- Ask students why they think the water turns clear. Why does shaking it make it turn blue? Keep asking questions until they make the connection with the oxygen in the bottle.
- Point out that even when the water's clear, there's a slight color difference at the surface -- it's slightly blue.
- This chemical reaction likes to eat oxygen. When you shake it, oxygen gets into the liquid and the methylene blue turns blue. Then the reaction eats up the oxygen in the water and turns it clear.



Souffle cup in tray at top contains lye powder. Student uses measuring spoon to transfer lye to the souffle cup that sits on the digital balance in the lower tray.

- Take the second bottle out of the cold ice chest and shake it so it turns blue again.
- Shake the first bottle and set them both side by side on the table for at least two minutes.
- Ask students to predict which one will turn clear first (the hot one).
- Hot water makes things go faster, and cold water makes things go slower.
- Methylene blue likes oxygen, so it turns clear.

At left, blue bottle is placed in hot water; then it gradually becomes clear.

Equipment List: "Blue Bottle"

Items needed for Instructor:

Consumables:

- Methylene Blue
- Pipette
- Tray, plastic, about 4-5
- Souffle cup, plastic, 3/4 oz, about 4-5
- Measuring spoon, plastic, 1/4 tsp
- Ice, about 5 lbs
- Water (hot tap water), about 3 gal

Other:

- Ice Chests, 5-gal, with lids (2)
- Bucket, 5-gal

Items needed for Students:

Consumables (per group of 2 students):

- Water, half-liter plastic bottle, 2 each, with caps
- Lye, Red Devil, 1.8 grams
- Corn syrup, 20 grams
- Tray, plastic
- Souffle cup, plastic, 3/4 oz, 2 each
- Paper towels (if needed for cleanup)

Other (per group of 2 students):

- Digital balance
- Measuring spoon, plastic, 1/4 tsp.
- Graduated cylinder, 500-milliliters
- Cup, plastic, 16 oz.a
- Goggles
- Rubber Gloves

Prep Work:

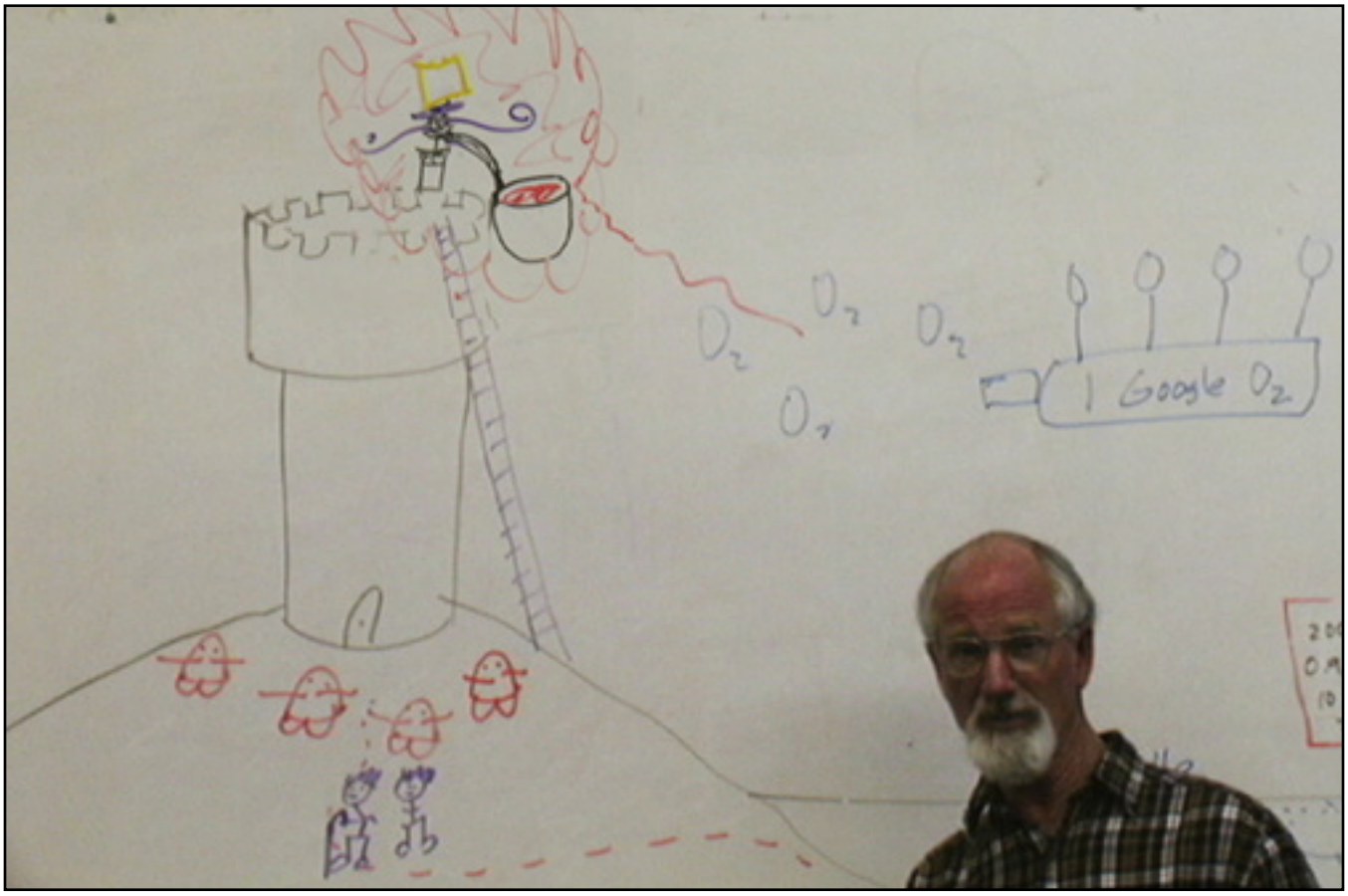
- Put hot water in first ice chest.
- Put ice in second ice chest.
- Transfer some corn syrup from the jug into a smaller bottle so it's easier to pour.

Story Recap: "*Evil Mister Fred's Blue Blood*"

Part 1:

- Evil Mister Fred wants to trick people into thinking he's a leader.
- He built a bigger castle on a hilltop and would try to make wise sayings whenever someone walked by.
- Jack and Jill lived in Goodville. People there would bring their problems and disputes to Jack and Jill because they were good at solving them. And everyone liked Jack and Jill.
- This made Evil Mister Fred jealous. He called the Acme Store of Everything to get some wisdom, but they didn't have any. Instead, they sent him some blue blood so he could appear to be royal.
- The blue blood came in the form of a floating gun that shot a bullet at Evil Mister Fred. It didn't seem to do anything to him, but later, when he accidentally cut himself, his blood was blue.
- He put on a purple hat, dyed his mustache purple, and put on a crown so he'd look like a king. He also had the minions wear red robes so they'd look like servants, and he bought a book of wise sayings. But when he went to the town and told everyone he was their king, they threw fruit and cabbages at him.
- Then he told people that if they brought him their problems, he could solve them perfectly. People didn't believe him, but they brought him some problems anyway just to see what he'd do.
- One guy said he had loaned fifty gold coins to a guy with a cane and never got paid back. The guy with the cane said he did pay it back.
- Evil Mister Fred told the guy with the cane to give the cane to the other guy and come up to the top of the castle so he could talk to him. So the guy climbed the ladder and came up. He swore to Evil Mister Fred that he had paid back the loan.
- Then Evil Mister Fred sent him back down and had the other guy come up, and he still said he hadn't been paid back.
- Then Evil Mister Fred had the first guy come back up and bring his cane. The guy still swore that he had paid back the loan. Evil Mister Fred got angry because he didn't know what to do, so he grabbed the cane and hit the guy over the head. The cane broke and the coins fell out of it.
- Everyone thought Evil Mister Fred was a genius, and they believed he knew the coins were hidden in the cane and only broke it to show everyone they were in there.
- Now all the people in Goodville are taking their problems to Evil Mister Fred to solve, and chaos reigns, because Evil Mister Fred isn't really that smart. But everyone's been taken in by him.

Story Recap (cont.):

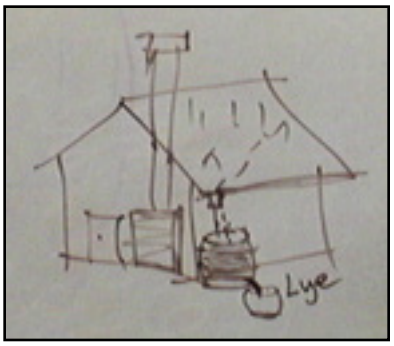


Ending:

- Evil Mister Fred's blue blood made people think he was destined for royalty, and they were all coming to him for judgments.
- Jack and Jill called the Acme Store of Everything and ordered a giant tank of oxygen, with some helium balloons attached so it could float.
- They turned on the oxygen, and it started flowing out.
- The people in Goodville started breathing this extra-oxygenated air. It made them feel good, smarter, and able to work harder. They started solving their own problems.
- Evil Mister Fred decided he needed to look more regal, so he bought a big pipe, a sweater with leather patches on the elbows, and glasses. He thought this would make him look smart.
- He struck a match to light his pipe just as a breeze of pure oxygen wafted by. His blood turned red, and everyone realized he wasn't a blueblood anymore.
- When the oxygen got into the pipe, it flashed into a huge fireball.

Transcript: Intro

In the old days, if you lived in a cabin, the cabin usually had a roof. And it had some way to collect the rainwater, because they didn't have enough water. They'd take some old wine barrel and they'd put it under the gutter, and it would fill with water. And they didn't use the water for drinking. What they did was, in a house like this, one way to heat it up was with a fireplace or a pot-bellied stove. And someplace there's be a chimney sticking up. And if you burned wood you ended up with ashes. They took the ashes and put them in the barrel. You know, collect ashes month after month after month. Pretty soon, the whole barrel would be full of ashes. And it rains, and the water goes down and drains into the ashes. And it slowly comes out the bottom. And they'd put a clay pot at the bottom. And as water filters through the ashes, it would leach something out of the ash, and it would go into this pot.



Rain barrel and lye pot.

In those days they cared about their kids, to a certain extent. They thought that kids should learn things on their own to find out if things are good or bad. So houses had fires in them. If the child stuck his hand in the fire, they'd eventually pull it out and say, "Ow." You know, they had sharp knives. They taught kids how to dress a deer and cut it open and take all the guts out, and gut fish, cut their food. If they cut themselves, they'd say, "Ow."

And they had this pot that looks like water. If a kid stuck their hand into the pot, the skin would fall off their hand. And they'd say, "Ow." And they gave a name for the liquid in the pot. They called it lye, L-Y-E. And it's mostly potassium and sodium hydroxide that's in it. But today we're going to use some lye. It's always good to have lye.

[Student: It takes your skin off?] Yeah, it really burns. *[Student: It could really take your skin off?]* Oh, yeah. *[Student: It's like acid.]* It's like acid, but it's a strong base. In chemistry terms, it's called sodium hydroxide *[NaOH]*. *[Student: If you get it on your shirt, will it go through the shirt?]* It doesn't go through shirts. *[Student: Will it absorb and then go through the skin?]* Yes.

And they use it to make soap, of all things. If you put animal fat in lye and warm it up, stir it all around, it can make soap. *[Student: Don't stir it with your finger.]* Yes, just don't stir it with your finger.

We're going to use it in a dilute form, but it comes in a powdered form. It used to be you could buy it at the grocery stores. It's called Red Devil Lye. And if you spill it on the table, it kind of sits there. You can sweep it up. It develops a lot of static electricity and tends to cling to things. If you leave it on a surface, there's moisture in the air. And the moisture gets absorbed by the lye and forms little droplets of water all around itself. And then you come back later and say, "Oh, look, somebody left some water on the table *[pantomimes using bare hand to wipe water away]*. Oops!" Little blisters all over your skin.

It does take a little while for it to eat your skin. It feels really slippery at first. So you've got a few seconds to decide what to do before your skin starts to blister. And the proper thing to do is put your hand in water and wash it all off. But lye actually soaks in through the top layer of skin, so what I usually do is I put vinegar on it afterwards to kind of kill it off.

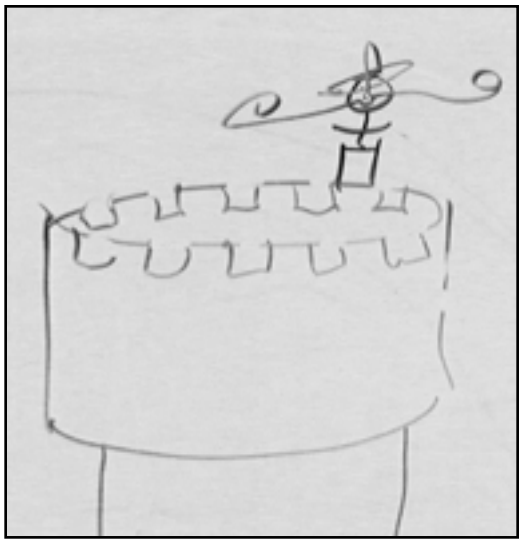
When we're using lye, or any strong chemicals, you want to be kind of careful. Today you're going to learn how to weigh it, how to dilute it, what happens when you dilute it, and then we're going to create an experiment with it. *[Student: Has this ever happened to you, have you burned yourself?]* Oh, yeah. Everybody that's a chemist has accidentally gotten some lye on themselves at one time or another. *[Student: Did it hurt?]* It kind of burns. You don't want to get a lot on you. *[Student: Can I wear gloves?]* Yes, everybody will wear gloves. Chances are you won't get it on your skin unless you want to.

It dissolves hair really fast. The oddest thing is, they sell something at the stores called a depilatory. Ladies think that their legs look better without being all hairy and gross, and you rub this on your skin. Well, that's a solution of, I think it's potassium hydroxide. It's not quite as bad as regular lye. But it's a really, really strong chemical. Dissolves hair right off. *[Student: My friend says it doesn't work.]* It doesn't work? Oh. Does your friend have steel wire hair?

But first, we need a crazy story, and then we'll do some experiments.

Story: *"Evil Mister Fred's Blue Blood"*

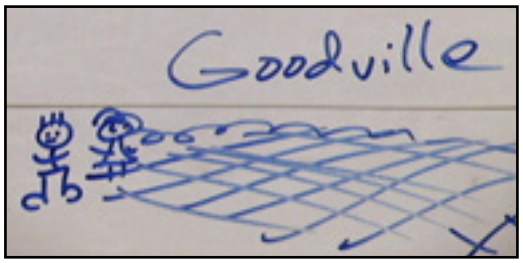
Let's suppose Evil Mister Fred has decided that trying to take over the world by force is too hard. He wants to trick people instead. So he says, "You know, some people are meant to be great. Some people are meant to be leaders. And others are not." And he was looking at the minions and he said, "You're not." And he decided that he was meant to be great and everybody else was not.



Evil Mister Fred on his castle.

So he built himself a bigger castle than usual, because you have to do public relations. You have to look like you're the person for the job. If you don't look like you're the person for the job, they aren't going to give it to you. So he built a nice tall castle and he put it on top of a hill. And he would stand on the castle every morning and look wise, like that. And there's a horizon back there.

And he would try to say wise things. You know people would come up to him and say, "Hi, Evil Mister Fred, how's it going?" And he'd say, "Yes, you know, when the squirrel climbs up the tree, that means we're ready for a warm summer." And the person would go, "Whoa," *[scratches head]* and walk away. And Evil Mister Fred said, "Boy, I bet I impressed them!"

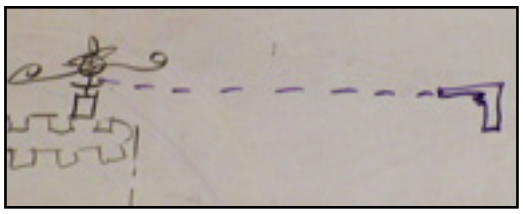


Jack and Jill live in Goodville.

Now, there's a city down here. It's Goodville. And Jack and Jill live in Goodville. And whenever people have problems that they can't solve, they come to Jack and Jill. So if your neighbor has a cat, and the cat just ate your pet parrot, and you're mad, then you'd go to Jack and Jill and say, "Hey! I just had a parrot and their cat ate it. They have to buy me a new parrot." And Jack and Jill would have to decide what you should do with that situation. Or if somebody lent somebody else some money and they didn't get paid back, well they'd go to Jack and Jill and get this figured out, because Jack and Jill were pretty smart about things like that.

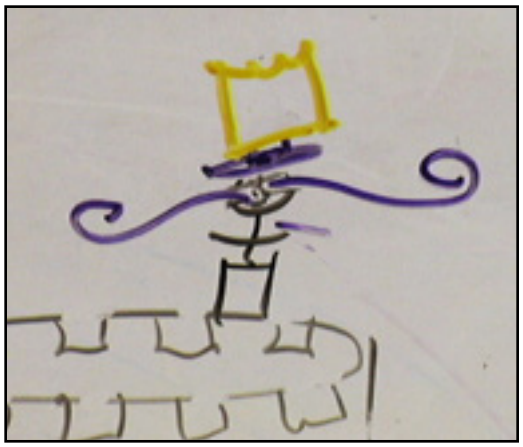
Evil Mister Fred saw that Jack and Jill were getting all these people liking them and asking them questions and thinking they're important. And nobody came to Evil Mister Fred to ask him important question. So he said, "What to do? What to do?" So he called the Acme Store of Everything and he says, "Hey, Acme Store of Everything, I need some wisdom." And they said, "Oh, man, we've got everything, but we don't have that." And he says, "Oh, man! What else have you got?" And they said, "Well, let me look around." And they looked around all the shelves, and they said, "We've got some blood here. You want some blood?" And Evil Mister Fred said, "No, I've got my own blood." And they said, "Ah, but this is special blood. It's blue blood." And Evil Mister Fred said, "Whoa, cool! Yeah, give me some of that."

Next thing you know, this gun appears in the middle of the air, like that. And a bullet hits Evil Mister Fred. He thinks, "Oh, man, I've been shot!" But nothing happens.

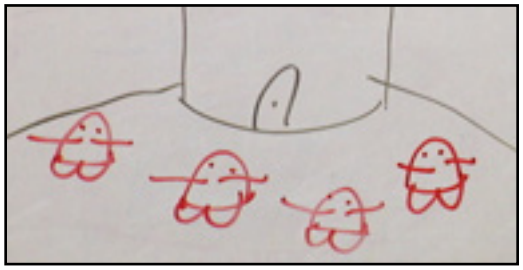

The floating gun shoots Evil Mister Fred.

And then a few days later, he accidentally cuts himself and sure enough, he's got blue blood. Gasp! And he says, "Hey, this is cool! I've read about this. Kings have blue blood. Now I've got blue blood. That must mean I'm a king."

So he took off his black hat and he put on a purple hat because kings wear purple. And he dyed his mustache purple, like that. And then, just to make sure nobody missed out on the whole deal, he got himself a crown. And then he made all his minions dress in red robes so they'd look like they were servants, like that. So now he's got red minions running all over the place. And he bought a book of wise sayings.


Evil Mister Fred's hat, mustache, and crown.

He says, "Now, I've got blue blood, I've got red minions, I've got a castle tower. I'm going to just declare myself king." So he did. He now called himself King Fred. And he'd march through the town saying, "Everybody bow down. King Fred is coming through." And the people said, "King Fred? Ha! What for?" And they threw cabbages at him. And apples and tomatoes. And Evil Mister Fred went running away and he says, "Arrrg, what am I going to do? I know. I'm going to make it so that if people have problems, they come to me and I'll solve those problems for them."


Minions dressed in red.

So he told everybody in town, "If you have problems, come up here, form a line, and I'll listen to your problems and solve them in a perfect way." And the people thought, "Oh, boy, he's dumb. We've got to go see what's going to happen." So they started making up all sorts of problems to take to Evil Mister Fred. And one of the guys came up and he said, "Hey, I lent fifty gold coins to this other guy. And he said he'd pay me back in a year, and he hasn't paid me back." And the other guy was a little bent over guy, like that. And he says, "But your honor, I did pay him back. I paid him back every single gold coin, and he refuses to acknowledge it."

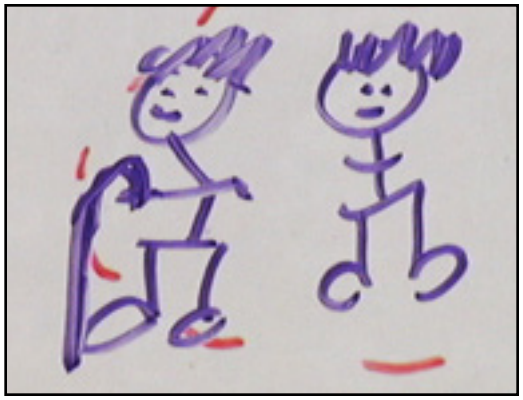
And Evil Mister Fred is standing on top of his castle listening to this. And Evil Mister Fred said, "You, with the cane. You're the one who borrowed the coins, is that right?" And he said, "Yeah." And Evil Mister Fred said, "Come up here, I want to talk to you." So the guy with the cane had to hand his cane to the other guy, and he climbed the ladder and went up to Evil Mister Fred. And Evil Mister Fred said, "Did you really give him back those coins?" And he said, "Absolutely, sir. I'd swear to it." And Evil Mister Fred said, "Okay. You go back down." And then when he got back down, he took his cane back.

And he called the other guy up the ladder, and he said, "Are you sure you didn't receive those coins back?" And the other guy says, "Positive. I never received those coins back. I'd swear to it." And he went back down.

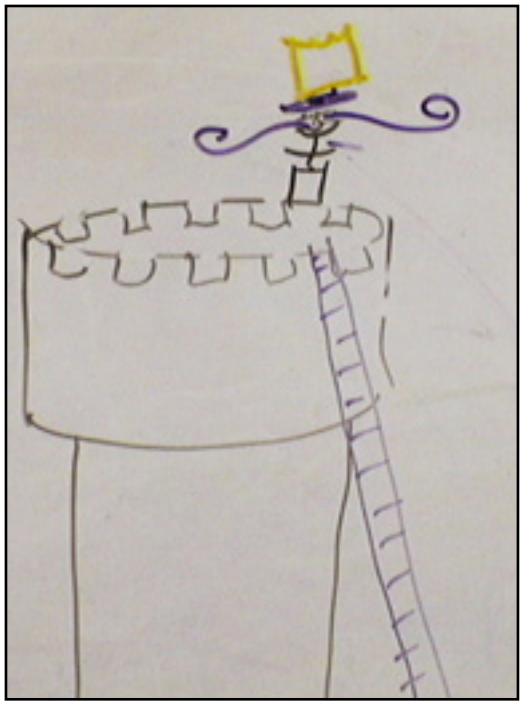
And Evil Mister Fred brought the first guy up again. He says, "Come up here, sir. Bring your cane with you." Evil Mister Fred didn't know how to solve this problem. And he was mad, because here he was, trying to impress everybody, and he had no clue. And when the other guy climbed back up with his cane, Evil Mister Fred did what only Evil Mister Fred does well. He grabbed the guy's cane and hit him over the head with it. Crash! And when he did, the cane broke, and all the coins fell out on the ground. And everybody said, "Whoa, that Evil Mister Fred is a genius! He knew that when this guy handed the cane to that guy, he paid him off the debt. And just to show us, he broke the cane over the guy's head and all the coins fell out."

And now everybody thinks Evil Mister Fred is the smartest guy that ever was, and everybody in Goodville was coming to him for problems. Of course, chaos reigned.

Now, Jack and Jill are down there saying, "Oh, boy. These people are taken in by that shyster." If you were Jack and Jill, what would you do?



Two guys with a problem.



Ladder up to the top of the castle.

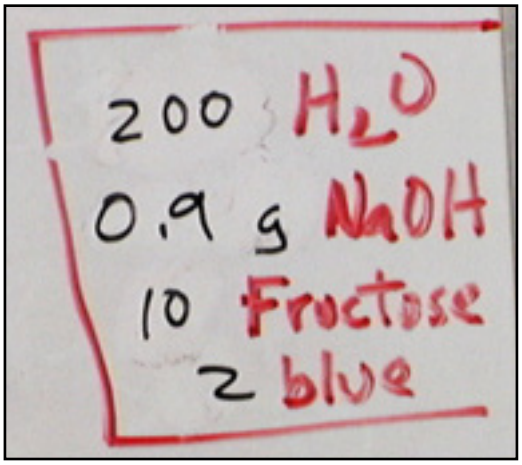
Imagination and Brainstorming Time

[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: "*Blue Bottle*"

We need a bottle, like a water bottle. And you're going to make up a double portion of potion. One portion is 200 milliliters of water, and you can measure milliliters with these things *[holds up a graduated cylinder]*. What you're going to want in your bottle is 400 milliliters. And you're going to make some for you and some for your neighbor. And these are marked off in one hundred and two hundred, three hundred, four hundred milliliters of water. If you pour the whole bottle in there, it's supposed to be 500 milliliters *[pours water from bottle into cylinder]*. A little bit more than 500 milliliters.



Ingredients for single portion.
(We doubled it for this experiment.)

So, you have to make a hundred milliliters go away. You could drink it, I suppose. *[Student: (Indicating cylinder) But doesn't it have all kinds of chemicals in there?]* Yes, that's a good point. There's all kinds of nasty stuff that's been in there. I wouldn't drink it out of that thing. So it's better to not drink anything when you're doing chemistry classes.


Pouring 400 ml of water back into bottle.

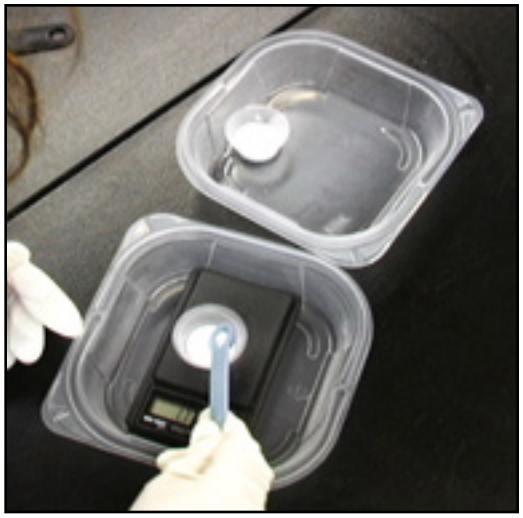
You're going to pour out about a hundred milliliters *[pours water from cylinder into plastic cup]*. It doesn't have to be exact. Okay, there's about four hundred milliliters. Now, you have to put it back in the bottle *[pours remaining water from cylinder into bottle]*, and you have the right amount. And if you pour too fast, it goes all over the table. Then you have to start over. There, that's the right amount.

Then, instead of nine-tenths of a gram of sodium hydroxide, you're going to put twice that amount, 1.8 grams of sodium hydroxide. And we have a thingamajig here *[holds a digital balance]* that you can use to weigh it. This balance has an On-Off button. It says 8-8-8-8-8-8. And it's got a Zero button, which is really handy. If you put it on the table and push the Zero button, it should say zero. You can put a cup on it. We don't care what the cup weighs. We want to make the stuff in the cup weigh the right amount *[puts a small plastic souffle cup on the balance]*. So now it says the cup is 1.1. We push the Zero button, and now it's zero again.


Press ZERO button to delete weight of cup.

You want to put in 1.8 grams of lye. We'll place containers of lye here and there on the table. The lye will be in a container like that *[sets out plastic trays with high sides]*, and the lye will be in a *[souffle cup inside the tray]*. Then you grab a measure *[holds a small plastic measuring spoon]*, and you'll

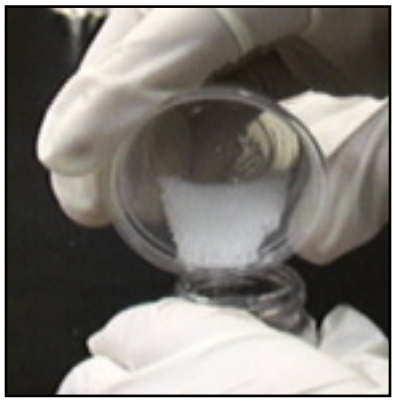
scoop out some lye from here and pour it into there *[transfers a scoop of lye from the container in the tray into the student's souffle cup]*. And you'll discover that as you pour, the static electricity on the lye makes the lye jump all over like pop-corn. So it's better to put the balance in a pan like that *[places balance in a plastic tray with the student's souffle cup on the balance]*. And then some of it's going to go where it wants to go, but most of it's going to end up somewhere in there. When you get 1.8 grams of it, then you're going to take this *[picks up student's souffle cup]* and pour it into your bottle *[pours lye into bottle of water]*. It's going to jump around, too. So you just have to be careful. You'll be wearing gloves and stuff. And we'll give you a wet paper towel. If it ends up on the table, you just wipe it up with a wet paper towel.



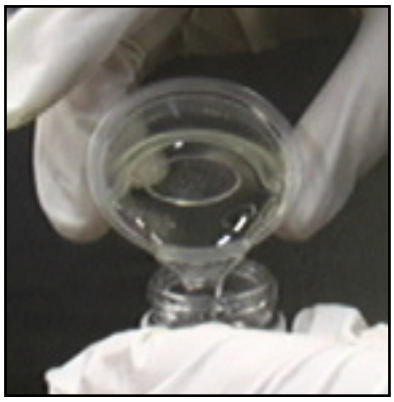
Weighing the lye powder.

Once it's dissolved in here, it's pretty harmless. It's like soap. It's fairly strong soap, it's kind of like bleachy soap that, if you do spill some on yourself, it's not going to dissolve your skin. It's only the stuff that you spill on the table and say, "Ooh, what's that?" *[pantomimes poking something on the table with his finger]*, and you burn your skin.

1.8 grams of lye in the cup.



Pour lye into bottle.



Pour corn syrup into bottle.

So, once it's in here, it's going to get really hot. So it's a good idea to put the cap back on and swirl it around. Once you've got it in there, you're going to add some corn syrup -- Karo corn syrup. This has got fructose in it. It's a high-fructose corn sweetener. I put it in this bottle *[holds up a smaller plastic bottle with corn syrup in it]*. It's easier to pour. And you're going to put in, instead of 10 grams of fructose, you're going to put in 20 grams.

Now, chemists always weigh out things or measure things with these graduated cylinders. They don't weigh grams. So you can take another one of these little guys *[holds up a souffle cup]* and see if twenty grams will fit in there. Do you think it will? It says zero right now. Let's pour some in. This is really thick. That's seventeen. If you put in too much, it's not bad. If you put in too little, it's not bad. For some reason, that doesn't seem to matter. That's 19.7. Then you've got to get that to go into the bottle. You can pour and see how much of that goes into the bottle.

Once you've got the lye in there and you've got that in there, then we're going to add something called methylene blue. In one of the experiments online, it says "Be sure that you don't add more than two drops of methylene blue, because if you add more, the experiment won't work." So I tried it with two drops, and sure enough, it worked. So then I tried it with four drops, and it worked. Then I tried it with eight drops, and it worked. And I tried it with sixteen drops, and it worked. *[Student: When did it stop working?]* It didn't. They made a mistake. *[Student: What if it's less than two?]* If it's less than two, it won't work very well. So I would put in maybe five or ten drops of methylene blue. Don't squirt a whole ton of it in there, because it might not work that way.

Adding methylene blue with a pipette.

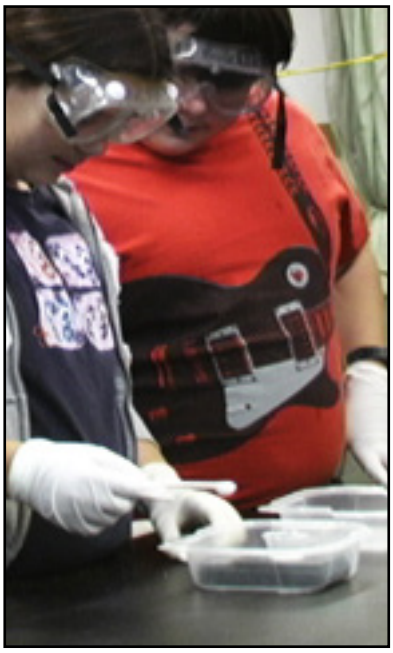
Then, when you've got the methylene blue in there, and you've got the lye in there, and you've got the corn syrup in there, you go shaky, shaky, shaky, shaky, shaky, shaky. If you put the cap on tight, it should stay tight, and you shaky, shaky, shaky, shaky, shaky. And then you set it down. Now it's got everything you need in it. It should be blue because of this stuff. And then after sixty seconds, something should happen inside the bottle.

Now, your bottle is going to be pretty full. Then you're going to have your partner go get another bottle. When your partner has a bottle full of water, we're going to dump all the water out into the bucket so they have only an empty bottle. Then you give them about half of your stuff, so both of you have about half. And you both shake them and set them down and fold your arms and stare at them. And then, when you get bored of doing that -- you have to wait at least two minutes -- you're going to take one bottle and put it in this ice chest, which is full of hot water, and put the other bottle in that ice chest, which is full of ice. And then, when you get bored of them sitting there, you can take them out, shake them both, set them on the table, and see what they do. They should do something.

At left, blue bottle is placed in hot water; then it gradually becomes clear.

So pick a partner. Get gloves first. The gloves are here *[takes out a box of rubber gloves]*. If you pull the gloves out hard, they will rip. Then go get some goggles from the goggle box. When you have gloves and goggles, come over here and get a tray and a scale. One tray and scale per group. When you're working with chemicals, you don't sit down, so push your chair way back. Each group needs some way to measure water *[sets out graduated cylinders]*. If there aren't enough things, you'll borrow your neighbor's.

[When students have their equipment ready, the Instructor sets out containers of lye and measuring spoons. The students measure their water in the graduated cylinder and pour it back into the bottle. Then they measure the lye and pour it into their water bottles. Then the Instructor sets out the corn syrup, and the students measure it and add it to their bottles. Then they add several drops of methylene blue to the water in their bottle, put the cap on, shake it, then let it sit for two minutes.



Students measuring water, lye, and corn syrup.

After two minutes, they place their bottle in the hot water and watch it for a couple of minutes to see what happens. The blue water gradually turns clear again as the bottle sits undisturbed in the hot water. Then they take the bottle out of the hot water, divide it into two bottles, put the caps on, but DO NOT shake them. The water should still be clear. Then they put one bottle in the cold water for a few minutes. While the bottles are chilling in the cold water, Instructor starts cleaning up the chemicals. Then the students take their second bottle, shake it so it turns blue again, and set it back down on the table. They wait to see if it turns clear again. Meanwhile, the Instructor starts putting away the lye and other materials. After a minute or two, the bottles start to turn clear again.]

This is sometimes called a clock reaction. It depends on the temperature. But you have to find out -- why do you suppose it turns clear? *[Students offer suggestions.]* Why does shaking it make it turn blue? *[Students offer suggestions. Eventually, as the Instructor asks followup questions, they make the connection with the oxygen in the water.]*

Fish breathe oxygen. So when you shake it, oxygen goes into the water. What else happens when you shake it? Turns blue. So, when oxygen gets into the water, it turns blue. Now, why does it turn clear? *[Students make suggestions.]* So, you're right on the brink of discovery. When you shake it, it turns blue. When you don't shake it, it turns clear. If you look very carefully at one that's clear, you might notice there's a color difference at the surface. It's kind of blue. This is one of those chemical reactions -- the lye plus the corn syrup plus water -- likes to eat oxygen. So when you shake it, oxygen gets into the liquid and the methylene blue turns blue. And then, the reaction eats up the oxygen in the water. If there was a fish in there, it would die. It eats up all the oxygen.

Now, go get your bottle out of the ice water and shake that one and set it on the table and see if it turns clear. *[Students shake cold bottle, and it turns blue.]* Now shake the other one and set them side by side *[both bottles are now blue]*. Which one do you predict will turn clear first? *[Students make suggestions, then wait to see what happens. The warmer bottle turns clear first.]* Now take the cold bottle and put it in the hot water and put the hot bottle in the cold water. *[While the bottles are sitting in the ice chest, students put away their equipment.]* Now put all the bottles in the cold water and sit down.

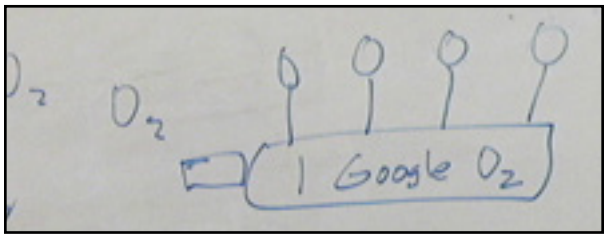
Which one will turn clear first, the hot one or the cold one?

So it looks like hot water makes things go faster, cold water makes things go slower. Whatever methylene blue is, somehow it likes oxygen. It turns clear. Somehow, syrup can eat oxygen if you put lye with it. So if you drink a bottle of syrup and then drink a bottle of lye, your body will be deprived of oxygen and maybe you'll turn blue and die. *[Student: I think if you drink lye, you die.]* You probably do die. You'd scald the lining off your throat, and it reacts to the acid in your stomach. And that's bye-bye for you.

End of Story

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

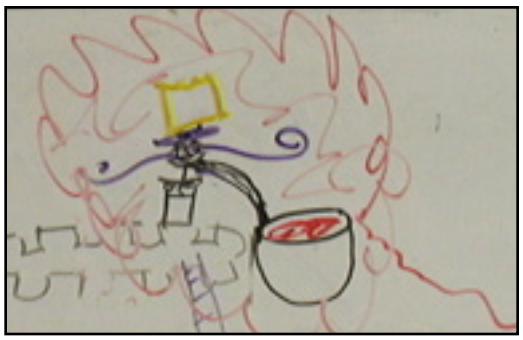
So now Evil Mister Fred has blue blood. He's royal. He could prove to the people that he is destined for royalty by stabbing himself and blue blood squirts out. And all the people are coming to him because he made one judgment work out all right by hitting some guy over the head with a cane. And Jack and Jill are trying to figure out how to discredit Evil Mister Fred and get the people to think for themselves. They say, "Huh, what are we going to do? He's got blue blood." So Jack and Jill said, "Oh, I wonder how good that blue blood really is."



Floating oxygen tank.


Evil Mister Fred with pipe.

So they called the Acme Store of Everything and said, "Acme Store of Everything, we need a whole bunch more oxygen." So the the Acme Store of Everything sent a flying oxygen tank: one google O2, with some helium balloons to float it, like that. And they turned on the oxygen, and oxygen guys started flying out all over the place. The people in Goodville started breathing this extra-oxygenated air, and they said, "Ooh, I feel good. I feel smart. I can work harder." And they started solving their own problems. Evil Mister Fred wasn't getting anybody up there to bother him.


Fireball around Evil Mister Fred.

And he said, "Well, I need to look more regal. I know what I'll do. I'll buy myself a cigar and smoke a cigar. That looks regal. Or maybe a big pipe." What do you think, should it be a pipe or a cigar? *[Students: Pipe.]* Okay, we'll give him a pipe. So he bought himself a pipe and some tobacco, and he put on a sweater with leather on the elbows, elbow patches so he looked regal. And he bought himself some glasses. People look smart who wear glasses, like that.

And he was ready to light his pipe. He bought the extra dry, good quality tobacco. And he struck a match and lit the pipe. And about that time a breeze of pure oxygen wafted up towards Evil Mister Fred. And his blood turned red, and everybody said, "Ooh, Evil Mister Fred is not a blueblood anymore."

And when the oxygen got into the pipe, the tobacco flashed into a huge ball of flame. And Evil Mister Fred and all his glory was consumed by the flames. And they all lived happily ever after, except Evil Mister Fred.

End of Lesson

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