Teacher's Guide for:

Osmosis

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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Osmosis
A Rock-it Science Lesson
Filmed November, 2009

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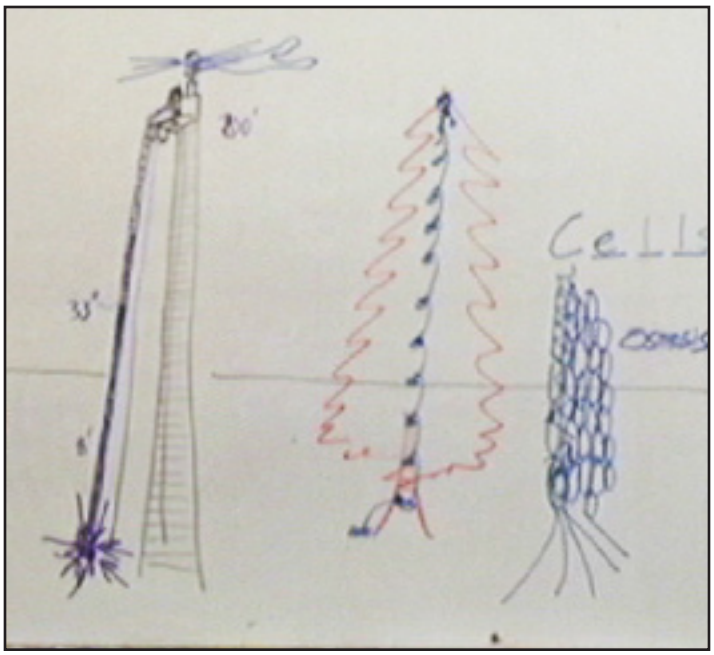
Intro Quick Recap:



- Suppose you're sitting on a chair that's 200 feet tall.
- You left your grape juice in a cup on the ground. So you pull a long straw out of your pocket so you can drink the juice. Will you be able to?
- Suction isn't what makes the juice go up. The air pushes it from all directions and makes it go up the straw.
- You suck as hard as you can, but the juice only rises about 8 feet in the straw.
- You notice that a kid with a cape and a big "S" on his chest is standing behind you on the chair -- SuperKid. He tries to suck up the juice.
- When the juice gets up to about 33 feet, it starts to boil in the straw. All the water in the grape juice turns to steam, but the liquid stays at 33 feet.
- That's because the atmospheric pressure around us can only push it that high.
- If you went to Venus, where the atmospheric pressure is 500 times greater, you could suck the juice up 500 times higher.
- If there's a redwood tree that's 200 feet tall, you could climb to the top and find sap there. Since the sap is wet and the branches are green, there must be water in the tree. How come the tree can take water up 200 feet, but we can't?
- Maybe the redwood tree has little swimming pools in its trunk every 10 feet, and swimming pool pumps that pump the water up to the next pool. And maybe it has an electrical outlet to plug in the pumps. Have you ever cut a redwood tree open to see if it has pumps inside?
- Turns out there are no swimming pools and no pumps and no electricity in a redwood tree.
- What it does have is long, skinny, kind of oval-shaped things that the bark and outer layers of the tree are made of. They're cells.
- The cells act kind of like swimming pools and pumps. Each cell can make its own electricity, and it has skin on it, and it can absorb water and get rid of water.
- It can take water from the roots, make it go to the next cell, and then that cell can give water to the next cell. The process goes on and on and up and up as far as they want to go.
- The process where water can go through a cell is called "ostrich-mosis," but they abbreviate it "osmosis."
- Osmosis is also how water can go through the cells of your body. Have you ever gone swimming and your skin get wrinkled? Only your fingers and toes, right?

Intro Quick Recap (cont.):

- Where your skin is thick, it can get wrinkled. Where it's thin, it doesn't wrinkle.
- So why does your skin wrinkle? If you look online, one site says it's osmosis, because if you put one hand in a bucket of fresh water, and the other hand in a bucket of really salty water, only the first hand will be wrinkled. The salty water prevents the other hand from wrinkling.
- Another site says the thick skin absorbs the water by diffusion, just like if you dip a chunk of leather in water. It can grow like a sponge absorbs water, and that's what makes it wrinkle.
- On a third site, a doctor tells about how he does surgery to reattach severed limbs. He follows up with his patients for years afterwards. When they go swimming, one hand gets wrinkled, but the hand that was reattached doesn't. Some people think it has something to do with the nerves, because the nerves don't grow as well in the severed hand. But nobody's figured it out.

Experiment Quick Recap: *"Osmosis"*

Part 1: Glue and Borax Demo

- We're going to make a chemical that works something like a snail or a slug.
- There's a particular chemical that works with osmosis. They us it in reverse osmosis water purification systems. It's called polyvinyl alcohol.
- Polyvinyl alcohol loves to absorb water. Under the right circumstances, you can also take the water back out of it.
- You'll find it in things like Elmer's Glue, that you glue things together with. It's also in stuff called Hi-Float, which you put inside balloons. You get the entire inside of the balloon covered with this stuff, and then you fill the balloon with helium. It forms a layer of plastic inside so the helium doesn't leak out.
- The molecules in both the Hi-Float and the glue are like you. If I were to attach rocket packs to your back and light them off inside the room, you'd be bouncing off the walls.
- But when we put the rockets on you, you all of a sudden hate each other. You can't stand to be near the other person.
- Then a giant hand rips open the roof and sprinkles Love Potion Number Nine on everyone. Now you all get into a group hug. A giant blob of a group hug.
- There's a love potion for polyvinyl alcohol. It's a common chemical called sodium tetraborate decahydrate. Borax soap.
- Suppose you're at home and you spill glue on your parents' new table. (Instructor deliberately knocks over the bottle of Elmer's Glue and lets a puddle of glue run onto the lab table.) And you have to find a way to clean it up.
- You want to use water, but the plumber is there and the water is turned off.
- So you pour some soap on it. (Instructor pours Borax soap onto the puddle of glue and starts mixing it around with his fingers.) It's cleaning the table. (The glue combines with the Borax to make a glob, leaving only some excess soap powder on the table.) The polyvinyl alcohol guys have joined each other and glumpified. (Instructor tears off a piece of the blob and drops it into a glass of water and leaves it to sit there, to see what it does.) We're going to make a better version of this stuff by adding water to it.

Pouring Borax onto Elmer's Glue

Part 2: Students Mix Glue and Borax

- Instructor takes a pre-mixed solution of water and Elmer's Glue and pours a puddle of it on the table in front of each student.
- Borax is very gritty, so Instructor has mixed some in water.
- Pour the Borax mixture onto the glue puddles and have the students mix it with their fingers.

Experiment Quick Recap (cont.): "*Osmosis*"

- After they mix it well, students get a popsicle stick to push the mixture around so it becomes a blob.
- This is artificial rubber, called vinyl rubber. Let students color their blobs with water-based markers.
- Students divide their blob into two pieces. One goes into a ziplock bag for them to keep; the other will be used in the next part of the experiment.
- Pour table salt onto the remaining pieces of blobs and have students mix it together. Is the salt getting wetter or drier? (The glob will get wetter and start to dissolve.)
- If you squeeze the glob, you can squeeze the water right out of it. You can turn it into little lumps like sawdust, or little grains.
- Have the students use their popsicle sticks to scrape their glumpy stuff into a pile, then go to wash their hands. While they're washing, Instructor scrapes all the glumpy stuff into a clear plastic cup.
- This batch is similar to the first batch that had no water in it.

Part 3: Four Kinds of Slime

Slime

- We're going to see what happens with a purer form of polyvinyl alcohol. Instructor mixes a 4-to-1 mixture of water and Hi-Float in a clear plastic cup.
- We're going to make something like the slime in Ghostbusters. We want to find out what makes the best slime. Instructor pours out the Hi-Float mixture in 4 puddles on the table.
- In the first puddle, Instructor pours Borax straight from the box and mixes it with his fingers. It makes a white blob, similar to the original one, but a bit softer.
- In the second puddle, Instructor adds a large amount of the Borax-water solution and mixes it with his fingers. It turns into a clear slime.
- In the third puddle, Instructor does the same, but with less of the Borax solution. It makes a stickier slime.
- In the fourth puddle, Instructor adds just a tiny amount of the Borax solution. It makes a very sticky slime. The less Borax you use, the stiffer it will be.
- Instructor gathers the second, third, and fourth puddles of slime together into one glob and puts it in a clear plastic cup. Then he pours salt on it and works the salt into the slime.
- When he squeezes it, the water comes out of the salt-and-slime mixture.
- When you stick your hands in salt water, it makes the water come out, so your hands don't wrinkle.

Equipment List: "Osmosis"

Items needed for Instructor:

- Elmer's Glue
- Hi-Float
- Borax soap
- Water, a couple of cups
- Cups, clear plastic, 16-oz. (4 each)
- Measuring spoon, 1 Tbsp.
- Measuring cup, 1 cup
- Elmer's Glue and water mixture (see Prep Work for formula)
- Borax and water mixture (see Prep Work for formula)

Items needed for Students:

Consumables (per student):

- Craft stick
- Ziplock bag, one-quart size

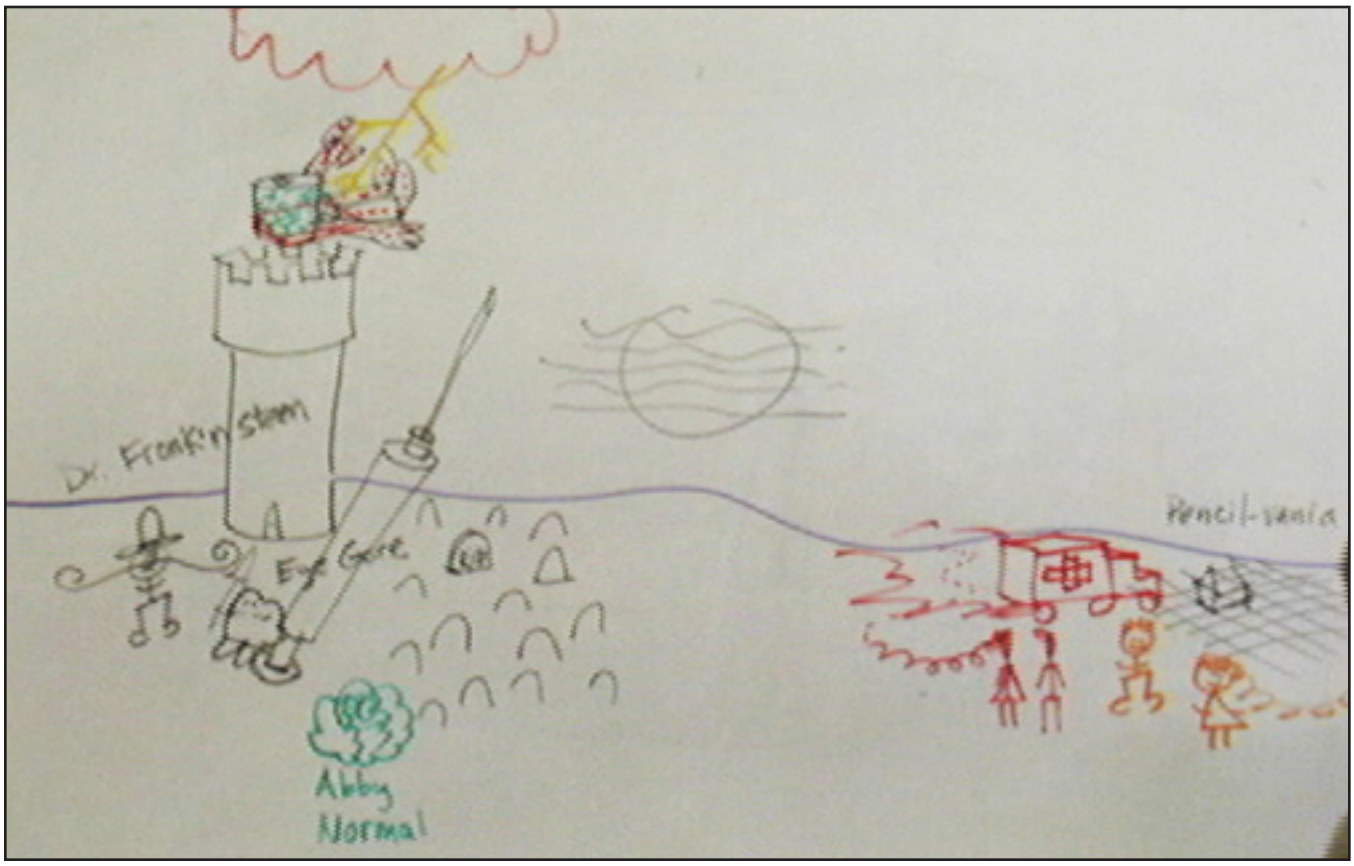
Other:

- Markers, water-based, colored

Prep Work:

- Pre-mix Elmer's Glue and water (half and half), about 1 cup of each.
- Pre-mix Borax and water:
  - 1 Tbsp Borax
  - 1 Cup Hot Water (doesn't have to be precise)
  - Let mixture sit until it cools and most of the Borax settles to the bottom.
  - In the experiment, use the clear liquid from the top.

Story Recap: "*Dr. Fronk'nsteen's Giant Brain*"



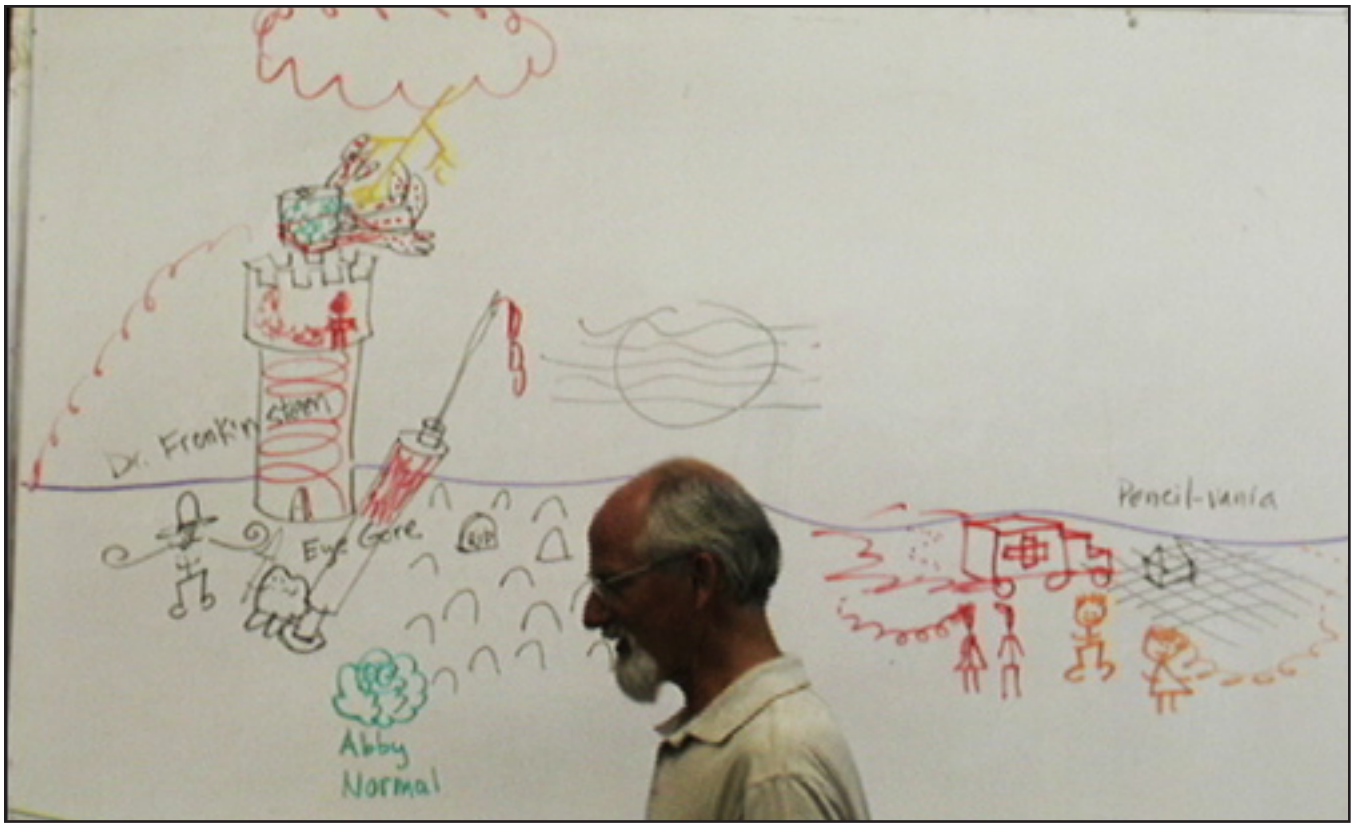
Part 1:

- In Transylvania, there lived a guy named Dr. Fronk'nsteen. He was the great-great-grandfather of Evil Mister Fred and looked a lot like him.
- His helper was one of the very first minions. He was a hunchbacked minion, and his name was Eye Gore.
- Dr. Fronk'nsteen wanted to create life where there was no life before. So he would send Eye Gore to dig up body parts in the cemetery.
- One day Eye Gore found a casket with a giant brain inside, and the brain was still alive, because it winked at him. The brain's name was Abby Normal.
- Dr. Fronk'nsteen put together a bunch of body parts and added the brain. The brain was squishy, so he put it in a bucket and cut a hole in the bucket so the brain could see out. The brain also had electrical connectors on the back of it, so Dr. Fronk'nsteen could hook it up to electricity.
- He needed blood for the body, so he sent Eye Gore with a giant hypodermic needle to get some. Eye Gore got a Red Cross truck and went to the nearby town of Pencil-vania.
- Jack and Jill lived in Pencil-vania making and selling pencils that had mirrors on the back. This is because the people living in Pencil-vania were very vain so they liked to look at themselves in the mirror.

Story Recap (cont.): "*Dr. Fronk'nsteen's Giant Brain*"

- Jack and Jill saw the Red Cross truck and offered to donate blood. Jack went into the truck first. He was concerned when he saw the giant needle, but Eye Gore hit him on the head with his baseball bat and drained out all of his blood. When Jack left the truck, he was really skinny.
- Then Jill went in and the same thing happened to her. Then Eye Gore drove away with their blood.
- Dr. Fronk'nsteen transferred the blood to the monster. Then a storm came by, a lightning bolt hit the monster, and it came alive and starting dancing around and singing the Barney song, which was driving people crazy.
- Jack and Jill needed to find a way to reinflate themselves so they could help the town.

Story Recap (cont.): "*Dr. Fronk'nsteen's Giant Brain*"

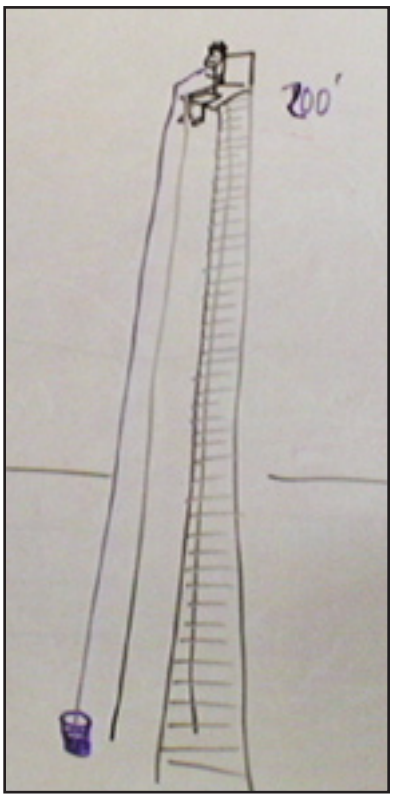


Ending:

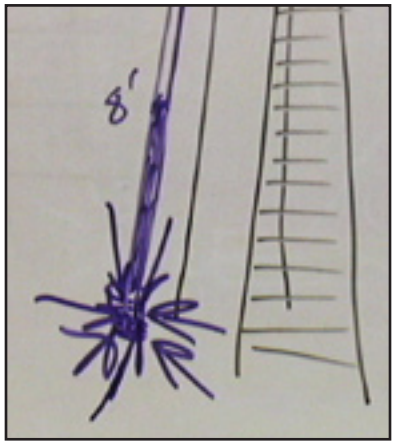
- Jack and Jill ran to Dr. Fronk'nsteen's castle, but the door was closed and locked. But Jack and Jill were really skinny, so they squeezed in through a crack around the door.
- They ran up the spiral staircase that ended in a trap door that was also locked. They looked up through a knothole and saw Dr. Fronk'nsteen dancing happily with the monster. Eye Gore was there with his giant needle.
- Jack and Jill jumped up through the knothole. Dr. Fronk'nsteen told Eye Gore to get them, so Eye Gore started to charge at Jill with his giant needle.
- Jill shoved the needle aside and it stuck into Dr. Fronk'nsteen.
- When Eye Gore tried to pull it out, he sucked out Dr. Fronk'nsteen's blood, so he became skinny.
- Jack saw this and jumped onto the end of the needle, so the blood went into his body. But there was non left for Jill.
- There was a kitchen sink there, so Jack put Jill in the sink and turned on the water, and Jill puffed back up.
- The monster saw that Dr. Fronk'nsteen was really skinny, so he picked him up and started dancing with him and singing the Barney song. The song gave Dr. Fronk'nsteen so much stress that his head exploded. Jack and Jill sent the monster to Barney Land, where he could sing as much as he wanted.

Transcript: Intro

Now, let's suppose that your parents bought you a new chair. And you like to sit on your chair and dangle your feet over the edge. There's you, sitting on your chair. And your chair is about two hundred feet high. And if you climbed all the way to the top and were sitting there enjoying the countryside around you, and you remembered you left your glass of grape juice on the ground -- and there it sits on the ground -- and you'd have said, "Aw, no!" And you reach in your back pocket and you pull out a straw. A bendy straw. And you just *[draws long straw]* right down into the grape juice. And now here you are, two hundred feet up in the air, and you start sucking on the straw. Will you have your grape juice? Some say yes, some say no.



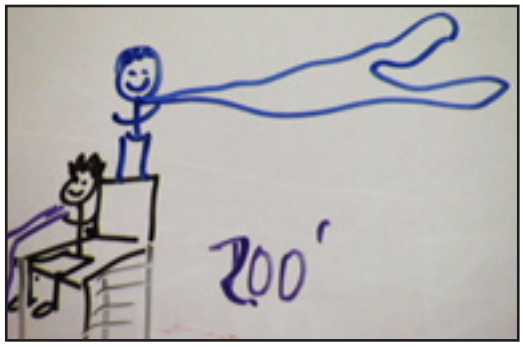
Sucking through a long straw.



Air pushes juice up 8 feet.

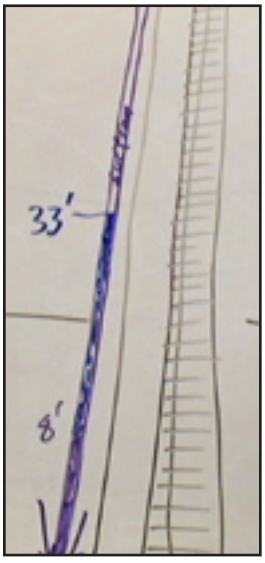
Well, it turns out that grape juice goes up the straw because of . . ? *[Students: Gravity. Sucking.]* So you create an area with suction in the straw. But suction itself isn't what makes the juice go up. Something has to push it up. It's hard to pull things up. You ever tried to pull air up? There's air all around this, and the air pushes on the juice in the cup, and pushes on the bottom of the straw, and pushes on the side of the straw, pushes from every direction. And it's the pressure that's all around us that we're not usually aware of, and it pushes the juice up the straw.

Let's suppose that you're able to suck the juice up about eight feet. And it's not coming up and you're still thirsty. And now you want to see if this is even possible. And you happen to look behind you, and right behind you there's somebody standing on the back of your chair. And he's wearing a big cape, and he has a giant "S" printed on his chest -- SuperKid. So you say, "Hey, SuperKid! I can't suck the grape juice up here. You're super. If you can't do it, nobody can do it." SuperKid says, "I'll do it!"



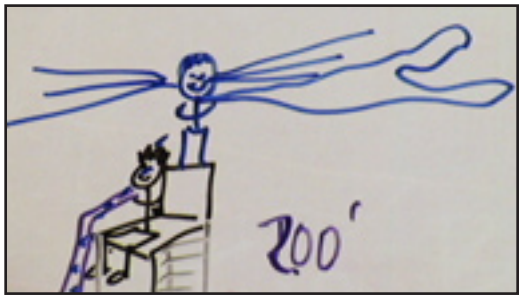
SuperKid on the chair.

So he takes the straw and goes *[makes sucking sound],* "Superpowers!" and sucks as hard as he can, and the grape juice starts going up: eight feet, ten feet, twelve feet, fourteen, sixteen, eighteen, twenty, twenty-two, twenty-four, twenty-six, twenty-eight, thirty, thirty-two, thirty-three feet.



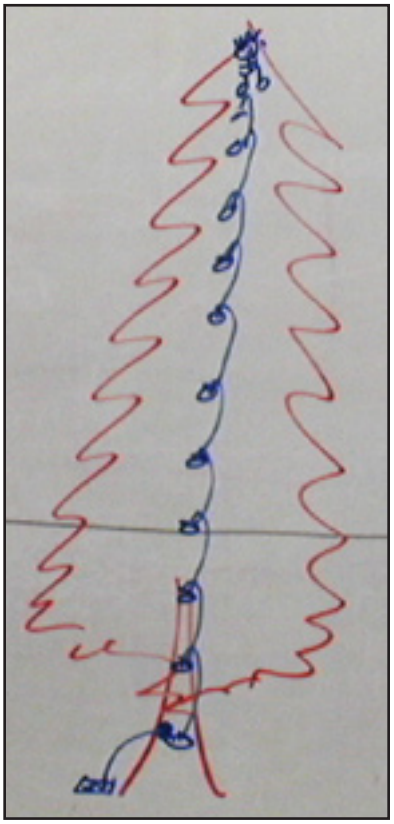
Sucked up 33 feet.

And then it starts to boil in the straw. The grape juice -- all the water in the grape juice turns into steam. The steam goes up the straw and comes out the ears of SuperKid. But the liquid stays at thirty-three feet. Because the atmosphere pressure around us, that's as high as it can push it. If you went to Venus, where the atmospheric pressure is five hundred times more, then you could suck it up five hundred times higher. But we're not on Venus. So that's as far as it will go.

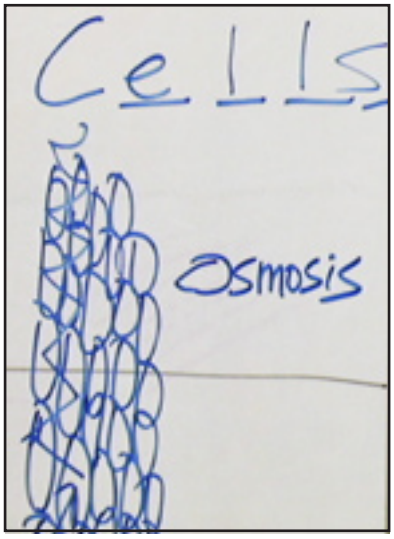


Steam coming out of SuperKid's ears.

And then you say to SuperKid, "There's something wrong here, SuperKid." And SuperKid says, "Yeah, I can't get any grape juice." And you say, "No. In my back yard, there's a redwood tree. And the redwood tree is two hundred feet tall. And I climbed clear to the tippy-top of the redwood tree one day, and I broke off one of the branches, and you know what was coming out of it? Sap. And it was wet sap." So here you are at the top of the tree. "And the branches were green, so there had to be water at the top of the redwood tree." How come they can take water up two hundred feet, but we can't? *[Students offer suggestions.]*


Redwood tree with pumps.

Well, maybe the redwood tree has in its trunk little swimming pools every ten feet, and swimming pool pumps that pump the water up to the next pool. So there'd be just a pump there, and maybe the redwood tree has an outlet there to plug in the pumps. So it would pump from one to the next, all the way to the tippy-top. And if you're just doing it ten feet at a time, that's no problem. You can get water all the way to the top. Have you ever cut a redwood tree to see if there are swimming pools inside?



Cells moving water upward.

Well, it turns out there are no swimming pools in a redwood tree and no pumps and no electricity. But what there is, is long skinny kind of oval-shaped things that the bark and the outer layers of the tree are made out of. And these things have a name that start with the letter "C". *[Students guess.]* They're cells. And the cells act kind of like the swimming pools and the pumps. Each one of these cells can make its own electricity, and it has a skin on it, and it can absorb water and get rid of water. It can take water from the roots, make it go into the cell, and then that cell can give water to the next cell. And he can give it to the next one, and he can give it to the next one. This process can go on, up and up and up and up and up and up, as far as they like to go. And the process where water can go through a cell like that was so cool that they gave it its own name. And they call it "ostrich-mosis," but they abbreviate it "osmosis."

Osmosis is how water can go through all the cells of your body. Have you ever gone swimming, and does your skin get wrinkled? Only your fingers? Did you look at your toes? Wherever your skin is thick, it can get wrinkled. And where your skin is thin, it doesn't wrinkle. So I went online to find out why the skin wrinkled. And on one site it said, "It's osmosis, because if you put one hand in a bucket of fresh water, and another hand in a bucket full of really salty water, and leave them there for three or four days, when you take your hands out, one will be all wrinkled. The other one won't, because the salty water prevented it from wrinkling." They said, "That's the osmosis!"

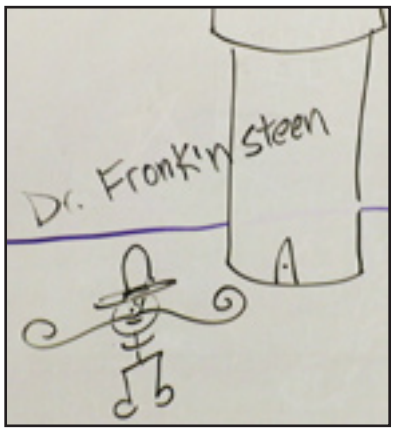
Another site said, "Those guys are crazy. Don't listen to them. The reason the one gets all wrinkled is because the thick skin absorbs water by diffusion, just like if you dip a chunk of leather in water, it can grow like a sponge absorbs water, and that's what makes it wrinkle."

And these guys said, "Don't listen to them." And this guy says, "Don't listen to them." And they're fighting back and forth. Now a third guy jumped in. And he said, "I'm a doctor. I do surgery twelve hours at a time sometimes. I reattach people's chopped-off hands, arms, legs, and feet and stuff. And I follow them, or I listen to them or talk to them for years after we reattach their limbs. When we first reattach it, it's numb. They can feel almost nothing on their hand, and it's hard for them to wiggle their fingers. Over time, they develop a little bit more feeling and can use some parts of what we reattach. But the weird thing is, when they go swimming, one hand will get wrinkled, and the one that was reattached doesn't." And he said, "I don't understand exactly why, but that's the way it works."

And other people said, "Well, maybe it has something to do with the nerves, because the nerves don't grow as well in reattached hands as they do in regular hands." But nobody's figured it out.

Story: *"Dr. Fronk'nsteen's Giant Brain"*

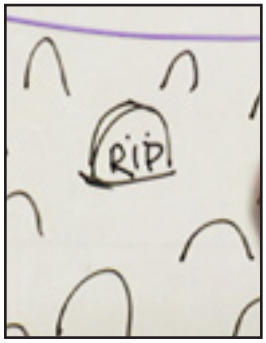
Let's see, we need a good story. Should it be a fairytale story, or should it be something else? *[Students make suggestions.]* An evil brain with a mustache? Okay. We're going to have a giant evil brain with a mustache.



Doctor Frank'nsteen.

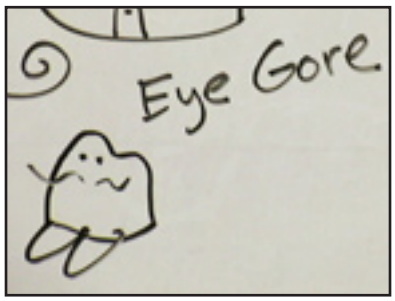
Once upon a time, there was a city in Transylvania. And there was a guy living in the city. His name was Dr. Fronk'nsteen. He was the great-great-grandfather of Evil Mister Fred. And he just happened to look a lot like Evil Mister Fred.

Dr. Fronk'nsteen. And he had a helper. One of the very first minions was his helper. He was a hunchbacked minion, and his name was Eye Gore.



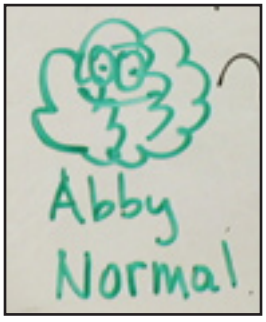
Cemetery.

And his objective in life was to create life where there was no life before. So he went to the local cemetery. Rest in Peace. And he would dig up bodies and take a part here and a part there, here a part, there a part, everywhere a part, part. He would put the parts together.



Hunchbacked minion Eye Gore.

Well, one day Eye Gore was out in the cemetery digging away stuff with his shovel. And he went and hit the casket, opened up the casket, and instead of a body in there, there was a giant brain. The brain had a big smile on its face, and it looked at Eye Gore and said, "Wink!" *[winks]*. And Eye Gore says, "Hey! I didn't know a brain could wink!" And the brain said, "Wink, wink!" *[winks twice]*. And Eye Gore says, "Cool!"

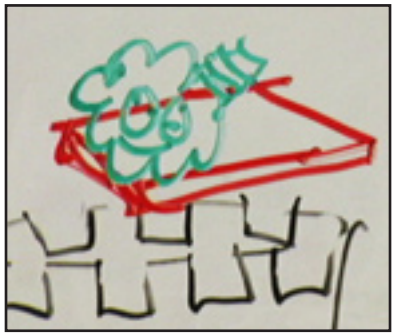


Giant brain.

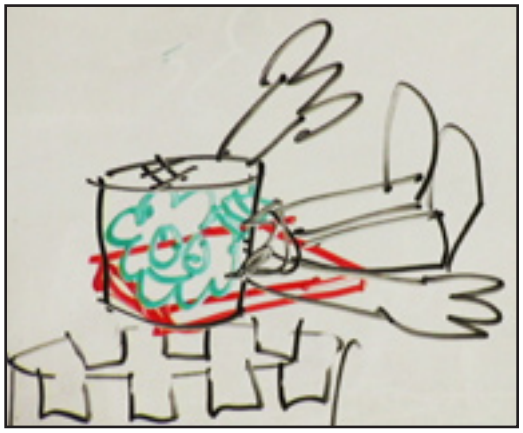
The brain had a name. Its name was Abby. Last name Normal. *[Student: I don't get it.]* It's an Abby Normal brain. *[Student: Oh, I get it.]* Abnormal, yeah.

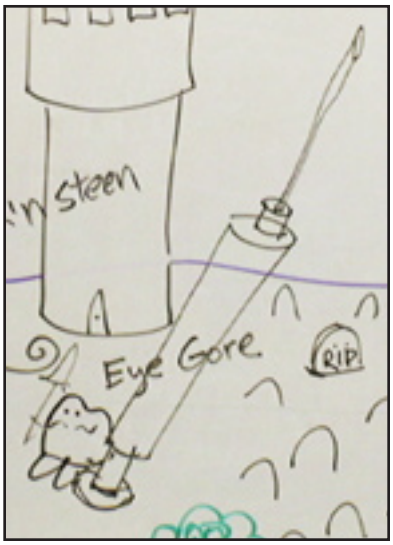
So Eye Gore took the brain back to Dr. Fronk'nsteen and said, "Doctor, we've got a brain for you." And the doctor looked at it and said, "What a fine brain that is. Look how large! We'll implant it right away."

And we'll put a bed up here. They put the brain on the bed. And they needed to attach some stuff to it. And he saw that there were electrical connections on the back of the brain, just like a computer. And he grabbed some arms and some legs and some bodies and a little of this and a little of that, and started putting them together. Sewing them all together. And the brain is kind of squishy, so he put the brain in a bucket. And he attached the other stuff to the bucket with tape and things. Oh, and it's got feet, and some arms, like that, and a body. And he put a window on the bucket so the brain could look out. There. He's created his monster.


Brain on bed.

The brain is alive. It can wink and do stuff. But the body is just parts. So he had to put life into the body. He says, "Well, it needs blood. But all these dead people, they always take the blood out. We've got to get some blood somewhere."

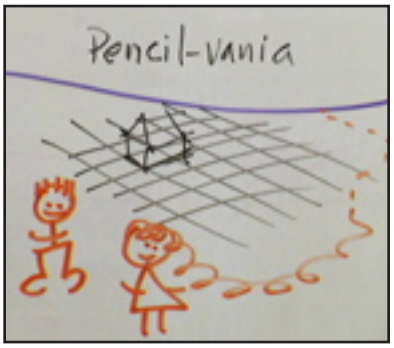

Monster body attached to brain.



Eye Gore's giant hypodermic.

So he sends Eye Gore out to get blood. He gave Eye Gore a hypodermic needle. There you go. He's got a big hypodermic needle, and his job is to go out and get some blood. And Eye Gore says, "Can I take blood from a horse? Or a pig or a cow?" And Dr. Fronk'nsteen said, "No, it has to be human blood."

So Eye Gore's wandering around. It's a dark and stormy night, and suddenly a shot rang out -- bang! Which woke up Jack and Jill, who lived in a small village near Dr. Fronk'nsteen's castle. *[Student: Pennsylvania!]* Pennsylvania? *[Writes "Pencil-vania."]* Pencil-vania. And Jack and Jill make pencils, with mirrors on them. *[Student: Everybody there is vain.]* Yeah, they're vain. So you have to have a pencil with mirrors on the back so they can look at themselves, because vain people like to look at themselves. And Jack and Jill are selling pencils to everybody in town.



Jack and Jill in Pencil-vania.

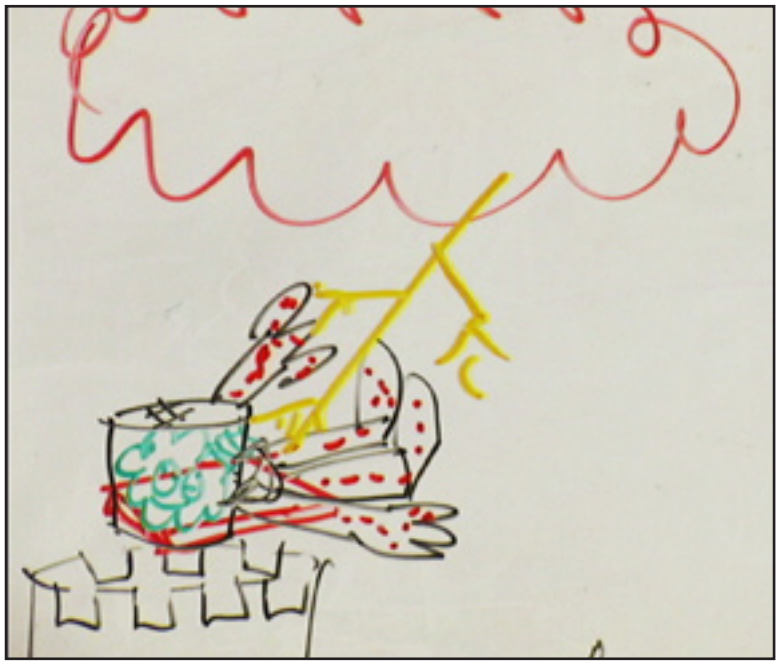
And Eye Gore is looking for someone to donate blood. So he found a Red Cross truck, and he drove into Pencil-vania. And Jack and Jill saw the Red Cross truck and they said, "Oh, someone needs blood. We're good folks. We'll donate blood." So Jill says, "Jack, you go first." Jack says, "All right!" So he went in there and Eye Gore says, "Now, just lie down and everything'll be fine." And then Jack saw the giant hypodermic needle. And Eye Gore hit him over the head with a baseball bat -- ba-donk! And he sucked all the blood out of Jack.


Jack and Jill with Red Cross truck.

And Jack came back out of the truck, and Jack's head looked like that. His body looked like that. He's really skinny. And Jill said, "Jack, you look a little drained." And Jack says, "Yeah, I don't know." And Jack had a bump on his head. So Jill went in, and Jill came out the same way, all drained out.

[Student: Except for the hair.] Yeah, except for her hair. And Jack and Jill looked at each other and said, "Uh-oh. This is not so good."

And Eye Gore drove away in a cloud of smoke and took the blood over to Dr. Fronk'nsteen, who transferred it into his monster. And the monster started to wiggle. He was getting warm. *[Student: He needs a heart.]* Oh yeah, he needs a heart. Where can he get a heart from? He went and found a clock down in the castle and implanted that in there and called it a heart.



Monster injected with blood is struck by lightning.

And then of course, a storm came by, and a lightning bolt hit the monster. And now, it's alive! And the monster started singing songs and dancing. He was an entertainer monster with a big bucket on his head with a window in it so he could dance around like this, with his brain sloshing around inside. And Dr. Fronk'nsteen didn't like this. He wanted a monster that would scare people so he could steal all their money.

Now, Jack and Jill are all drained out. They're trying to find some way to fill themselves back up. And the monster came into town and started singing . . . either the Barney song or It's a Small World After All. *[Students: Barney!]* The Barney song. Okay. He sang the Barney song, and people were going insane from the Barney song. Jack and Jill had to reinflate themselves so they could protect the people from monster Barney. If you were Jack and Jill, what would you do to reinflate yourself so that you could protect the town from the giant thing?

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 . . .

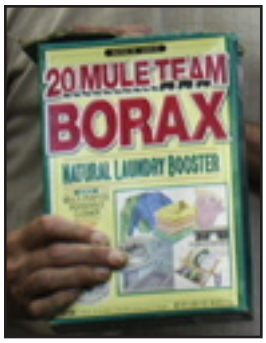
Experiment: "*Osmosis*"

Part 1: Glue and Borax Demo

Okay, we need to make a chemical that acts something like a snail or a slug. So this is a particular chemical that works with osmosis. They use it in reverse osmosis water purification systems. The chemical is called poly-vinyl alcohol. Polyvinyl alcohol loves to just absorb water, and under the right circumstances, you can take the water back out of it. You'll find it in things like Elmer's Glue, and you'll find it in stuff called Hi-Float. You all know what you do with white glue -- you glue things together with it. With Hi-Float, you put it inside of a balloon, and you smoosh it around so the whole entire balloon is covered with this gooey stuff. And then you fill the balloon with helium. Well, the Hi-Float dries inside the balloon, and it forms a layer in there of plastic that keeps the helium inside. Both of these have lots of polyvinyl alcohol in them. So we're going to test them and see what happens.

The molecules in both the Hi-Float and the glue are like you. If I were to attach rocket packs to your back and light them off inside the room, and then now you're going boing, boing, boing, boing, boing, boing, boing, boing, bouncing off all the walls.

But when we put the rockets on you, you guys all of a sudden hate each other. You can't stand to be near another person. So as you're flying around the room, you say, "Stay away! Stop that! Get away from me! No!" And then a giant hand rips open the roof and sprinkles on everybody Love Potion Number Nine. And now everybody says, "My buddy!" Group hug. Now there's a giant blob of group hugs.



Well, it turns out there's a love potion for poly-vinyl alcohol. And it's a common chemical that you've obviously heard of. And it comes in a green box, and it's called sodium tetraborate decahydrate *[holds up box of Borax]*.

Pouring Borax onto the puddle of Elmer's Glue.

Now, suppose you're at home and your parents have just bought a brand new table. And you want to do an art project at the table. And your parents say, "Now, whatever you do, don't spill any glue or anything on our brand new table." And you say, "Okay! *[knocks over bottle of glue]* Oops! *[glue starts pouring out onto table]* Oh, no! The poor table! Glue on it!" And your parents say, "Oh, boy, now you're in trouble." What are you going to do? You say, "Get some water and clean it up." And the parents say, "Oh, sorry, the plumber's here. The water's turned off." And you say, "I know! I'll get some soap and clean it up." The parents say, "What good is soap?"

Mixing the glue and Borax.

The mixture turns into a blob.

So you pour some soap on it *[pours Borax onto the puddle of glue]*. "There! Now it's clean!" And they say, "No, it's not." So you go, "Oh, I'll just mix it all around." *[Use fingers to mix Borax into the glue.]* So you mix it all around. And your parents say, "Wait, what's happening here? It's doing something." *[Student: Cleaning the table.]* It's cleaning the table. There. Now we just have some flakey soap on there, but your table is clean, and you have a . . . *[picks up the blob of Borax-glue mixture and drops it on the table a few times]*. The polyvinyl alcohol guys have joined each other and glumpified. That's a technical term *[tears off pieces of the blob and and hands them to the students to feel]*. It's tough.

So we want to make a better version of this stuff. You can put those in the middle. We'll save them because we're going to compare them with something else later. So we want to add water to that. If we just take some of this *[picks up a piece of the blob]* and throw it in water *[drops it in a glass of water]*. There. There's a chunk of it in water. We'll see if we can get it to turn back to liquid. It's just swimming around in there. *[Student: Did it get softer?]* No, unfortunately. We're going to let it sit there and see what it does.

Glue and water.

Scooping out glue mixture onto table.

Now, we want to make a better version of this, and someone said we need to add water to it. So we'll add water to it. We're going to take some glue and add about the same amount of water as there is glue. And I already have some mixed up because it works better. This stuff is half water and half glue. It's more liquidy. *[Student: Don't drink it though. Other student: It's delicious, though!]* Well, it'll stick to your ribs. Let's see, *[reading label on glue bottle]* it says easy cleanup, dries clear, nontoxic, no harmful fumes. You could drink it! Yecchhh! I'm not going to drink it.

So we're going to give you each some of this stuff, and then we're going to give you Borax. But Borax is really gritty by itself. It's like dust or dirt. So we're going to pour the Borax in water. And this has been sitting in water overnight. You can see that most of the Borax has settled to the bottom. Clear water is on the surface.

Borax and water.
Upper part is clear.

Part 2: Students Mix Glue and Borax

So we'll give each of you a couple of scoops of this stuff *[scoops out glue-water mixture onto table in front of each student]*.

When you go to college, they don't usually do chemistry experiments on the tabletop like this. And they don't usually let you mix chemicals with your bare fingers, because you might not have fingers when you're done. They usually do it in beakers or test tubes or flasks. But here, since this is nontoxic, we can do it on the table.

Now I'm going to put on some of the liquid, and then you can stir it around *[pours some of the Borax-water mixture onto each puddle]*. *[Student: With your fingers?]* Yes, with your fingers. Mix it really well, so it all turns into stuff.

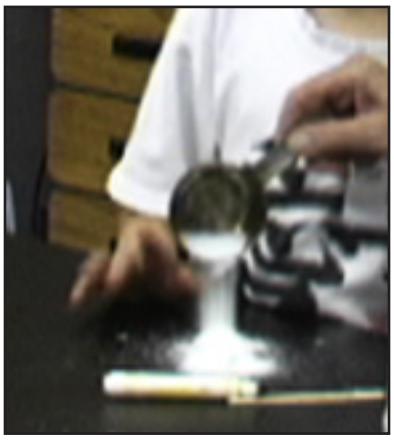
Pouring Borax mixture onto the glue puddle.

Pushing with popsicle stick.

After you get it mixed really well, I'll give you a popsicle stick. And you use it like a bulldozer and go back and forth and back and forth and back and forth and go chunka, chunka, chunka, chunka, chunka, chunka. Keep pushing it around until it becomes kind of like a floating blob. Try not to get it on your clothes. It'll wash out of your clothes, but it'll be there for awhile. Try to get as much un-stuck from the table as possible. And then play patty-cake with it once you get it un-stuck from the table. If you keep squeezing it like this, and mix the Borax into it, slowly it'll become more and more rubbery and drier.

Coloring the artificial rubber.

What we've made is artificial rubber. This is called vinyl rubber. You can color it *[passes out water-based markers and students use them to color their blobs]*. After you have yours colored, you're going to divide it into two pieces. One piece you're going to keep, one piece you're going to experiment with. Pick whatever you've made, set it on the table, take your popsicle stick and cut it in half. One half I'll give you a ziplock bag. You can set it in there *[passes out a ziplock bag to each student]*.



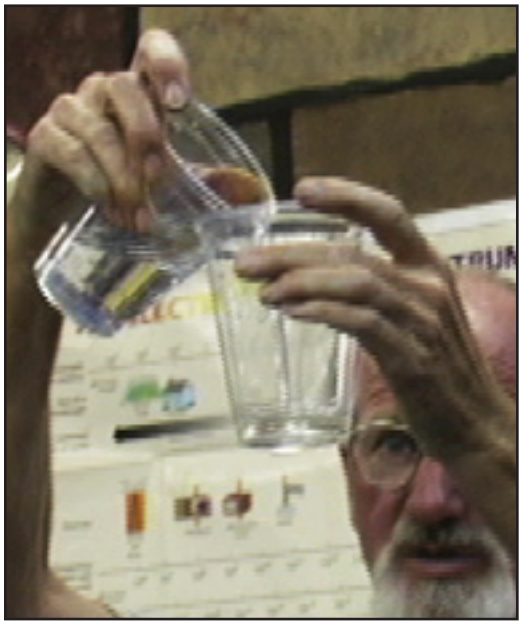
Pouring salt.

Now we have ordinary table salt. It's going to snow on one half of your piece. When I pour snow on the piece that you still have, then you're going to goosh it around and smoosh it around *[pours salt on each piece]*. Work the salt in as much as you can. Is the salt getting drier or wetter? *[Students: Wetter. Drier --it's tearing apart.]* You need to keep working the salt in. *[Student: It's dissolving.]* It's dissolving?

Look at that, you can squeeze the water right out of it. You should be able to turn it into almost like lumps of sawdust or something. It's just glumpy. You can rub it between your hands, and it'll turn into little grains of crud. If you have any sores on your hand, this is a good way to help your sores clean up and heal. Salt kills off the bad bacteria.

Scrape the salt water and the glumpy stuff into a pile. After you have a pile there, you can go wash your hands. *[While students are washing their hands, Instructor scrapes all the students' glumpy stuff off the table and into a clear plastic cup.]*

Squeezing the water out.



Adding water to the Hi-Float.

Now we have layers of stuff. Now, this stuff is a lot like the first batch that we made with no water in it. It's just this hard lumpy thing. We want to see what happens if we use some polyvinyl alcohol that's more pure.

Part 3: Four Kinds of Slime

If you take some kind of this polyvinyl alcohol *[pours some of the Hi-Float into a clear plastic cup]* . . . You're supposed to carefully mix it, one part of this stuff to four parts of water, but we're not being careful today. It's only going up that high. And we can mix some water with this . . . that's one part. Four parts is probably right about there *[pours water into the cup containing the Hi-Float],* so we'll go up to about there. There. Then we'll stir it *[starts mixing it with a popsicle stick].*

Have you ever seen the movie Ghostbusters? *[Students: Yes!]* In the movie, in the first scenes of the movie, they're in a library. And they're running around -- *[Student: The mucus stuff!]* Yeah, the mucus slimey stuff. You know, they have to make something that's nontoxic, that doesn't really harm furniture too much, that they can put all over the bookcases and they can pour all over the guys. You're supposed to stir this a long time, but we're not going to. Usually, if you put it in a blender it works better. We're just going to mix a little bit of it.

Four puddles of Hi-Float mixture.

Now, we want to try to find out what looks like the best slime. So we're going to make a couple of different puddles *[pours the mixture onto the table, forming four separate puddles].* There's puddle one, puddle two, puddle three, puddle four. There. Now we've got puddles. We're going to take one puddle and put on the Borax straight from the box *[pours Borax onto first puddle].* There we go. And mix it all up *[mixes it with fingers]* and see what kind of a slimey stuff it makes.

There. Now, it's made a blob of stuff that's *[pulls it apart]* a lot like -- it's a little bit softer than that stuff. You can pass that around.

Soft glob from first puddle.

Pouring Borax solution on puddle.

On the next one, we're going to add a whole bunch of the Borax solution *[pours Borax-water solution on the second puddle and mixes it with fingers]*. And then this stuff, if you mix longer, now let's take a look at it *[picks up some of it]*. This is pretty good slime. It makes a nice sound when it hits. It kind of goes splot! Just like worms.

Slime.

Then we'll take this puddle and add a little less stuff *[pours Borax-water solution on the third puddle and mixes it with fingers]*. With pure polyvinyl alcohol, it absorbs the moisture from the Borax mix. So the less Borax you use, the stiffer it's supposed to be. And now it's getting stiffer.

Then for our last puddle we'll just put in a little dab *[pours Borax-water solution on the fourth puddle and mixes it with fingers]*. *[Student: I want to put salt on mine.]* Oh, yeah, we could put salt on one, too. That's about the limit to it's stiffness. The slime will stay slimey -- it's not as bouncy as the other stuff you created.

Let's take some of this -- let's collect what we can of it *[gathers up the second, third, and fourth puddles with fingers]*. Come over here if you want to touch it. You just need to clean your hands off when you're done.

I'm going to put salt on this stuff. I'm going to put this slime in this cup *[puts the slime in a clear plastic cup]*. *[Student: It doesn't want to get off (of your fingers).]* No, it definitely doesn't want to get off. And add some salt to it *[pours salt over it, then works the salt into the slime]*. There we go. Now we've got slime and salt. So if you get slimed by a ghost, pour salt all over yourself. Here's the salty slime. Now it comes off, and you can squeeze the water right out of it. And it comes off your hands. *[Student: So basically, salt makes water come out?]* Yeah, exactly right. When you stick your hands in salt water, it makes the water come out and your hands don't wrinkle.

Pouring salt onto the combined slime.

So now, this is the slime after we added salt to it and squished it. It becomes more like the other stuff did.

Now we need to create an ending for our story.

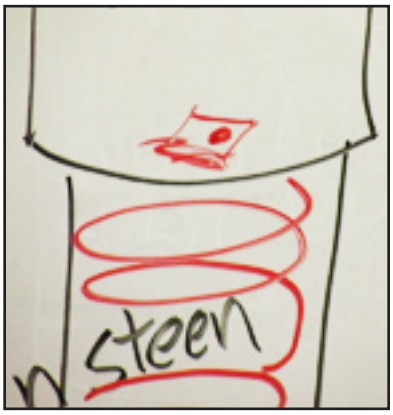
Slime and salt mixture after water is squeezed out.

End of Story

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

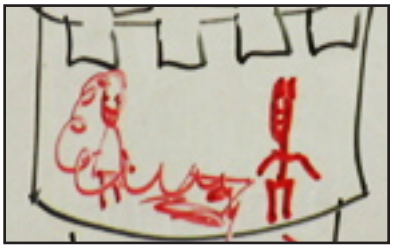
So Jack and Jill are living in Pencil-vania. They've given blood, and they became very, very skinny. Evil Mister Fred's great-great-great-grandfather, Dr. Fronk'nsteen, has created a monster with a bucket and brain and a bunch of body parts -- and blood from Jack and Jill. Eye Gore has still got his giant hypodermic needle laying around somewhere. You never know what he's going to do with that.

Jack and Jill are running around really, really skinny, which is kind of handy if you need to sneak in somewhere and help yourself. So they ran over to Dr. Fronk'nsteen's castle, and the door was closed and locked. But they could see light from around the edges of the door. And Jack said, "We've got to get inside and find out what they've done with our blood." Jill said, "No problem." She backed up, ran toward the door, and ran right through one of the cracks by turning sideways. And Jack said, "All right! I can do that." And then Jack zoomed right through, too.

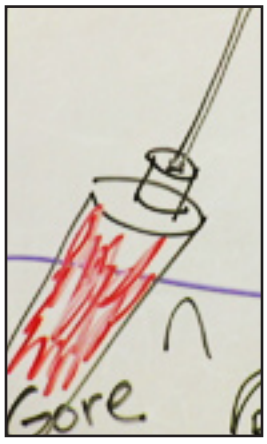


Trap door with a knothole at top of spiral stairway.

Once they got inside, they found a spiral staircase that went up and up and up and up and up. And the staircase ended at a trap door in the ceiling. And the door was locked and bolted. And of course, they found a knothole. And they could peer through the knothole. And they saw evil Dr. Fronk'nsteen, dancing around with the monster, saying, "You've done it! You've done it! You're driving the people of Pencil-vania crazy with your songs. I love this job!" And the monster was singing the Barney song, dancing all around.


Jack and Jill in the castle.

And Eye Gore was up there, dancing with them, with his giant hypodermic needle. And Jack and Jill said, "We've got to go in there and get our blood back. Obviously, he's put it into that monster." So Jack jumped up throught the knothole and appeared right before Dr. Fronk'nsteen, right there. And he says, "You're evil Doctor Fronk'nsteen, and you'll never get away with this." And Dr Fronk'nsteen said, "Oh, a little pencil creature. Pretty cool!" And then Jill jumped through the hole and appeared on the other side, all skinny. And he said, "Aww, two of them, how nice!" And he said, "Eye Gore, take care of these two."



Hypodermic with blood in it.

And Eye Gore took his needle like this and he started running towards Jill. And Jill grabbed the needle and shoved it aside, and it stuck right into Dr. Fronk'nsteen. And Eye Gore says, "Oops!!" And he tried to pull it out. He was grabbing on this end, and he was pulling it out of Dr. Fronk'nsteen, and he accidentally sucked the blood out of Dr. Fronk'nsteen.

And Dr. Fronk'nsteen said, "Noooo, you idiot!!" And Eye Gore says, "Oops!" And he tried to push it back in. But when he did, the blood was squirting out the end of the needle in droplets. And Jack said, "I could use that!" And Jack jumped on the

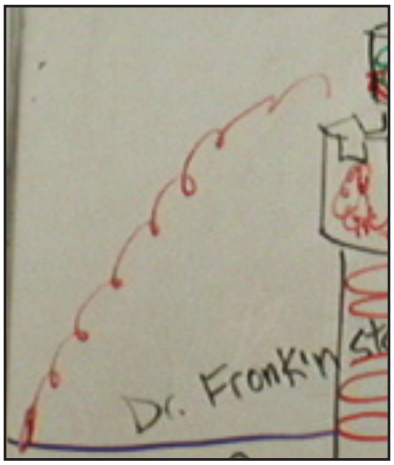
needle to sacrifice himself, and all of Dr. Fronk'nsteen's blood went into Jack. And Jack puffed up.


Jack puffed up.

And Jack said, "I feel better already. I've got strength!" And now Dr. Fronk'nsteen's really skinny. Imagine him a little skinny guy. And Jill said, "I need some of that! You took all of it!" And Jack said, "Oh, no!"

He looked around and there was a kitchen sink there. He put Jill in the kitchen sink and turned on the water. And Jill puffed back up, because osmosis made the water go into Jill. Now Jack and Jill are full size and Dr. Fronk'nsteen is all skinny. And the monster says, "Oh, look! Someone to dance with!" He picked up evil Dr. Fronk'nsteen and started dancing with him and singing the Barney song. And Dr Fronk'nsteen's eyes are going, "No! No! Please, not that song! Any song but that song!" He was under such great stress that his head exploded.

And Eye Gore says, "Finally rid of him!" So we need a head explosion off in the distance.



Dr. Fronk'nsteen's exploding head off in the distance.

So now it looks like everybody has a possibility of living happily ever after, except evil Dr. Fronk'nsteen. The monster is still singing the Barney song. And he can get out of the castle and go and drive other people all over the world crazy with his song. Jack and Jill have a tough decision to make. Should they kill the monster, or should they let it live someplace where he can do the most good? *[Students: Live!]* Live. Where should you send the monster that sings a song like this where it will do the most good? *[Student: To Barney Land!]* To Barney Land! And everybody lived happily ever after, except Dr. Fronk'nsteen.

End of Lesson

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