Brains On (APM) | Brains On! Shocking! The science of static (Electricity Series pt. 1) 1QDE6EPJKVR9E3RPHGM6PYEGJG

KID: You're listening to *BrainsOn!* where we're serious about being curious.

KID: *Brains On!* is supported in part by a grant from the National Science Foundation.

[MUSIC PLAYING]

MOLLY BLOOM: Our Listeners write us every day with questions.

SUBJECT 1: But there's one topic that has been more popular than any other.

MOLLY BLOOM: That's right.

SUBJECT 1: Electricity.

ELIJAH: Hi, I'm Elijah Danielson from Albuquerque, New Mexico. I'm eight-years-old, and I want to learn how static electricity works. Can you do a show on electricity?

KID: Where does electricity come from?

KID: How do batteries have that much energy inside when they are so little?

KID: I would like to know how your brain could make electricity.

[MUSIC PLAYING]

MOLLY BLOOM: And it makes sense electricity is central to our lives.

SUBJECT 1: It powers our gadgets.

[COMPUTER TURNING ON]

MOLLY BLOOM: Our vehicles.

[CAR STARTING UP]

SUBJECT 1: Our homes.

[DOOR BELL RINGING]

MOLLY BLOOM: It comes from the sky.

[THUNDER CRASHING]

SUBJECT 1: It courses through our bodies.

[HEART BEAT]

MOLLY BLOOM: It's everywhere.

SUBJECT 1: We have four electrifying episodes.

MOLLY BLOOM: Today's episode is truly shocking.

[THUNDER CRASHING]

Pun intended.

SUBJECT 1: Keep listening.

[MUSIC PLAYING]

- E-L-E-C-T-R-I-C-I-TY, electricity, my oh my. It's an exchange of charge from electrons, you'll see. And it's a form of energy. Electricity, electricity, electricity, electricity, electricity, electricity, electricity, electricity, electricity, electricity. E-L-E-C-T-R-I-C-I-T-Y.

MOLLY BLOOM: You're listening to *Brains On!* From American Public Media. I'm Molly Bloom, and my co-host for this electricity series is 10-year-old, Hobte Martone from Mountain View, California. Welcome, Hobte.

SUBJECT 1: Thanks for inviting me.

MOLLY BLOOM: Do you remember the last time that you got like an electric shock from something? Like, when you touch a doorknob, or like someone's sweater, or something?

SUBJECT 1: Maybe every once in a while when I plug something in.

MOLLY BLOOM: And what did it feel like when that happened?

SUBJECT 1: It feels like a little tingling through my finger.

MOLLY BLOOM: Yeah, well, it happens to me all the time, because here in Minnesota, the air is really dry, and it's really easy to shock yourself. And sometimes it even hurts. And I think this happens to a lot of people because we've gotten a lot of questions on this topic, like this one from Nora.

NORA: I live in Sant Pere, Wisconsin. And my question is, why do I sometimes get an electrical shock?

MOLLY BLOOM: That shock comes from static electricity.

SUBJECT 1: And that story of static electricity starts with a gem.

MOLLY BLOOM: Amber specifically, that translucent, orange hued material that is actually fossilized plant resin.

SUBJECT 1: And a scientist named Thales in the year 600 BCE.

SUBJECT 2: He's the first one who wrote down his observations, observations he didn't understand about rubbing Amber and noticing that when he rubbed it, it would attract small lightweight objects.

MOLLY BLOOM: That's Becky Burnett, she's in charge of Education at the Bakken Museum in Minneapolis.

SUBJECT 1: At this science museum with a special focus on-- you guessed it.

[ELECTRIC SHOCK SOUND]

Electricity.

SUBJECT 2: He called in his friends and he asked them, what do you think is happening here? And a good portion of them said, oh, it's magic, because that was a perfectly reasonable explanation. Other people thought that Amber, this rock, was alive, and that when Thales rubbed it with his wool or his fur pad that it would wake up, yawn, and small objects would be attracted to it.

MOLLY BLOOM: Others thought that it was a magnet, not fully understanding what a magnet was.

SUBJECT 1: Fast forward about 2,000 years to the 1500's and a man named William Gilbert.

MOLLY BLOOM: He was investigating magnets on behalf of his employer, the Queen of England.

SUBJECT 1: Gilbert was trying to determine which materials were magnets and which weren't.

MOLLY BLOOM: What a cool job.

SUBJECT 1: Right?

MOLLY BLOOM: Many people thought amber was a magnet because it attracted these small objects.

SUBJECT 1: Through a series of tests, Gilbert determined, nope, amber is not a magnet.

SUBJECT 2: And he felt that this attraction, this action, this phenomena deserved a name. And so he decided to use the Greek word for amber, which is electra, to call whatever this force that was growing on the outside of the amber as you rubbed it. He determined that it should be called electricity based on the Greek word electra for amber. And that's how the word electricity came to us.

MOLLY BLOOM: So what is happening on the outside of amber when you rub it?

SUBJECT 1: It's the same thing that happens when you make a balloon stick to your head.

MOLLY BLOOM: Or your skirt clings to your tights.

SUBJECT 1: It's static electricity at work.

MOLLY BLOOM: To understand electricity, we need to know a few basic things.

ROBOT: Number one.

SUBJECT 1: Electrons have a negative charge.

ROBOT: Electrons are negative.

MOLLY BLOOM: Everything is made up of tiny atoms. And atoms have a center called a nucleus.

SUBJECT 1: Which contains even tinier particles called protons and neutrons.

MOLLY BLOOM: And then zipping around that nucleus are electrons.

SUBJECT 1: Quick tip, protons are positively charged and electrons are negatively charged.

MOLLY BLOOM: Neutrons are neutral as you would guess from their name. That means they aren't positive or negative. They're just there.

SUBJECT 1: Because these electrons are zipping around the outside, it's possible for atoms to give away electrons.

ROBOT: Bye, bye, electron.

MOLLY BLOOM: Or pick up electrons.

ROBOT: Hello, electron.

SUBJECT 1: If an atom picks up enough electrons, it can end up with more negatively charged particles than positive ones, and it becomes negatively charged.

ROBOT: Hello, electron. Now, I'm negative.

SUBJECT 1: If it loses electrons and ends up with more positive particles than negative ones, we say it's positively charged.

ROBOT: Bye, bye, electron. Now, I'm positive.

MOLLY BLOOM: Here's the second thing to remember.

ROBOT: Number two.

SUBJECT 1: Opposites attract.

ROBOT: Opposites attract.

MOLLY BLOOM: So if something has a positive charge, it will attract something with a negative charge.

SUBJECT 1: This also means if you have two things with a positive charge or two things with the negative charge, those things repel.

MOLLY BLOOM: Opposites attract, and like repels like. So when you rub a balloon on your head--

SUBJECT 1: Your hair gives away electrons really easily.

ROBOT: Bye, bye, electron.

MOLLY BLOOM: And latex, the material the balloon is made out of picks up electrons really easily.

ROBOT: Hello, electron.

SUBJECT 1: So when you rub these two things together, they exchange electrons.

ROBOT: Bye, bye, electron. Now, I'm positive. Hello, electron. Now, I'm negative.

MOLLY BLOOM: And since they now have opposite charges, they can stick together.

SUBJECT 1: Now, you can walk around with a balloon on your head.

MOLLY BLOOM: And the reason your hair stands on end is that each individual hair is positively charged. Since like charges repel like charges, each hair is trying to get away from the other ones making them stand up.

SUBJECT 1: And looking really awesome in the process. [LAUGHING]

MOLLY BLOOM: Now, some materials just naturally want to give away electrons and others naturally want to pick them up. So if you rub two things together that both like getting rid of electrons--

SUBJECT 1: Like hair and skin.

MOLLY BLOOM: You won't get that buildup of static charge.

SUBJECT 1: But rub something that loves getting rid of electrons against something that loves taking them--

MOLLY BLOOM: Like hair and latex.

SUBJECT 1: Static magic.

MOLLY BLOOM: So let's get back to Nora's question.

NORA: Why do I sometimes get an electrical shock?

MOLLY BLOOM: When you build up a static charge, there's nowhere for it to go. It's just sitting there.

SUBJECT 1: The word static actually means not moving.

MOLLY BLOOM: Here's the third thing you need to know.

ROBOT: Number three.

SUBJECT 1: Conductors let electron flow.

ROBOT: Conductors go with the flow.

MOLLY BLOOM: Metal is a great conductor. But things that aren't metal generally aren't, like your hair or your clothes. Those are called insulators.

SUBJECT 1: So that means if you get a buildup of electrons on your clothes or your hair, they just sit there until--

[SHOCKING SOUND]

MOLLY BLOOM: You come into contact with a conductor.

SUBJECT 1: Like a doorknob.

MOLLY BLOOM: Which allows the electrons to flow away.

ROBOT: Bye, bye, electron.

MOLLY BLOOM: Here in Minnesota, winter is a shocking time because the air is so dry, meaning, there's very little water in the air.

SUBJECT 1: In water, it's a conductor.

MOLLY BLOOM: So if there's humidity or water in the air, or if your skin, or hair, or clothes have even a little moisture on them, you're less likely to have a buildup of static charge.

SUBJECT 1: That wetness helps those extra electrons flow away before they build up. But if it's dry--

MOLLY BLOOM: Those electrons build up and are ready to jolt you when you least expect it.

SUBJECT 1: Zzzap!

MOLLY BLOOM: Now, Hobte, this won't shock you, but we have a charge for your ears. It's time for the mystery sound.

[RANDOM SOUNDS]

SUBJECT 3: Mystery sound.

[RANDOM SOUNDS]

MOLLY BLOOM: Here it is.

[CLICKING SOUNDS]

[BELL RINGING]

OK. What is your guess?

SUBJECT 1: I think it's something to do with machines and air pressure pressurization.

MOLLY BLOOM: Excellent guess. And what other sounds did you hear there besides a machine?

SUBJECT 1: I heard something that sounds like an instrument.

MOLLY BLOOM: OK. Excellent. So we are going to be back with the answer in just a bit.

[MUSIC PLAYING]

BOB: Hi, it's me, Bob. I think you should support Brains On! because Molly, and Mark, and Sanden are my best friends. OK. They're my only friends. I mean, maybe my friend skills need some work. I always forget their birthdays, and I hog all the artichoke dip for myself. [SIGHS]

SUBJECT 4: [MUMBLING]

BOB: What's that?

SUBJECT 4: [MUMBLING]

BOB: Get back to the point?

SUBJECT 4: [MUMBLING]

BOB: Right. You should support Brains On! because the show gives you something to talk about. I know families that listen and they have great, big, long discussions afterwards. It sounds so fun. I wish they'd ask me to join. And sometimes, I talk about Brains On! episodes at parties and people actually listen to me. But then I show off my dance moves and they usually walk away. Oh well, I guess disco isn't back in style yet.

[MUSIC PLAYING]

Go to brainson.org/donate and keep the show going. That way, you'll have plenty of new episodes to talk about with your family, your friends, and your new friend, me, Bob. We can be friends, right? I'll let you see my popsicle stick collection, huh, huh?

MOLLY BLOOM: Gifts before December 31 are tax deductible. To support the show, go to brainson.org/donate. Giving does not mean you have to be friends with Bob.

BOB: But you can.

[MUSIC PLAYING]

SUBJECT 1: We know this is probably a topic you've thought a lot about.

MOLLY BLOOM: You've discussed it at dinner.

SUBJECT 1: Ruminated on it at recess.

MOLLY BLOOM: Mulled it over on your motorcycle.

SUBJECT 1: Which is cooler, dolphins are octopuses?

MOLLY BLOOM: It's a tough one. And it's the subject of the next Brains On! debate.

SUBJECT 1: And we need your input. Which do you think is cooler? Be sure to tell us why.

MOLLY BLOOM: Send your dolphin and octopus arguments to hello@brainson.org.

SUBJECT 1: And you can also send mystery sound questions and drawings to that same email address.

MOLLY BLOOM: Need some inspiration? We'd love to see a drawing of what it looks like when you get all staticky.

SUBJECT 1: Send it to hello@brainson.org.

MOLLY BLOOM: High-fives.

[MUSIC PLAYING]

SUBJECT 1: You're listening to Brains On! I'm Hobte.

MOLLY BLOOM: I'm Molly.

SUBJECT 1: And today, we're getting electric.

MOLLY BLOOM: Ready to go back to that mystery sound? Here it is one more time.

[CLICKING SOUND]

[BELL RINGING]

OK. Any new guesses?

SUBJECT 1: Now, I feel like the musical instrument part of it is spoons tapping on water glasses. And I-- and I still think it's the same for that the air pressurizing and the ticking, I think it's those arrows things ticking on the car.

MOLLY BLOOM: There's a lot of things there, yeah, like a turn signal.

SUBJECT 1: Yeah.

MOLLY BLOOM: Well, you're hearing a lot in that sound. So let's hear the answer. Here is Richard Johnson from the Bakken Museum.

RICHARD JOHNSON: Yeah, the ringing you hear is the sound of Franklin's bells.

MOLLY BLOOM: OK. So I probably need to describe what Franklin's bells is for you because you probably-- have you heard of it before?

SUBJECT 1: No.

MOLLY BLOOM: OK, so Franklin's bells, what it is, is two bells sitting side by side. And you can make them ring without touching them at all.

SUBJECT 1: Nice.

MOLLY BLOOM: I'll tell you more about how static electricity makes those bells ring in just a little bit. But first, who is the Franklin in Franklin's bells? Have you heard the name Franklin before?

SUBJECT 1: Is there a President with the name Franklin?

MOLLY BLOOM: Yes, there is a President with the first name Franklin. But in this case, were talking last name. And we're talking Benjamin Franklin. He's known as one of the founding fathers of the United States. He was living here when it was a British colony, and he helped shape the country in its early years after the American Revolution.

He was a printer. He printed books and newspapers. He was an inventor. He invented bifocal glasses. And he was a scientist.

CAROLINE WINTERER: In every facet of his life, he is just really, really curious about everything.

MOLLY BLOOM: That's Caroline Winterer.

CAROLINE WINTERER: I'm a professor of American history at Stanford who works on a lot of interesting people, including Benjamin Franklin.

MOLLY BLOOM: And Benjamin Franklin was very curious about electricity.

CAROLINE WINTERER: Electricity was this really interesting and mysterious substance. And people were fascinated by it. And so it was kind of like the Silly Putty of the 18th century.

MOLLY BLOOM: Scientists in Europe were starting to experiment with electricity. They developed equipment that helped them harness static electricity. One apparatus is the Ramsden Generator. That's what you heard at the beginning of the mystery sound. This machine was basically a large wheel that you turned with a crank, and that clicking sound you heard. The wheel would rub against a piece of fur or wool and generate a static charge.

Then that charge could be transferred to something called a Leyden jar. The Leyden jar is a glass jar about the size of a pop can with metal inside it as well as a metal rod sticking out the top and metal wrapped around the outside, kind of like an electricity burrito, a conductor wrapped in an insulator, wrapped in another conductor. The Leyden jar had a lot of uses, but in the case of the Franklin bells we just heard, it can make them ring without touching them. Because of the exchange of electrons, the ball that makes the bell ring is attracted back and forth. And every time it goes back and forth, the bells ring.

[BELL RINGING]

So Franklin played a lot with electrostatic generators, Leyden jars, and kept asking questions and making observations. Have you ever played with static electricity before?

SUBJECT 1: Once, I tried rubbing my finger on some platforms and seeing if it made a static electricity charge.

MOLLY BLOOM: And did it?

SUBJECT 1: Sometimes, when I rub my finger on something without expecting it, there's a charge. But when I do expect it, there's not a charge.

MOLLY BLOOM: Interesting. So you know, speaking of that little charge, what does lightning look like to you?

SUBJECT 1: Oh, like, purple, yellow. They're very light. And then they just split, zigzag.

MOLLY BLOOM: And next time you get a shock, if you're able to charge yourself up and touch a doorknob, you'll notice it looks incredibly like a lightning bolt. And that was the observation that led Franklin to wonder, what is lightning? Is it the same thing happening between my finger and the doorknob? So Franklin published a book called *Experiments and Observations On Electricity.* And this book caused quite a stir among European scientists.

CAROLINE WINTERER: And they're shocked, like, literally, they're shocked, because they don't expect any new scientific knowledge to be coming out of this very, very fringe part of the British empire. It would be like some great scientific experiment coming out of the bottom of the ocean from a fish. That's the equivalent in the 18th century.

MOLLY BLOOM: But not everyone agreed with what he wrote about in this book. And since there was no Facebook, or email, or telephones, they discussed their differences through letters.

CAROLINE WINTERER: A lot of the letters that he wrote were basically him fighting with other people over things like how electricity worked, how the Leyden jars worked, how you could harness the powers of electricity. It took him writing a lot and fighting a lot to make his opinions known.

MOLLY BLOOM: And as we continue through our electricity series, we're going to see this is a common thread, fights about electricity.

CAROLINE WINTERER: This was one of the things people fought the most about in his time period.

ANNOUNCER: Welcome to the electric games.

[MUSIC PLAYING]

Scientists going head to head, mind to mind, duking it out over electricity.

[CROWD CHEERING]

Today, an epic tennis match between two 18th century scientists, Benjamin Franklin, shocking, and Jean-Antoine Nollet.

JEAN-ANTOINE NOLLET: We like to say [SPEAKING FRENCH].

[APPLAUSE]

MOLLY BLOOM: The volley begins.

BENJAMIN FRANKLIN: Electricity and fire are not the same.

JEAN-ANTOINE NOLLET: Quoi? There's no evidence. [SPEAKING FRENCH]

BENJAMIN FRANKLIN: My lightning rod can save your home.

JEAN-ANTOINE NOLLET: [SPEAKING FRENCH] how can man control the sky?

BENJAMIN FRANKLIN: Stop being so stubborn.

[APPLAUSE]

ANNOUNCER: Game, set, match, Franklin.

[APPLAUSE]

MOLLY BLOOM: So Franklin had two roles in the world of electricity. One was experimentation and invention. The other was to publicize and popularize his ideas. Here's historian, James Delbourgo from Rutgers University.

JAMES DELBOURGO: Franklin's key insight was that whatever you could demonstrate inside the laboratory helped you to manipulate electricity on a vast scale outside the laboratory. The lightning rod is simply an application of that theory. All electrical experimenters had used various forms of metal wire to conduct electricity and to discharge it in their demonstrations. Franklin reasoned by analogy. If lightning is simply electricity, we can simply use larger metal rods, extending them up off the side say of a chimney, running this metal in an unbroken line all the way down the side of the building and into the Earth.

MOLLY BLOOM: After his invention of the lightning rod, Benjamin Franklin wanted to share this discovery with the public.

JAMES DELBOURGO: Franklin and some of his friends start to perform these electrical demonstrations up and down the colonies, offering to electrify people in the audience so they could see what electricity felt like.

MOLLY BLOOM: He also had miniature houses to demonstrate how lightning rods worked.

JAMES DELBOURGO: Small model house, which they called thunder houses. And he would fit the house with a miniature lightning rod. He would then generate the charge of electricity from his electrostatic machine, and he would take that charge, and send it into the lightning rod.

[ELECTRICITY SOUNDS]

And so people in the audience would see this machine cranking, and would see a large spark issue from a metal chain right into the top of this model house, but the model house was not damaged.

[AUDIENCE GASPING]

What he then did to conclude the experiment was to take that model lightning rod off the thunder house, and he would then crank another charge, and there would be a massive discharge and a large spark.

[SPARK SOUND]

Without the lightning rod, the thunder house blew apart.

[EXPLOSION]

To demonstrate that you needed a lightning rod to protect your house.

MOLLY BLOOM: After being exposed to these traveling electricity shows, some people wanted to have their own electrostatic fun at home.

JAMES DELBOURGO: Not just men, but women and children, having apparatus at home, an electrostatic machine. One of the really interesting things about the 18th century is that science like electricity starts off as a kind of spectacular entertainment, but it is then domesticated, and it is something that families, well-to-do families recreated in their own homes.

MOLLY BLOOM: The Bakken museum in Minneapolis has some of these electrostatic party games at their museum. So I went to check them out with a friend.

MAX: Hi, I'm Max, and I'm 10. I live in Saint Paul.

RICHARD JOHNSON: You're holding what's called a Leyden jar. It's a plastic jar. And we're going to fill it with electrons.

MOLLY BLOOM: Using a Ramsden generator and Leyden jars, we made confetti dance in our hands.

MAX: The paper is blowing up from the table to my hand.

RICHARD JOHNSON: So you are kind of like a piece of amber.

MOLLY BLOOM: Sorry. [LAUGHING] We made bells ring.

[BELL RINGING]

And Max even charged himself up using a Van de Graaff generator.

MAX: Well, I put my hands in this metal wall that was being charged by 400,000 volts of electricity. It felt like ants were crawling over me. I can't-- you can't even describe it. It didn't feel good or bad. It just felt weird.

RICHARD JOHNSON: It feels like you're flying without actually leaving the ground. You just-- yeah. And your clothes kind of come into your-- just like you would if you were flying or skydiving. OK. You put both hands on the machine.

MOLLY BLOOM: Richard took out a pencil and started flicking it at Max like a wand. He could style Max's hair into a mohawk without touching it, and he could make Max's clothes move just by moving his pencil from a distance and making electrons move.

MAX: It was amazing. It was just awesome. The fact that we can do this in our world is just amazing. The fact that he can make my hair move without touching it by just using my finger and static electricity.

MOLLY BLOOM: If you want to try some static electricity fun at home, you can head to our website for instructions on how to bend a stream of water without touching it.

MAX: I'm going to explode my brother's mind with the bending water trick.

[MUSIC PLAYING]

MOLLY BLOOM: Some materials pick up electrons easily, and others give them away.

SUBJECT 1: When they do this, they can get a positive or negative charge.

MOLLY BLOOM: Opposite charges attract, and like charges repel.

SUBJECT 1: When you touch a conductor--

MOLLY BLOOM: The charge flows away with a spark.

SUBJECT 1: And early experiments with static electricity opened the door to a whole new world.

MOLLY BLOOM: That's it for this episode of Brains On!

SUBJECT 1: Brains On! Is produced by Marc Sanchez, Sanden Totten, and Molly Bloom.

MOLLY BLOOM: We had production help from Lauren Dee, Jon Lambert, and Emily Allen, and engineering help from Veronica Rodriguez, Corey Schreppel, and Ryan Roberts. Many thanks to Rahel [? Hilay, ?] Leah Martone, Jennifer Ehrlich, Sarah Swisher, Hans [? Butoe, ?] Brenna Iversen, and Jeffrey [? Bisoi. ?]

SUBJECT 1: And before we, go let's welcome the latest group to join the Brains honor roll.

MOLLY BLOOM: These kids power our show with their drawings, questions, and mystery sounds. Here we go.

[MUSIC PLAYING]

[LISTING HONOR ROLL]

[MUSIC PLAYING]

Remember, if you want to be on the honor roll, record a mystery sound, draw us a picture, or send a question to hello@brainson.org. We'll be back next week to talk power lines, electric grids, and a true power battle between Tesla and Edison.

SUBJECT 1: See you then. Thanks for listening.

[MUSIC PLAYING]

- E-L-E-C-T-R-I-C-I-T-Y, electricity, my oh my. It's an exchange of charge from electrons, you'll see. And it's a form of energy. Static is a charge with potential. Current is a charge when it's in the flow. Batteries can take the charge on-the-go by electric bodies of charge animal. Whoa! Zap. E-L-E-C-T-R-C-I-T-Y, electricity, my oh my. E-L-E-C-T-R-I-C-I-T-Y, electricity, electricity, electricity, electricity.

Atoms, electrons will leap and will fly sharing negative charges, hello, and goodbye. Hello, goodbye, hello, goodbye. Hello, goodbye, hello, goodbye, hello, goodbye, hello, goodbye. Hello, goodbye, hello, goodbye.