But Why: A Podcast for Curious Kids

What Is Electricity?

July 5, 2019

[Jane] Hello But Why listeners. Today's episode is a little bit different. We recently answered your questions about electricity in a live call-in hour on the radio on our home station, Vermont Public Radio. Today we're bringing you the first half of that program for your podcast feed. We hope you enjoy it.

Hello I'm Jane Lindholm.

Normally, Vermont public radio listeners are used to hearing Vermont Edition at this time of day but today we're going to do something a little bit different. Today instead of Vermont Edition we're bringing you a special live version of But Why: a podcast for curious kids.

Vermont Edition has graciously allowed VPR's kid show to occupy this hour. In case you're outside the age range of about three to eleven and you're not deeply familiar with But Why, we take questions from kids all over the world on anything they're curious about and my co-producer Melody Bodette, and I help find answers. We've been making this program for more than three years now and in that time we've gotten nearly 5,000 questions from kids in all 50 states and more than 50 countries and we have made episodes on everything from how babies are made, to why flamingos stand on one foot, to who invented the idea of a president. Today we're going to focus on an area that perhaps not only kids have questions about: Electricity.

We've been getting a lot of audio files from kids like this one from five-year-old Izzy who lives in New York.

[Izzy] And my question is how is electricity made?

[Jude] How does electricity get made?


[Mitchell] My name is Mitchel, I am five years old. And I live in California San Diego. And my question is how does electricity get made.

[Jane] You also heard from Jude in Portland Oregon and Luke in Chino California there. And those are just four of the many more questions we've gotten as many as 80 came in before we even solicited questions for this show. So today we're going to spend the whole hour learning more about
how electricity works how it moves through wires, how it powers TV's and cars and light bulbs and more. Sitting across from me at the studio table is our guest for the hour. His name is Paul Hines and he's an electrical engineer and a professor at the University of Vermont. So, he thinks a lot about electricity. He even started a company called Packetized Energy. Paul Hines, thank you for being our guide to all things electric today.

[Paul] I'm really excited to be here. This is a lot of fun.

[Jane] I'm really excited you're here too because I have to admit I don't totally understand electricity so let's actually start at the beginning with some of our questions.

[Julie] Hi my name is Julie. I'm eight years old and I live in Memphis, Tennessee. What is electricity “

[Milo] My name is Milo. I live in Redlands California. What is electricity made of?

[Jane] All right, here's a question from Axel. “My name is Axel, I'm five and a half years old, I live in California and my question is, where does electricity come from?”

[Jane] All right, but here's one that's raised slightly differently.

[Elisha] My name is Elisha, I'm seven years old. I come from California Sacramento. And my question is, who created electricity?

[Mason] My name is Mason, I'm six years old. I'm from Pennsylvania. My question is how is electricity invented?

[Jane] And here's just one more way to think about it before we get to it

[Ari] My Name is Ari, I’m six years old and I'm from Brookline Massachusetts.

[Sarah] Hi my name is Sarah and I'm six years old. I'm from Boston.

[Elena] Hi. My name is Elena. I'm nine years old. I live in New Jersey. How does electricity work?

[Jane] All right there, you got it Paul? So, the questions are what is electricity? Where does it come from? and How does it actually work?

[Paul] Well the amazing thing about electricity is that no one invented it. Electricity is everywhere. Electricity is just the flow of electrons and electrons
are one of the basic building blocks of the universe. So, everything that we're working with, this balloon and everything I've got here, all of these things are made of three basic particles, neutrons protons and electrons. And whenever those electrons start moving, that's electricity.

[Jane] All right. So, whenever these pieces are moving that's what electricity is. So, you said nobody invented it. We did have questions about that from Eliza in Sacramento California and Mason in Pennsylvania who wanted to know who invented electricity So, nobody invented it.

No one invented electricity, it was really discovered.

[Paul] It was just something that exists and you know honestly, we've always known that electricity is here because lightning, we had a big lightning storm here in Vermont yesterday and we saw a whole bunch of electricity popping out of the clouds and hitting the ground. And it's loud and it's bright and all of that loud and bright is energy. And so, when electrons flow, that's the flow of energy, just like when you've got fuel pumping into your car. It's a flow of energy and so electricity is a flow of energy. It's a flow of stuff that we call charge. And so it's, just like, basically, energy moving around.

[Jane] Okay. Energy moving around. I think I understand you but I am going to ask you this question because you know we talk about how we use electricity, how we run it but you mentioned these things electrons, neutrons, protons. Here is an elemental question.

[Zoe] My name is Zoe. I am eight years old. I come from London England. My question is: What are electrons made of?

[Jane] So, you said electrons, but what are electrons?

[Paul] That's actually a really great question and we don't really know. I mean electrons as far as we know aren't really made of anything. They are just a basic building block of the universe. And we know that they move around we know some things about what they do but we don't exactly know what they are. They're just things that have charge and so yeah, they exist everywhere but we're not quite sure exactly what they are.

[Jane] Well that's not helpful.

[Paul] It's a great question because it's a question that scientists haven't actually completely resolved yet.
[Jane] But it's sort of fundamental to the earth and to who we are and to being alive is that these are just things that are out there it's part of what makes the world the way it is.

[Paul] Everything runs, electricity is everywhere and without electrons we wouldn't exist.

[Jane] All right so speaking of electricity being everywhere some of our listeners have noticed that and they're curious about it.

[Max] My name is Max and I'm from San Francisco, and I'm four years old, where does static electricity come from?"

[Kensey] I am Kensey, I'm five years old, I live in Malaysia and my question is why sometimes when I touch my mommy, I get the feeling of electric shock?

[Alden] I'm Alden from Wisconsin, I am ten years old and my question is why do we get static shocks when we touch people on like the slide or a carpet?

[Jane] All right so you said electricity is everywhere and you know a lot of us have noticed that sometimes when we touch people especially if we've been walking around on the carpet it's like “Ow” so what is static electricity?

[Paul] So static electricity is just when there's more electrons than protons in something and so I've got this balloon here. Maybe you can hear it.

I'm going to rub it on my head. So, when I rub this balloon on my head it starts to build up

[Jane] Your hair is sticking up, Paul!

[Paul] My hair is sticking up and what's happening is that the electrons moved between my head and the balloon and so now electrons and protons kind of like to be together. They're good friends. They want to match up with one another. And so, if there's not a good balance between the electrons and the protons, they'll try to like jump between one another and actually this is what happens with lightning. So, the clouds rub on the, rub on the earth's surface a little bit just like the balloon is rubbing on my head. And as a result, the electrons build up in the clouds and they want to jump back to the earth. And so that jumping of electricity is actually static electricity moving between one place and another. You don't really feel static electricity until it moves, when you get that little shock. That's when the static electricity is moving between one place and another but it's always. There are always little imbalances between the electrons and the protons and when they when they move you, feel it.
[Jane] So when your hair is trying to get back to the balloon, your hair's is sticking up, trying to reach out to the balloon, that's because it's trying to jump, it's trying to get that charge.

[Paul] Yeah. Because there are more electrons and protons in the balloon than on my head and so they want to kind of match up with their friends again. And so, they're attracted to one another, they're pulling against, to get back home.

[Jane] And so when I touch somebody, whether I'm doing it by mistake or doing it to be a little bit sneaky and mischievous, to touch them to give them that shock and then there's that shock, then the charges dissipated, where did it go?

[Paul] So the charges basically go back home, they go back to their places. So, all atoms have a balance, normal atoms have a balance between these protons, positive charges, electrons and negative charges. And so, when you rub things together sometimes that balance gets messed up. But then when the shock happens the balance kind of goes back to normal. And so, they basically they go back home.

[Jane] OK all right. So now that we know a little bit and we're going to continue talking about this but a little bit about how electricity is sort of out there in the world, let's talk a little bit about how it's generated.

[Paul] My name is Paul, I'm five years old. And I live in Pennsylvania.

[Gus] Hi, my name is Gus and six years old, I live in Johannesburg South Africa.

[Liam] Hi my name is Liam, I live in ...

[Red] My name is Reed, I'm five years old. I live in California.

[Sophia] Hello my name is Sophia. I'm five years old. I live in California

[Ruby] Hello my name is Ruby, I'm 5 years old, I come from Naperville Illinois. My question is: how does the electricity get made before it goes to your house.

[Jane] And Paul before we have you answer how electricity is made. Let's go to Will who's calling in from Milwaukee Wisconsin.
[Jane] Hi Will. You have a question about electricity. Well go for it. Tell us what it is.

[Will] My name is Will. And I’m five years old. My question is how is electricity made?

[Jane] Great question. Okay so everybody's wondering how is electricity made? Now, we know that it's out there in the world, but we also make a lot of electricity because we need it for a lot of things, so how is electricity made Paul Hines.

[Paul] Yes, that's a great question, Will and Ruby and everyone, all these kids have really great questions, so how electricity, what's interesting about saying that electricity isn't really made because it's always exists in everything, like we talked about. It's just that we have certain ways that we figured out how to get it to move in the right directions. And so, the way that we do it is by combinations of wires and magnets. I’ve got two magnets here. And when they're attracted together, they snap. You can kind of hear it.

[Jane] They pull together like they want to be really good friends.

[Paul] Yeah, but one of the really amazing things about magnets is that when you move a magnet across a wire, the electricity in that wire starts to move, so the electrons, particularly if its copper, so copper wire basically holds on to its electrons very loosely and so they like to move around a lot. And so, if I start moving these magnets on a wire the electricity moves, the electrons start to move. And so, if I connect a light bulb to that wire when I'm moving the magnet around, I can actually see it work. I can see the light turn on. And so, what's really cool about that is that we can use that idea of moving magnets around wires or moving the wires across a magnet and get the electricity to flow. And so, if you go to a big power plant like a hydro station where the water is rushing through and it's turning a giant turbine all that's really happening is that you're turning a bunch of wires past magnets. And as a result, the electricity starts to flow, and we can run our radios and TV stations and radio stations that's great.

[Jane] Wait. So, Paul you’re telling me that we don't ever actually make electricity. All the electricity that's out there is already out there in the world and we're just sort of harnessing it but we're not making it.

[Paul] That's it. The electricity is always there. All we to do is move it around in ways that are useful for us.
[Jane] And so, when we say like all we've got a big power plant here and it's a nuclear power plant or we have solar panels or we're harnessing the power of the river to make electricity, what is happening?

[Paul] Well if you think about, like let's think about water. So when we, when you turn on the tap, the water system isn't actually making water, all it's doing just moving water like from the lake up to a storage tank and then down to your house and then it moves to the drain and back to the system. It's the same way with electricity. So that power plant, nuclear or hydro or wind or solar or whatever, it is all it's doing, is using one form of energy to pump that electricity around just like we would pump water around into our homes.

[Jane] So when we talk about what we use to make the electricity, we talk about power plants sometimes, we talk about the sun. We talk about wind. We talk about water. Alex, who is five and lives in Greensboro, North Carolina wants to know “why don't we harvest electricity to run things like our cars and our batteries in our houses.” So why not? Why not use the lightning? Yeah, sorry I did I say electricity and electricity from lightning.

[Paul] Oh I know, lightning is amazing. There is a ton of electricity inside of lightning and when it moves, it moves incredibly fast and it makes a lot of light and a lot of sound but it disappears really fast, and so you know, in way less than a second it's gone. And so, lightning it's just like this enormous burst of energy that disappears super-duper fast, is like an explosion. It's really hard to take an explosion, you know a big explosion, and turn it into anything useful. We need to figure out how to make electricity move around more slowly in order to make it useful.

[Jane] This is But Why: A Podcast for Curious Kids and today we're on Vermont Public Radio talking about electricity and we're taking questions from kids all over the world. We are going to be back in one minute with more questions about electricity.

[Jane] [00:15:47] I'm Jane Lindholm and this is But Why: A Podcast for Curious Kids. We're taking over Vermont Edition's broadcast slot today to bring you a live version of But Why.

We're answering questions from kids all over about electricity. We have University of Vermont electrical engineering professor and entrepreneur Paul Hines with us helping to explain how electricity works and what it's made of, how it gets into our TV's and cars and batteries. Let's go to Ari who's calling in from Brookline Massachusetts. Hi Ari. How old are you?

[Ari] Seven, and my question is how does electricity in my electric fence make the squirrels grab on?
[Jane] So are squirrels grabbing onto your electric fence Ari?

[Ari] Yeah, they are. And they won't let go unless we turn it off.

[Jane] Oh I see. All right. So, what about that Paul?

[Paul] Oh, that's a great question. So, squirrels will probably, they're not necessarily attracted to the electric fence, but squirrels are just jumpy. They love to move around. We've got squirrels in our backyard and our cat loves to chase them so they move around and sometimes they might grab onto your electric fence probably by accident.

But what's interesting is that your body runs on electricity too. So, if you grabbed on to electric fence which you should not do absolutely, then your muscles in your hands would tighten up because your muscles run on electricity. The electric signals from your brain actually tell your muscles to tense up and make a fist.

And so the squirrel has the same things that we've got in our body. There's electricity inside the squirrel and so when it grabs that electric fence the squirrel muscles basically get confused and it might grab on to that wire and get stuck there. And so, it's the idea that the body runs on electricity which is interesting.

[Jane] We have electricity in our blood?

[Paul] We do. Well, it runs through other parts of your body but yea, absolutely it's in your blood too.

[Jane] You've been talking about movement. Let me play for you a few questions that we have about how electricity moves from one place to another.

[Isaiah] Hi my name is Isaiah and I'm from Menlo Park California and I'm five years old. My question is how does electricity travel?

[Child] I'm four years old, I live in Shoreham VT, and my question is how does electricity move?

[Child] … of 6. I live in California and my question is, how does electricity flow?
[Jane] So Paul, you mentioned that you can use a magnet on a wire, and you can move the electricity but we're moving electricity over many, many, many, many, many miles in a lot of cases. So, how do we make it move?

[Paul] Yeah, well electricity always would like to stay at rest. You know, though the electricity in the balloon doesn't really want to jump into my head. But if I rub it enough it'll have to move.

And so it moves when there's basically a force pushing on it. So, when I rub the balloon on my head, there's so much energy that kind of got moved between one place and another. All those electrons want to move back home and so they start to jump eventually. That's the same thing that happens with lightning. So, the clouds are rubbed across the sky, the earth and then they eventually want to jump. And so, this idea of like giving the electrons extra energy and then they want to jump, is kind of like the same way we pump water uphill and it wants to go back down the hill.

[Jane] So we've talked a little bit about what electricity is, how it moves, how humans don't really make it but we kind of harness it, but how does electricity actually power things like a phone or a TV or a toaster or a refrigerator?

[Rory] Hi, my name is Rory. I'm eight years old, I live in Dublin, Ireland and I want to know, how does electricity power up TV and smart phones?

[Vivian] I'm Vivian and I live in Pennsylvania. I'm five years old. How does electricity power up all of the electrical things in our house?

[Sam] I'm Sam. I'm seven, I live in Sydney Australia. And my question is, how does electricity power stuff?

[Jane] And Annie is even more specific.

[Annie] My name is Annie. I'm four years old, I live in Carlsbad, Texas. Why does electricity control TV's?

[Jane] And let's go to Vaughn who is calling in from Montpelier Vermont on this question. Hi Vaughn.

[Vaughn] Hi my name is Vaughn. I live in Montpelier, Vermont. I'm nine and three quarters. My question is how does electricity power TV.

[Jane] Vaughn, Great question. And you're joining all these other kids from around the world who are wondering the same thing. So, Paul Hines, how does electricity power our TV and stuff like that.
[Paul] Yeah. Vaughn, and everybody, these are great. So, electricity is really interesting because it only moves when you make it into a circle and you close a circuit, so when you plug your TV in and you turn the TV on your TV will basically close a circuit make a circle of four that electricity and the electricity will start moving around and then what your TV does. Let's talk about the TV in particular. So the TV, your TV screen is made up of all sorts of little teeny tiny lights, red lights, and green lights and blue lights and your TV takes the electricity and chooses which lights to turn on based on what's happening on the show. It's doing really, really fast so it's constantly changing millions of little tiny lights in order so that you can see pictures. It's probably also putting a little bit of sound so on your phone, it says the same idea all these little teeny tiny light bulbs called LED's are turning on and off to show the image but they're also producing some sound and the way the sound moves is that the electricity moves back and forth really, really fast across a speaker or at least basically just a plate and that moves the air and by moving the air back and forth really, really fast, we get sound out of things.

[Jane] All right, and listeners if you have not heard our episode about how podcasts are made you might want to go listen to that because we actually talk in that episode a lot about how sound works and how sound travels and also how we get sound waves that are doing what Paul just described and then hear them as voices or music or other sounds. We're going to stop it right here for today, but we will be back in two weeks with the rest of our electricity show. Thanks to our guest Paul Hines. Paul is a professor of electrical engineering at the University of Vermont and he started a company called Packetized Energy. It focuses on the millions of small devices that get plugged into the power grid every day. If you're a curious kid and you have a question about anything have an adult record it. It's easy to do on a smartphone. Send the audio file to questions@butwhykids.org with your name where you live and how old you are, as well as your question of course. We'll do our best to get an answer for you. And adults, if you want to know about But Why events like this call-in program or new episodes that are coming up or other ways to get involved, you can sign up for our newsletter. You'll find the link at: butwhykids.org. Today's live show was directed by Jake Rusnock, we had production assistance from Rick Barrett.

It was produced by Melody Bodette, Sam Gale Rosen, and me, Jane Lindholm as well as the Vermont Edition crew that's usually on the radio at that time, Ric Cengeri, Matthew Smith and Olivia White

Our theme music is by Luke Reynolds. We will be back in two weeks with the second half of our electricity show. I'm Jane Lindholm. Stay curious.