

Erin Allmann Updyke

"I have lately made an experiment in electricity that I desire never to repeat. Two nights ago, being about to kill a turkey by the shock from two large glass jars containing as much electrical fire as 40 common files, I inadvertently took the whole through my own arms and body. The company present say the flash was very great and the crack as loud as a pistol, yet my senses being instantly gone, I neither saw the one nor heard the other nor did I feel the stroke on my hand, though afterward I found that it raised around swelling where the fire entered as big as half a pistol bullet by which you may judge the quickness of the electrical fire, which by this instance seems to be greater than the sound, light, or animal sensation.

What I can remember of the matter is that I was about to try whether the bottles were fully charged by the strength and length of the stream issuing to my hand, as I commonly used to do and which I might safely enough had done if I had not held the chain in the other hand. I then felt what I know not how to describe. A universal blow through my whole body from my head to my foot which seemed within as well as without, after which the first thing I took notice of was a violent quick shaking of my body which gradually my senses gradually returned and I then thought the bottles must be discharged but could not conceive how till at last I perceived the chain in my hand and recollected what I had been about to do.

That part of my hand and fingers which held the chain was left white as though the blood had been driven out and remained so 8-10 minutes after feeling like dead flesh. And I had a numbness in my arms and the back of my neck which continued till the next morning but wore off. Nothing remains now of this shock but a soreness in my breastbone which feels as if I had been bruised. I did not fall but suppose I should have been knocked down if I had received the stroke in my head. The whole was over in less than a minute."

TPWKY

(This Podcast Will Kill You intro theme)

Erin Allmann Updyke

I had a lot of fun reading that one.

Erin Welsh

So I am really glad that you read that because you always do such a great job. And I'm also glad because it means that I get to tell you then who that quote was from.

Erin Allmann Updyke

Please, because I don't know anything about it.

Erin Welsh

Benjamin Franklin.

Erin Allmann Updyke

Yes! Oh, that was my second guess.

Erin Welsh

Yeah. So Benjamin Franklin, as we all know, was a huge lover of turkeys but he was most fond of eating them.

Erin Allmann Updyke

I absolutely did not know that about him.

Erin Welsh

Oh yeah. But one of his preferred methods of killing a turkey before he ate it was electrocution until this incident in which he was like wow, that was really bad, I could have died. And so he went back to normal killing a turkey. But one of my favorite things about this passage is that I think this was in a letter to a friend or something because then he followed it up with okay, you can tell this person but don't spread it more widely because I'm really embarrassed.

Erin Allmann Updyke

(laughs) Oh my goodness. I also don't understand how he was about to electrocute this turkey.

Erin Welsh

I don't either because I still feel like I don't fully understand electricity.

Erin Allmann Updyke Oh yeah. Woops. Same.

Erin Welsh Yeah. But I think that over the course of this episode and then the next week's bonus episode we'll have a greater understanding of how he did that.

Erin Allmann Updyke Yeah, I think so too.

Erin Welsh Hi, I'm Erin Welsh.

Erin Allmann Updyke And I'm Erin Allmann Updyke.

Erin Welsh And this is This Podcast Will Kill You.

Erin Allmann Updyke And today we're talking about lightning?

Erin Welsh Electricity? Either way.

Erin Allmann Updyke Kind of both. I mean a little bit of both.

Erin Welsh Yeah. Electricity and the impact that it has on biological systems.

Erin Allmann Updyke Yes.

Erin Welsh Especially unexpected electricity. Not how do our nerve impulses work.

Erin Allmann Updyke Right, right, right. Yeah. Okay, cool.

Erin Welsh Is it quarantini time?

Erin Allmann Updyke It's quarantini time. Let's get to it.

Erin Welsh Let's get to it. What are we drinking this week?

Erin Allmann Updyke Thunderstruck. Is that what we decided on?

Erin Welsh That is what we decided on. But I want everyone to know that I think the discussions for the quarantini name for this episode went longer than any other one has at least in recent memory or the past couple of years. So I wrote down a few of my favorites.

Erin Allmann Updyke Oh I love it.

Erin Welsh The Power Sour.

Erin Allmann Updyke That's a good one.

Erin Welsh Lightning In A Jar. Current Affairs.

Erin Allmann Updyke I really loved all of the 'current' ones because when you kept suggesting those I was like I don't get it. Oh electric current. Okay, now I get it.

Erin Welsh Super Juice.

Erin Allmann Updyke Super Juice.

Erin Welsh Plug And Chug. And I think finally the least creative but the one that we were both maybe second most tempted by was Energy Drink.

Erin Allmann Updyke I actually love Energy Drink.

Erin Welsh But we went with Thunderstruck. So Erin, what is in Thunderstruck?

Erin Allmann Updyke It is lemonade, vodka, and blue curacao.

Erin Welsh Yeah. It's based on a real drink whose name I can't remember now. Maybe Blue Lagoon? It's delicious.

Erin Allmann Updyke Yeah.

Erin Welsh And we'll post the full recipe for our quarantini as well as our nonalcoholic placeborita on our website [thispodcastwillkillyou.com](http://thispodcastwillkillyou.com).

Erin Allmann Updyke On our website [thispodcastwillkillyou.com](http://thispodcastwillkillyou.com) we have everything that you could ever want to find on a website. We've got merch. We've got lists of all of the sources from all of our episodes. We have a Goodreads list. We have a bookshop.org affiliate account. You can find links to Bloodmobile, our music, you can find our Patreon account. You can find...that's all of it, right?

Erin Welsh I think it's close enough.

Erin Allmann Updyke It's pretty close. Transcripts!

Erin Welsh There we go. I have one more piece of business.

Erin Allmann Updyke Please.

Erin Welsh So a lot of people have asked us how we find our first hand accounts and it's a mix of things really. But one of the ways is that listeners will often reach out to us and be like oh if you're recovering this in the future, I am willing to share my story, etc. And so if you have a firsthand account that you might like to share on the podcast or want to at least learn more about it, the best way to get in touch is either through the CONTACT US form on our website or by emailing us at [thispodcastwillkillyou@gmail.com](mailto:thispodcastwillkillyou@gmail.com).

Erin Allmann Updyke Yeah.

Erin Welsh And I want to just take this opportunity to say a big thank you to everyone who has ever reached out to us over the years with their experiences. And also for everyone who has ever shared their firsthand account.

Erin Allmann Updyke

Yeah.

Erin Welsh

Okay. Should we take a quick break and then get into it?

Erin Allmann Updyke

Let's. Okay.

TPWKY

(transition theme)

Erin Allmann Updyke

So today we're talking about mostly lightning. When we first were talking about this episode, it was a lightning episode. But then we realized that to talk about lightning, we have to also talk about electricity of course. So I want to just say up front, I don't understand electricity. It still feels like magic to me. Lightning seems to genuinely be magic. So that's the end of the episode. Just kidding. We're going to do our best as always. But what I want to focus on, like you said Erin, is our body's responses to electricity and especially the difference in how we react or how electricity reacts with us when it comes from say your household outlet versus lightning. Because they are very different as it turns out.

So electricity really basically, electric current is simply the flow or the movement of positively and negatively charged ions, right. Electrons and protons moving around, that's electricity. All of the things around us have charge, either positive or negative or neutral charges. Our earth, our atmosphere, our bodies, our couches, our cats' hair that we rub, right. We're all made up of atoms that have protons and electrons and thus carry charges or have the potential to carry charges. So electricity is all around us. Lightning in a very, very simplified sense is one massive electric discharge essentially. Here's how it happens kind of. Lightning is created when there are temperature differences between air masses.

So what happens is the warm air down close to the earth moves up since warm air rises, it condenses to form clouds. The water droplets freeze to become ice crystals or whatever and they're continually being pushed around by all of the air movement and all of this movement between the ice crystals creates this friction that causes electrons and protons to be transferred between these water molecules. And they're continually moving around in this giant storm, right? And this storm is moving along the ground. And so what happens is these ions, the positive and negative ions, redistribute into these layers. And generally the positive ones hang out on the top of the cloud, the negative ions accumulate at the bottom, and the Earth which usually is kind of negatively charged compared to the atmosphere now has this positive charge because of how strong the negative charge at the bottom of this cloud is.

So these positive charges are accumulating, they're running along the ground, they're running up the trees along buildings trying to move upward towards this cloud to close this gap. And when it just gets to be too much, when the potential difference between the charges at the top of this cloud and the bottom of this cloud and the Earth get to be just too strong, boom. Lightning strike. And then thunder, which is a really important part of lightning because it shows you the power of what's happening, thunder is the shockwaves from this explosive expansion of air that becomes superheated and ionized by this massive bolt of electricity that just shot through it. Now on a really, really, really tiny scale, we are all very familiar with this phenomenon because it's the same phenomenon that creates the static electricity that we're familiar with, right. You pet your cat too hard and then you shock their nose by accident.

Erin Welsh

I like that that's your example.

Erin Allmann Updyke

It happens so often.

Erin Welsh

I like socks on carpet.

Erin Allmann Updyke

Yeah, I was gonna say that too but I don't wear socks as much lately and I don't have a lot of carpet. Or you rub a balloon on your hair, right. Those actions cause the same kind of ion transfer and lining up of those positive and negative charges and then eventually a little teeny tiny bolt of lightning happens between you and the floor or your cat's nose. So that is lightning and some real basics about how it happens. Now when it comes to lightning there are a few different ways that it can end up traveling from that cloud to your human body. And they vary and I couldn't find good statistics on how often you have one versus the other. And really as we'll see when it comes to lightning strikes statistics in general, we just don't have good stats. But all of these are possible types of the way that you would come into contact with lightning.

First of all, you can have a direct strike. If that lightning from that cloud hits a person directly, that's a direct strike. It's probably less common but again stats are not great. And some papers will say a direct strike is absolutely the most deadly but I think because our stats are so poor it's actually probably hard to get a handle on whether or not that's true. But you can imagine you're taking a greater amount of that lightning strike if it hits you directly versus in some of the other ways I'll talk about. So the next way is you can have a contact injury and that happens if you are touching an object that's part of the path of that current. Let's say you're touching a faucet in your house and your house pipes get hit by lightning and then it goes through that faucet and into you.

Erin Welsh

Right.

Erin Allmann Updyke

Or you're touching a tree at the moment that that tree gets hit. That's a contact injury. Then there's something that I think is so fascinating that's called a side flash or a splash and that's when the lightning hits somewhere nearby to you and then jumps, it crosses an air gap and then jumps to you as a nearby person. So you're just splashed with some of the force of the lightning as it makes its way towards the ground.

Erin Welsh

Oh that's really fascinating.

Erin Allmann Updyke

Yeah.

Erin Welsh

So the numbers that we have are not great, like you said. And so I'm guessing that I already know the answer to this question which is how much do we know about the strength or variability of those different types of contact with lightning?

Erin Allmann Updyke

That's a great question. I don't fully know. Definitely the less direct contact is, the less total amount of electricity or energy that you're being exposed to. But in all cases the duration of contact is unbelievably short in all of these cases. And then there is also ground current and that is if the lightning hits the ground near you and then spreads out radially and then comes up and hits you from the ground up. Those are the main types. There's also, and I think this is just oh my goodness, there has been reports of something that's called an upward streamer. So you know how I said that all those positive charges are running along the ground and up to try and get to the cloud as that energy from the cloud is coming down? So there has been reports of people being struck from the energy just from those upward streamers of energy even without them making contact with the actual lightning strike. Which is like what?

Erin Welsh

Well it's also interesting because how do you determine what it was?

Erin Allmann Updyke

I will post the paper where they did this. It was a really interesting forensic analysis paper where they determined it wasn't all of these other types and it couldn't have been from the electric lines they were working on because of the patterns of injury etc. And so yeah, that was what they were left with. And I think it had been a theoretical concept prior to that but this was one of the first documented, look this is what caused this injury.

Erin Welsh

Oh man.

Erin Allmann Updyke

Yeah.

Erin Welsh

Wow.

Erin Allmann Updyke

So that is how you can be struck by lightning. What happens when you get hit?

Erin Welsh

Yeah.

Erin Allmann Updyke

Yeah.

Erin Welsh

There's a lot.

Erin Allmann Updyke

Oh Erin, there's just so much. And so much of what it comes down to that I think is so interesting is that A) we do not understand lightning, we do not understand the effects that it has on the body. And 2) the rules that apply to electricity and electric shocks and the body don't seem to apply to lightning.

Erin Welsh

Why?

Erin Allmann Updyke

Let me get into it. So a lot of the papers that describe both lightning and electricity injuries talk a lot about the characteristics of electricity that determine how much of the electric current actually flows through someone's body, right. So these papers tend to focus on 6 main things, 6 components of electricity. They talk about the type of current, which is whether it's an alternating current or a direct current. They talk about the voltage, the voltage being the pressure that causes that current to flow. They talk about the amperage, which is the volume of electrons that are flowing, it's a measure of the rate of flow.

And then they talk about the resistance, which is an intrinsic property of an object and different body tissues have different resistances, it's the ease or the difficulty with which the electric current can actually travel. And then they talk about the pathway that the current takes which I kind of talked with lightning, the different ways that you can come into contact. And if you're thinking of household electronics, you can grab it with your hand by accident, little kids might put electric cords in their mouth, right. So that will determine literally where in your body is this current going to flow. And then the duration of contact. Now when it comes to lightning, the voltage and the amperage that we're talking about - unbelievably high, like 10 million or more volts and 40,000 or more amps.

Erin Welsh

I don't have a frame of reference for that but that sounds like a lot.

Erin Allmann Updyke

So your household electric outlet is 110 volts and 15 or 20 amps.

Erin Welsh

Oh okay.

Erin Allmann Updyke

Yeah, okay?

Erin Welsh

That's a lot.

Erin Allmann Updyke

That's a lot. But lightning does a few things that regular electricity doesn't do. First of all, it's a very different type of current. So your household electric outlet is alternating current. A battery is direct current. But lightning, some papers that I read said that lightning is a direct current but the paper that I liked the best described it as quote: "A unidirectional massive current impulse."

Erin Welsh

Right. It's a strike, it's not a current in that there's not a continuous flow for long periods of time.

Erin Allmann Updyke

Exactly.

Erin Welsh

Okay.

Erin Allmann Updyke

And that's the thing that makes it so massively different from any other source of electricity is that the duration of contact is instantaneous. It's fractions of milliseconds. Whereas especially if you come into contact with a household electric source or something that's putting out alternating current, your body reacts to that alternating current by having repetitive contractions. So it can force you to actually grab and continue to hold on to that source, prolonging the duration of contact and therefore prolonging the damage. But this is the literal opposite because it's such an instantaneous thing that it actually causes an effect that I still don't fully understand that's called flashover. Let's talk about flashover.

So if you think of your body as an empty can, bear with me, when you come into contact with our home electricity, an A/C current, it flows in and out of that can, in and out in and out. And every time that it flows in and out and that current reverses, it's doing damage the whole time, over seconds and seconds or even just a fraction of a second but a long fraction, almost a whole second. That creates a lot of thermal energy, right. Because that electrical energy gets transferred into thermal energy. That results in a lot of burning, superficial as well as deep burns, as it penetrates through our tissues or burns through the can or whatever.

With lightning the amount of current and the rate at which it travels is so massive that that can gets filled up instantaneously and the rest of that current flows out and over the can, it spills all around it rather than staying contained within and causing damage. That is flashover. And so as it flows over it can cause other damage that normal electricity wouldn't cause because it's flowing out over your body rather than through it, even though it's going through it also.

Erin Welsh

Yeah.

Erin Allmann Updyke

But again it happens so quickly that we're exposed to all of that current for a matter of fractions of milliseconds. So it can definitely cause superficial damage, it can melt our clothes to our skin, it can rip apart clothes from steam vapor, explosion of the steam within our clothes, it can singe your hair, it can heat up metal buckles and melt them. But it's a very different pattern especially of burns than we see in typical electric burns. It's very, very different. Isn't that interesting?

Erin Welsh

It's really interesting and I think it's very... I mean honestly it's kind of terrifying. Enormous power.

Erin Allmann Updyke

It is. I think one of the ways that I started to think about this was that lightning strikes, the damage tends to be a lot less physical, so you might not see very much damage even if you look with an MRI or with imaging. It's almost it just does electrical damage in our bodies and we can't see what that ends up doing. Whereas electricity, if you're exposed to it from a household source, because that duration of exposure is longer that electrical energy gets transferred into heat energy. So you have a lot more typical burns, you have a lot more visual and physical damage that we're able to see and these type of injuries that your brain probably associates with electricity.

Erin Welsh

Yeah that makes sense. And I think that seems to be what makes it so difficult to characterize and to categorize and to understand because it seems we still don't know so much about how our brain delivers signals and blah, blah, blah. And so when something goes wrong, we know that something went wrong but we don't know how it went wrong.

Erin Allmann Updyke

Yes, exactly. Yeah. So let's talk about what kinds of damage this lightning is actually inflicting, shall we? Let's hear it. Because it's not to say that lightning doesn't cause physical damage, it certainly does. It's just quite different than the damage that we see with other types of electricity. So the most instantaneously deadly injury that happens with lightning strikes is damage to our heart. Our heart has its own little electrical system, so especially if current of any type, not just lightning, is passing vertically through our bodies, it has a pretty good chance of passing over our heart which sits kind of right in the center. And that current can then disrupt our heart's internal electric system and lead to arrhythmias. It can lead to asystole, essentially stopping the heart entirely, or it can lead to what's called ventricular fibrillation which is when the bottom of your heart, the part that's supposed to pump the blood out of your heart to the rest of your body, stops contracting and really instead fibrillates (fluttering sound). It's not good, sorry. You can't see my hands.

Erin Welsh

I think it was an adequate sound effect though.

Erin Allmann Updyke

Thank you. So what lightning can do is it can cause one single instantaneous depolarization of the entire heart, one massive contraction that just then stops the heart and that's what it does. Often because your heart has its own little electrical system, it will start again on its own. But if the respiratory centers of your brain which control our respiratory drive also get affected by this current then you can have respiratory arrest as well. So you stop breathing. If you stop breathing, your heart stops beating, that then can prolong the cardiac arrest. So lightning strike can cause death I read anywhere from 5-30% of the time. Most sources said 10-30% and a few papers said 5-10% of the time. And usually it's immediate death because of that cardiac arrest, either without the heart ever returning to normal function or if you have both a cardiac and respiratory arrest without resuscitation, then you have death because of that.

And one thing that's really interesting about lightning strikes specifically is that it's actually far more likely to have successful resuscitation in the case of a cardiopulmonary arrest from lightning than from a lot of other reasons for cardiac arrest. And there's a lot of different hypotheses as to why. Part of it might be that because it happens so... I just keep saying this, it feels repetitive, but it is so instantaneous, this complete stop, that there's a thought that maybe you have more time before the tissue damage starts to occur, right. Whereas with a heart attack or something that blockage starts to cause cell damage over a period of seconds or minutes, so you've already lost time.

Erin Welsh

Right.



Erin Allmann Updyke

But many times people who are struck by lightning are otherwise young and quite healthy. So it might just be that they have more reserves, so to speak. We don't really know. But it's really interesting because it changes the paradox of, for example in an emergency situation, who should be the first person that you go to to try and save?

Erin Welsh

Right. The triage is like opposite.

Erin Allmann Updyke

Exactly. With lightning, it's the person who looks dead, that's the person you go to first because their heart probably stopped, they might have stopped breathing, but you'll probably get them back. Whereas if someone is breathing, is moaning, is making any kind of movement or noise, they're going to be okay most likely in the immediate emergent period. But so that's kind of the most extreme thing that happens. But lightning can also cause a lot of skin damage. It can cause linear burns from water on the skin being vaporized. It can cause these fascinating feathery snowflake lightning strike patterns that actually aren't burns at all and we don't even really understand what causes them but they tend to disappear in a matter of hours. It can cause these small round burns that can be deep but they're really small in diameter or an area.

So in general the skin and burn injuries that we see from lightning tend to be much less severe first of all than you would expect from such a huge amount of electricity, but also less severe than what we see from a lot of other electric sources. Lightning though can cause a lot more trauma damage than some other electric sources, except for perhaps high tension wires. But because of the shockwave that's generated by lightning, that shockwave itself can actually cause barotrauma which can cause injury to our internal organs. It can cause a concussion, it can rupture the eardrums.

Erin Welsh

That is very scary.

Erin Allmann Updyke

It's wild. It's terrifying. It's also thought that during flashover the current can actually re-enter our body through our eyes and our nose which can then cause ocular damage like cataracts. And then of course you can have trauma from falls from being blasted away or from shrapnel from a tree, etc. So there's a lot of different ways that lightning can harm you.

Erin Welsh

Yeah.

Erin Allmann Updyke

But then of course there's the neurologic damage. And the neurologic effects can also be pretty wide ranging. They can be transient where they go away really quickly and it's actually pretty common to have something called keraunoparalysis which is pretty specific to lightning strikes. It's a total paralysis especially of the lower extremities, but it's transient and it goes away within a matter of hours. Not fully understood. Lightning strikes can cause a lot of autonomic instability which means your autonomic nervous system is the part of your body that controls all of our involuntary actions, your heart rate, your temperature control, your blood vessels, your digestion.

Erin Welsh

Right.

Erin Allmann Updyke

So this can manifest as temperature instability, as a fast heart rate for seemingly no reason, as blood pressure problems. But again these type of findings tend to improve relatively quickly. There can also be immediate effects from a lightning strike neurologically that don't recover as quickly that are more prolonged and that can happen either from direct damage from electric current or from things like ischemic injury from a hemorrhage or a stroke, if you have damage to blood vessels, etc.

Erin Welsh

Gotcha.

Erin Allmann Updyke

And then there are a lot of delayed onset of symptoms that can be anything from movement disorders like if there's motor neuron damage. But then of course there are neurocognitive and neuropsychiatric findings that in many cases can be profound and can be completely life-changing and we do not understand the mechanism or the extent.

Erin Welsh

I feel like lightning is portrayed as oh it's this deadly thing, which it absolutely is, and if you survive it then you have special powers afterwards where you can suddenly play the guitar or speak 9 different languages that you didn't know before. And first of all those stories, I looked into a couple of them and they're obviously not true.

Erin Allmann Updyke

They're not true. Yeah.

Erin Welsh

But I think also what's glossed over is that yes, you can survive lightning but it can be hugely disruptive for the rest of your life or at least for way longer afterwards.

Erin Allmann Updyke

Yeah.

Erin Welsh

I didn't know that.

Erin Allmann Updyke

No, I absolutely did not either. So the neuropsychiatric effects, they can be very wide ranging. They can be anything from photophobia, so difficulty with light, hyperacusis, so really sensitive to sounds. It can cause emotional lability, mood swings that go in a second from really, really overjoyed to everything is terrible but something that you have absolutely no control over. Sleep disturbances. It can cause anxiety or hypervigilance. It can result in a lot of memory deficits, especially in working memory or difficulty with word finding or auditory memory. There's been studies that have shown that it can affect your processing speed. Post traumatic stress disorder happens in about 30% of people after a lightning injury. It's so wide ranging and I think what's so important about this type of neuropsychiatric findings is the downstream effect that these can have on somebody's life because they not only can affect the way that somebody interacts with the world, but they then can go on to affect a person's relationships, marriages, friendships, things that make a person who they are. Which is terrifying.

Erin Welsh

Yeah. And it also seems I think probably very frustrating that we know so little about this, which means that we know so little about how to treat or help provide any sort of symptom management in terms of those sorts of things.

Erin Allmann Updyke

Yeah. And I think it comes down to we know so little about how the brain works.

Erin Welsh

Yeah.

Erin Allmann Updyke

That how do we know how this instantaneous massive force of electricity, how has that affected the wiring of your brain? It affects it, we know.

Erin Welsh

Right.

Erin Allmann Updyke

But we don't understand how. But yeah Erin, that's a very long winded and probably not detailed enough lightning.

Erin Welsh

It's so interesting because there's so much there but it's also so many questions.

Erin Allmann Updyke Oh my gosh, I know.

Erin Welsh It's making me flashback to the multiple sclerosis episode.

Erin Allmann Updyke (laughs) So Erin, tell me how did we get here?

Erin Welsh I'm definitely not going to answer those questions.

Erin Allmann Updyke I don't even know how to ask a question about lightning honestly.

Erin Welsh Well I will take you on a tour through the history of electricity right after this break.

TPWKY (transition theme)

Erin Welsh All right, so the entire history of electricity. Let's begin. Just kidding. There's absolutely no way I'm going to do that. I'm not even gonna try, never planned on it. Yeah, that's outside my reach. But instead what I decided to do was to pick 4 topics or stories or whatever in the history of electricity and tell you about them.

Erin Allmann Updyke Okay.

Erin Welsh So it's not going to be as deep of a dive as I normally do on a topic but I think it's going to be a fun or at least interesting time and I think that you'll end up with a lot of trivia about electricity.

Erin Allmann Updyke I can't wait.

Erin Welsh Right off the bat, I want to shout out the primary source I used which is the newest book from Dr. Timothy Jorgensen called 'Spark'. It's all about electricity from a biological perspective. It is a fascinating, an excellent read, and I really loved it. And you might remember Dr. Jorgensen from our episode on radiation that we did a couple of seasons ago when we had him on to explain how in the heck radiation worked. And since Dr. Jorgensen does such an amazing job of explaining these super complicated topics in a way that I feel I can actually understand, I wanted to have him on again to explain how precisely electricity works. So tune in next week for the bonus episode where I get to ask him a bunch of questions about how electricity works and why it's so important in understanding biology.

Erin Allmann Updyke Okay.

Erin Welsh But are you ready to hear my little vignettes?

Erin Allmann Updyke Yes, I can't wait.

Erin Welsh Do you want to know the 4 topics or do you want to be surprised?

Erin Allmann Updyke I think I want to be surprised.

Erin Welsh Okay, here we go. Number one. I've got to start of course with lightning.

Erin Allmann Updyke Oh yes!

Erin Welsh

And specifically one of the most famous stories in the history of lightning.

Erin Allmann Updyke

Is it BF and the kite and the key?

Erin Welsh

It is.

Erin Allmann Updyke

Finally a history story I at least have heard of!

Erin Welsh

(laughs) But starting way before that, people have long observed and revered lightning. It holds a really significant place in many historical religions or mythology. You have Zeus in Greek mythology, Thor in Norse mythology, Indra is the Hindu god of storms, Ukko is the Finnish god of thunder and sky and weather. And the Finnish word Ukkonen means lightning. And in the traditional religion of Bantu tribes in Africa, lightning is a sign of the gods being angry. And there's also representations of lightning in art and etchings going back thousands and thousands of years and the fascination that people had with lightning and the mystical power they ascribed to it, it's completely understandable, right? I mean, it's still fascinating and terrifying. But I'm not here to talk about lightning in mythology even though I would love to do that. But what I really want to talk about is when people realized what lightning was and how they gained that understanding.

Electricity itself has long, long been recognized by people and not necessarily in the context of lightning. People didn't look at lightning and immediately go, 'That's electricity.' The word electrical comes from the Latin word 'electricus' meaning amber-like. Which refers to the fact that amber when rubbed with a piece of wool gets statically charged. And so you get little shocks of static electricity which is actually the way you can tell whether it's real amber or not. But people saw this characteristic of amber and it was believed to have mystical or healing properties for that reason, for this electrical reason. There are amber pendants dating back to 12,000 BCE for instance.

And over time people began observing static electricity in other materials and began to characterize as much as they could about how this electricity worked and how these materials behaved under certain circumstances. And this process of observation and recording and reporting and so on, it allowed people to harness the power of electricity at least to a certain degree, a small degree, pretty small, for centuries. And I'm glossing over a lot here. The only way that people could intentionally produce static electricity is by rubbing materials together, petting your cat really hard. Just kidding. Rubbing amber with wool.

Erin Allmann Updyke

Yeah.

Erin Welsh

But doing that manually meant that the amount that you could generate was pretty limited.

Erin Allmann Updyke

Right.

Erin Welsh

So people began inventing tools to help such as hand cranked tools that rotated an object against a piece of silk, a static electricity machine. And ways to temporarily store that static electricity. By the mid 1700s, the concept of electricity had generated, and I put a little asterisk.

Erin Allmann Updyke

Did that on purpose?

Erin Welsh

Yeah.

Erin Allmann Updyke

Nice.

Erin Welsh

A lot of attention and interest. And people would only become more and more fascinated by this over the rest of the century. So where does Benjamin Franklin fit into all this? I teased his name and now I haven't talked about him yet. Okay. So the classic story of Ben Franklin is what?

Erin Allmann Updyke

Oh, he flew a kite into a cloud and got electrocuted by lightning.

Erin Welsh

Yeah.

Erin Allmann Updyke

Right? Is that it?

Erin Welsh

It's something like that. I feel like I learned it as Benjamin Franklin discovered electricity.

Erin Allmann Updyke

Oh yeah. Okay, sure.

Erin Welsh

By flying his kite in a lightning storm. But that obviously didn't happen, right? People already knew that electricity existed. We also don't know if the kite experiment happened itself or if Ben Franklin was involved or if he just designed the experiment, but it seems probable that it did actually happen. So if the story has been misrepresented over time and it's not really quite truthful, why do we all still know about it?

Erin Allmann Updyke

Yeah. Tell me why, Erin.

Erin Welsh

Okay. So several people including Ben Franklin had floated the idea that lightning storms were electrical. A lightning strike looks a giant spark in the sky, basically a giant-sized version of that static electricity discharge spark on your cat's nose. And so people thought that maybe electricity was stored in storm clouds and then discharged under certain conditions. That's a reasonable hypothesis but that's all it was. It was just a hypothesis and no one knew for sure. And so Ben wanted to find out. Ben, we're on first name basis.

Erin Allmann Updyke

Of course we are!

Erin Welsh

So he devised an experiment that fortunately went through several revisions because the first versions were incredibly dangerous, even more so than the final one ended up being. And they involved a person standing on top of a wooden platform holding a metal rod in the middle of the storm and stuff like that. Not good ideas. And so Ben made some adjustments to this experiment to make it safer. So he decided that all he needed was a kite that had a metal rod attached, a key, a device called a Leyden jar which is essentially used to store static electricity, apparently it's a modern day capacitor. I don't know how that works. So I'm just going to say it's a jar that's used to store static electricity.

Erin Allmann Updyke

Okay, yeah, cool.

Erin Welsh

He also needed a silk ribbon and nerves of steel. The only thing left to do was to wait for the right storm which arrived in Philadelphia in June of 1752. According to reports from that time, Ben and his son went out into the storm and threw the kite up into the skies. The metal rod attached to the kite picked up some of the ambient electricity from the storm, not lightning itself because he probably would have died if he had been struck by lightning or at least been severely injured.

Erin Allmann Updyke

Okay, yeah.

Erin Welsh

And that electricity traveled down the wet twine string into the key that was tied to the twine. And then Ben was like, is this key charged? Does this key have electricity? And he felt a little spark and he was like, 'Perfect.' So he was able to collect some of the storm's electricity and store it in that Leyden jar.

Erin Allmann Updyke

So he did it just with the storm, not with lightning.

Erin Welsh

Yeah.

Erin Allmann Updyke

That's a big difference.

Erin Welsh

Well it's a big difference and I think that there probably were strikes that happened, it was clearly a thunderstorm, lightning storm or whatever.

Erin Allmann Updyke

Right.

Erin Welsh

But he was able to collect that electricity without a lightning strike.

Erin Allmann Updyke

That's fascinating.

Erin Welsh

Yeah, yeah. It was a huge deal. And I also just want to take a moment to say don't do this at home probably.

Erin Allmann Updyke

Yeah. (laughs)

Erin Welsh

Because it's still a very dangerous experiment. And actually the year after he did this kite flying experiment, another scientist tried it elsewhere but was killed by ball lightning. So anyway. So newspapers all over published the accounts of Ben Franklin's experiment and it made him quite the celebrity. And even though he didn't discover electricity in this kite situation, his experiment did teach us several things. The first is that it showed that lightning is indeed electrical, right. The phenomenon that you had when you rubbed amber was the same but on a much much larger scale that you saw in nature when there was a thunderstorm.

Erin Allmann Updyke

Right.

Erin Welsh

Another is that it hinted at the enormous electrical power in storms and how we could possibly someday either harness it or that we could maybe generate great amounts of electricity ourselves.

Erin Allmann Updyke

Right. Oh, wow.

Erin Welsh

And the last big thing that I'll mention is that this experiment kind of immediately showed that lightning rods, the rod attached to the kite, could be used to protect structures which is an idea that Ben Franklin and others have been working on for a few years. I think that many of us, or at least I'll speak for myself, I definitely take it for granted that when I am inside my home I am protected from lightning.

Erin Allmann Updyke

Oh my gosh, yes.

Erin Welsh: Or in a public building, right. But A) that hasn't always been the case and B) it still is not the case for many people.

Erin Allmann Updyke: Yeah.

Erin Welsh: And in Ben Franklin's time, lightning posed a serious risk to people's houses and their crops and their lives. And there were always newspaper reports of these deadly lightning strikes and it seemed to be a very scary and real constant threat.

Erin Allmann Updyke: Yeah, absolutely. Reading this made me so much more terrified of lightning because I never realized how easy it would be to not have the protection that I have inside my home.

Erin Welsh: Yeah, absolutely. And so when this experiment showed that lightning rods could be used to protect your house or your building, people jumped on the idea and they begin installing them in houses and public buildings. And some of these are still in use today, such as the one on the Maryland State House which is one of Ben's original rods installed in 1788.

Erin Allmann Updyke: That's pretty cool.

Erin Welsh: I know. But I also just think this is interesting and this is sort of where I go right into trivia mode here. These lightning rods weren't universally popular. Churches actually didn't readily adopt lightning rods because many of these churches had bell towers, ringing bells. And ringing bells were widely believed to protect the church from lightning. And apparently there are bells that have this inscription of a Latin phrase that translated into English means 'I break the lightning'. I think that's so interesting. Turns out bells do not protect you from lightning and in fact can be quite dangerous, especially because in a storm bell ringers were called to go ring the bells.

Erin Allmann Updyke: Oh no.

Erin Welsh: And so they'd be ringing this wet rope and then get struck by lightning. And so a lot of deaths happen that way. So I want to wrap up this first story with a few pieces of trivia about lightning. In 2016, this is just literally bullet points here, in 2016 323 reindeer in Norway were killed all at the same time while huddling together during a storm.

Erin Allmann Updyke: What?

Erin Welsh: The longest lasting recorded lightning strike was 17.1 seconds in a storm over Uruguay and Northern Argentina in June of 2020.

Erin Allmann Updyke: Oh no.

Erin Welsh: And apparently the longest single flash was 477.2 miles or 768 km, just across parts of the Southern US in April 2020.

Erin Allmann Updyke: Wow.

Erin Welsh: Anyway, okay. Trivia over. Moving on to number two. Ben's kite flying, it had expanded the boundaries of what electricity could be and how and where it could appear. And in the decades after his experiment, electricity researchers dug deeper into the characteristics of electricity and especially whether different special types of electricity existed. Was all electricity the same? And this ultimately led to a huge debate over something called animal electricity. And that debate in turn led to one of the most impactful advancements in the history of electricity.

Erin Allmann Updyke

Okay.

Erin Welsh

So animal electricity was this idea put forth in the 1700s and championed heavily in the late 1700s by an Italian researcher named Luigi Galvani.

Erin Allmann Updyke

Okay.

Erin Welsh

And it was the idea that all animals created and stored electricity in their bodies, particularly in their brains, and that this animal electricity was responsible for movement.

Erin Allmann Updyke

Okay.

Erin Welsh

So he believed that this type of electricity was unique to living things only and it was not the same electricity that you could store in a Leyden jar for instance. And part of why he was so adamant that this was the way things were and that animal electricity was unique is because he was deeply religious and he believed that it was heresy to try to understand the inner workings of God's creations or to try to imitate them. And so he was like no, if you can generate static electricity and store that in a Leyden jar, there's no way that that could be the same thing that is in animals.

Erin Allmann Updyke

Okay, okay.

Erin Welsh

So to prove that animal electricity existed, Galvani did this series of experiments involving dead frogs and different metal wires. So when he attached these frogs' legs to the wires he noticed that they jumped or twitched, which he concluded was proof that the wires were simply allowing the stored up animal electricity to be released, like opening the valve. I know, I know.

Erin Allmann Updyke

Okay. I don't understand how you reach that conclusion but okay Galvani, give me some more.

Erin Welsh

You know who else didn't understand how he could reach that conclusion was another Italian researcher, Alessandro Volta.

Erin Allmann Updyke

Ah, Volta.

Erin Welsh

Volta. And so Volta was the opposite of Galvani in every way. And so he looked at this experiment and was like just like you said, I don't know how you could conclude that it was the frog and not the wires. So on the two sides of this, Galvani saying, 'No, the movement is coming from internal electricity from the animal itself.' And Volta was like, 'No, it is the application of external electricity causing the movement.' And the two went back and forth in their feud until Volta decided that he needed to settle the matter once and for all. So he was always experimenting with things and he had noticed that when he placed coins made of different metals on his tongue and put them down, he felt a bit of a tingle, kind of an electric shock.

Erin Allmann Updyke

(laughs) Okay.

Erin Welsh

And the strength of that tingle depended on which types of metals the coins were made of.

Erin Allmann Updyke

Okay.



Erin Welsh: And so he wanted to understand what was going on, that seemed to him electricity but how could he use that? And so he went to the literature and he came across the description of an animal that gave him a little spark of inspiration.

Erin Allmann Updyke: I love that you keep dropping these.

Erin Welsh: The torpedo fish, also called the electric ray.

Erin Allmann Updyke: Oh yeah!

Erin Welsh: Torpedo fish are so cool. So torpedo fish are kinds of rays found in the Eastern Atlantic Ocean and in the Mediterranean. And what makes them so unbelievably fascinating is that they have the ability to generate an electric shock so strong that it can knock a person unconscious.

Erin Allmann Updyke: Wow.

Erin Welsh: Yes. They use this to stun prey of course. I was so tempted to go into the evolutionary history of electricity, electrosensory organs and fish and stuff like that.

Erin Allmann Updyke: Oh my goodness.

Erin Welsh: But I resisted. But people had been aware of these torpedo fish for hundreds, even thousands of years and they were thought to have mystical properties because of this shock.

Erin Allmann Updyke: Of course.

Erin Welsh: They were used by some physicians in Ancient Rome to treat various medical issues, like they would just put the torpedo fish on the person.

Erin Allmann Updyke: Shock them?

Erin Welsh: One of the ailments that they were used for is hemorrhoids.

Erin Allmann Updyke: Ow!

Erin Welsh: I know. Terrible. But the nature of this shock that they delivered was debated. Was it electricity? There was no visible spark, so was it actually just a sting? Or was it something totally different? In the 1770s, so a couple of decades before the debate between Galvani and Volta kind of came to a head, an English scientist named Henry Cavendish showed that the torpedo fish produced electricity. But still there was this question of well what kind of electricity is it? Is this the same kind that we could artificially produce or is it this animal electricity? And so when Volta came across descriptions of this fish and particularly their electric organs, these columns of jelly-filled disks, he thought I wonder if these work in the same way that my metal coins on my tongue do. Just a couple of coins stacked together, give me a light tingle but if I increase the number of coins that touch the way these columns of disk in the electric fish are arranged with the amount of electricity also increase and lead to a larger shock.

So he tried it out. He stacked disks of copper and zinc and other metals along with cloth dipped in either dilute acidic solution or saltwater until he had this big pile of disks. He attached wires to each end and then he tested it on his tongue. Again, bad idea. And sure enough, a stronger tingle. But not only was it a greater shock, he was also surprised to find out that it was continuous. Electricity was flowing out of his pile like water. Hence why we call things electrical current or the flow of electricity, it was like liquid, people thought it was liquid in nature. It wasn't this one and done shock. And that is how, inspired by the torpedo fish, in 1799 Volta created the first true battery.

Erin Allmann Updyke

Battery!

Erin Welsh

How cool is that?

Erin Allmann Updyke

What?

Erin Welsh

I love it. It's so cool. And also not only did he just create this incredible source of electricity that would forever change things, he also proved Galvani wrong because he was like, 'I can generate electricity in the same way that the torpedo fish did but without any animal parts present.'

Erin Allmann Updyke

Yeah.

Erin Welsh

So he won.

Erin Allmann Updyke

Wow.

Erin Welsh

Yeah. So that's where volt comes from and also galvanized too.

Erin Allmann Updyke

Galvanized, yeah. Wow.

Erin Welsh

I know. So are you ready for number three?

Erin Allmann Updyke

Yeah, my brain is still just reeling. This is great. I want number three.

Erin Welsh

Okay, so let's now see one of the things that people did with this new knowledge of how to generate larger amounts of continuous electricity.

Erin Allmann Updyke

Okay.

Erin Welsh

Jumping ahead to the 1880s. So by this time the world had come a long way from Ben Franklin and his kite, several cities had street lights powered by electricity. And while we were still several decades away from being able to easily bring power into people's homes, electricity was in the process of becoming a more widely accessible everyday practical tool rather than something that was used in just magic shows or tinkered with only in scientific labs. But many people who were living in these cities that were lit by electrical lamps, they were still pretty wary of this power, especially as newspapers reported on an increasing number of accidental deaths from electricity. One of these deaths would inspire the invention of one of the US most gruesome devices. On August 7, 1881 in Buffalo, New York, a man named George Lemuel Smith had had a bit too much to drink and he stumbled into a power plant reportedly seeking the thrill of an electrical tingle.

Erin Allmann Updyke

What?

Erin Welsh

Yeah. I don't know. Well he got his tingle and a lot, lot more. His death by electrocution was presented by a coroner to an audience of medical professionals in Buffalo. And in that audience was a dentist by the name of Alfred P. Southwick. People find inspiration in all kinds of ways. Maybe an idea comes to you when you're in the shower or when you're reading a book or when you're on a long walk or maybe it comes to you in the form of an autopsy report of an electrocuted man. As Southwick listened to this case, an idea began to form. What if we could harness this power and put it to good use? Which in his eyes was to kill people who had been sentenced to death. Southwick teamed up with a physician and the head of the Buffalo ASPCA to test out this new method of execution on the stray animals of Buffalo. I know, it just gets worse.

Erin Allmann Updyke

Oh dear. It always does.

Erin Welsh

It always does. I'm not even going to venture a guess or say anything about whether Southwick was a sociopath or something that. But it does seem that his intentions were maybe not good but at least not evil because at the time capital punishment was done primarily through hanging, which is not always reliable and was associated with a lot of pain and injury and just bad, just gruesome.

Erin Allmann Updyke

Yeah.

Erin Welsh

Yeah. And so there was a series of botched hangings that had led to quite a bit of pushback against both hanging as well as capital punishment in general. And so Southwick viewed death by electrocution as a much more humane option. It seemed quick and painless and with practice more reliable. So he took the calculations that he had gathered from his animal experiments, scaled them up for humans and designed a delivery method: a chair not unlike a dental chair. And that is how the electric chair was born.

Erin Allmann Updyke

Wow.

Erin Welsh

So he brought this design to New York politicians and lobbied them to replace hanging with his electric chair. The governor at the time was like, 'You know what, you might be onto something here.' So he put together a commission to investigate the electric chair alongside the other common methods and not so common methods of execution that were used which by the end of their investigations totaled 34 different methods.

Erin Allmann Updyke

Whoa.

Erin Welsh

Yeah, I know. It's a disturbing number. Some of these methods were tossed out pretty quickly but others proved to be stiff competition like decapitation via guillotine.

Erin Allmann Updyke

Guillotine.

Erin Welsh

But the commission concluded that electrocution was the winner. They still had concerns but it seemed like the best choice. What also helped make this be the number one choice was that the electric chair got a vote of confidence from one very prominent figure in electricity, Thomas Edison. You know Erin, I would love to spend so much time talking about the electricity wars between Edison and Nikola Tesla and Westinghouse but I just can't. If there was ever an episode for it to happen, it would be this one but I decided against it.

Erin Allmann Updyke

I'm actually shocked by that because I know your feelings about Thomas Edison.

Erin Welsh

You're shocked by that?

Erin Allmann Updyke

(laughs)

Erin Welsh

So what you need to know essentially is that Thomas Edison was a huge proponent of direct current, that's what he worked in, that's what he invested so much time and money into having that be the type of energy used in homes, commercially, everywhere. Nikola Tesla on the other hand had worked with alternating current. Edison was extremely threatened by Tesla and Westinghouse's alternating current and so he launched essentially a smear campaign against it. One strategy of this campaign was to get the alternating current-powered electric chair approved for executions because if A/C was used to kill people, would you really want it in your homes? So with Edison's backing and just a few pesky details to be worked out like the amount of charge and how long and blah blah blah, the commission recommended the electric chair as a primary form of execution.

And on August 6, 1890, 9 years minus one day after the death of George Smith that kicked off this whole situation, the first execution via electric chair on a person was carried out. A man named William Kemmler had been convicted of murdering his girlfriend Tillie Ziegler with a hatchet in front of enough witnesses to easily put him away and he had been sentenced to death. His electrocution did not go well. I think the eyewitness account says it best.

Erin Allmann Updyke

Oh dear.

Erin Welsh

And if you would rather not hear a pretty gruesome description of an electric chair execution, I would suggest skipping ahead about a minute and a half to two minutes. Okay, quote:

"The scene of Kemmler's execution was too horrible to picture. Men accustomed to every form of suffering grew faint as the awful spectacle was unfolded before their eyes. Those who stood in the sight were filled with awe as they saw the effects of this most potent of fluids, electricity, which is only partially understood by those who have studied it most faithfully as it slowly, too slowly disintegrated the fiber and tissues of the body through which it passed. The heaving of the chest which it had been promised would be stilled in an instant of peace as soon as the circuit was completed, the foaming of the mouth, the bloody sweat, the writhing of shoulders and all other signs of life. Horrible as these all were, they were made infinitely more horrible by the premature removal of the electrodes and the subsequent replacing of them for not seconds but minutes until the room was filled with the odor of burning flesh and strong men fainted and fell like logs upon the floor."

Erin Allmann Updyke

That's horrific.

Erin Welsh

It's absolutely horrific. There were debates about whether he was brain dead and actually had any pain sensation and I think that that has long been a controversy in terms of electric chair execution.

Erin Allmann Updyke

Oh I'm sure, yeah.

Erin Welsh

But I think one of the things that surprised me the most, or maybe it shouldn't have, but this happened and people were like, 'You know what? It's fine.'

Erin Allmann Updyke

We're gonna keep going.

Erin Welsh

We're gonna keep going.

Erin Allmann Updyke

Yeah. Let's try it again.

Erin Welsh

I mean in popular news reports, the doctors were completely slammed, they were like you botched this, this is terrible, you need to do better. And so yeah, maybe they were just convincing enough that like no, we can do better next time.

Erin Allmann Updyke

Right. Ugh.

Erin Welsh

But yeah. And so in the months and years that followed this first electric chair execution, the entire process was tweaked a bit here and there to avoid a repeat of what happened with Kemmler. And death by electric chair became a very common method of execution in the US and basically nowhere else. And in the US, states appointed electrocutioners who were generally people whose skills lay not in human physiology and how our bodies worked, but in electricity.

One of these, Robert G. Elliott, was the state executioner for New York and ended up executing 387 people during his lengthy career. At the end of his life he wrote an autobiography reflecting on his whole life and career and experiences. And I wanted to mention it because I think his takeaway is super interesting. He believed at the end of all of this that the death penalty should be abolished. And it's not that he felt morally responsible for these deaths or worried about the people that he had executed having suffered, he thought that it was a painless process and he was like, 'I'm just doing my job.' But he felt that capital punishment in general wasn't any use. It wasn't a deterrent to crime and it was really more society taking its revenge. There was no good outcome of this. He felt that witnessing an execution should be a civic duty, like jury service for all citizens. And felt that if that were to happen, if there had to be like oh this is the committee that's going to watch this execution, he was like the death penalty would be gone very quickly.

Erin Allmann Updyke

That's an interesting thought.

Erin Welsh

Isn't that an interesting thought? Yeah. So since that first execution via electric chair of Kemmler in 1890, there have been over 4300 executions by electric chair in the US. And I feel it holds a pretty infamous place in history or in pop culture. There are famous electric chairs, Gruesome Gertie, Old Smokey, Old Sparky, and it's been featured in countless songs, shout out to Ride The Lightning by Metallica, which I was about to say forced to listen to for the first time the other day. And also it's featured in books and movies and shows. Off the top of my head I can think of several. The Green Mile, right?

Starting in the late 1970s, the electric chair began to be phased out as lethal injection took over in states where the death penalty still exists. But this gruesome chapter in electricity history is not quite over because the electric chair is still an option in some US states and some states allow people to choose their method of execution. So maybe how about we stop here in electric chair and we move on to a slightly lighter bit of history? Okay, okay. So I wanted to end the history section on a bit of a happier note by talking about how electricity has been used not to kill people, but rather to try to help them.

Erin Allmann Updyke

Okay.

Erin Welsh

I'm going to just do a very, very quick tour through this history and hope that one day I get to do a deeper dive on something like electroconvulsive therapy for instance. Okay, so I already mentioned how both amber and electric fish were used thousands of years ago to try to treat or cure people. But the age of electrotherapy really began when the study of electricity kicked off in the 1700s. People may not have understood exactly how electricity worked, turns out they still don't I guess, but they still tried to use it to treat basically any condition they could think of. Throughout the 1800s and into the early 1900s, electrotherapy became incredibly popular and physicians who practiced electrotherapy actually called themselves electricians. Isn't that great? Yeah. And it was an incredibly lucrative field to be in. And apparently I learned that many of the early advances in electricity technology were driven by physicians wanting to have better control over the electrical charge that they applied to their patients.

Erin Allmann Updyke

Interesting.

Erin Welsh

Yeah. Because unlike many of the electrical scientists at the time, the physicians actually had a strong revenue stream from their patients to be able to focus those research efforts.

Erin Allmann Updyke

Yeah.

Erin Welsh

And so many of these early electrical innovations were medical-focused. Some of these devices may have helped people a little but as you can imagine, this was a field full of snake oil. For example, I just want to talk briefly about one of the most popular electrotherapy devices in the early 20th century, which was the Pulvermacher belt. You could get it by mail order only.

Erin Allmann Updyke

Of course.

Erin Welsh

So picture if you will a normal belt, strap somehow batteries to it, and then put that around your waist directly on your bare skin.

Erin Allmann Updyke

Okay.

Erin Welsh

So it was supposed to release a steady electrical current that gave off a nice little tingle where the belt rested. At first the belt was widely marketed to everyone but then the focus narrowed a bit with the release of the Pulvermacher pouch which you would attach to the front of the belt and rest your genitals inside. (laughs) You have to see the drawing of this belt. It kills me, it's so funny. So it was advertised as improving sexual vitality.

Erin Allmann Updyke

Of course.

Erin Welsh

And it was an absolute best seller. So much so that, you know those click bait headlines that are like 'Doctors hate this one trick'? That is essentially the Pulvermacher device.

Erin Allmann Updyke

The equivalent. (laughs)

Erin Welsh

They wanted it to be banned. They were like we need patients to come in to see us and they're just sitting at home with these belts on. Also maybe they wanted it to be banned because it didn't work to do anything really. And that's what people were generally realizing about electrotherapy, especially as things like germ theory revealed the underlying pathologies of various diseases which didn't necessarily have any overt link to electricity. Whereas in the 1800s, electrotherapy was considered essentially a cure all, by the early decades of the 1900s it had fallen out of favor more or less and was kind of seen as a specialist treatment. But it didn't go away entirely.

In the 1920s and the 1930s there was a lot of research looking into a possible relationship between epilepsy and schizophrenia. And several physicians mistakenly believed that they represented opposite ends of a disease spectrum. And the implication of that was that if you induced seizures in someone with schizophrenia, you could treat the disease. And that is how electroconvulsive therapy first began to be used for schizophrenia. And it seemed at least somewhat effective but the how and the why was not and I think is still not fully known. And despite the bad popular reputation it has mostly owing to issues with informed consent and negative media portrayals which I would love to talk more about in a bigger episode, it's still used today to treat many different disorders in addition to schizophrenia, one of the most common being certain kinds of depression.

And it's successfully used and it seems we've come a long way from the 1920s and 1930s in the way that we treat people with this. And so I think that ECT is kind of this example that we have where something that started out a long time ago, electrotherapy in general, as snake oil or mostly placebo effect has now evolved so much over time that it is used very effectively in many different types of conditions, right. You have the ECT used to treat types of depression, vagus nerve stimulation to treat some epilepsy, deep brain stimulation to treat Parkinson's disease. And there are many, many more examples. And even if we still have more to understand about how electricity works, it's amazing to me to think of how much it has taught us about ourselves with different nerves and different muscles, or maybe in the future what lightning strikes can teach us about brain functionality.

Erin Allmann Updyke

Yeah.

Erin Welsh

So speaking of lightning strikes Erin, what's happening with electrical shocks and lightning strikes and whatever else today?

Erin Allmann Updyke

Well I don't know. Let's take a break and then find out.

TPWKY

(transition theme)

Erin Allmann Updyke

So bringing it all the way back to lightning, where we began. First off, like I said earlier, we truly have no clue how many people are struck by lightning or the death toll from lightning strikes straight up. Two recent studies estimated between 6000-24,000 fatalities per year which is a very huge range.

Erin Welsh

Yeah.

Erin Allmann Updyke

Really big differences in different studies. And a lot of papers kind of assume that globally there are at least 10 times as many injuries as there are deaths. So for estimates of 24,000 fatalities, that's over 240,000 injuries globally.

Erin Welsh

How has that changed over time?

Erin Allmann Updyke

It's a great question. It definitely has changed. The biggest problem., there's two biggest problems. Number one, most countries simply don't report this type of information because they're not collecting it, right. Even in the US our lightning data from what I read, and I think that this is still true, it's mostly gathered by NOAA and so it's not gathered in specific by any kind of medical establishment. And so we still don't even have good numbers for the US and the same is true in most if not all other countries. And also of course lightning isn't exactly evenly distributed across the globe. So there are some areas that at certain times of year have a lot of lightning and other places that don't really have much lightning year round, etc.

In general from what I could gather, the overall death rate does seem to be declining especially in developed and high income countries where we have good infrastructure that can help protect people from lightning strikes. So for example in the US, older papers that I read estimated 100 fatalities a year, even older ones said it used to be as high as 400 a year. More recent numbers cited about 30 deaths annually in the US. So in the US we've certainly seen a decline, in many other countries likely a decline. But there are still so many risk factors in a lot of places in the world associated with increased lightning deaths that really come down to infrastructure issues, right. Not having lightning-safe dwellings or workplaces or schools. So the short answer is we still don't really know.

Erin Welsh

Yeah. Figured.

Erin Allmann Updyke

As a comparison though I didn't realize, and this made me so much more terrified even though I'm in San Diego, we don't have a lot of lightning, although I heard thunder this morning, there are more than 20 million cloud to ground lightning strikes annually in the lower 48 states alone. 20 million cloud to ground strikes.

Erin Welsh

That's a lot.

Erin Allmann Updyke

That is so many!

Erin Welsh

In one year.

Erin Allmann Updyke

In one year!

Erin Welsh

Yeah.

Erin Allmann Updyke

Wild. So the other question then is what is going to continue to happen in the future? Certainly we know what types of infrastructure and what types of dwellings can help to protect people from lightning strikes. What happens globally, especially as our climate changes?

Erin Welsh

Yeah.

Erin Allmann Updyke

Our favorite thing to talk about on this podcast.

Erin Welsh

I was wondering about that.

Erin Allmann Updyke

Yeah, I'm still wondering about it. One paper that I read, which was a modeling paper, estimated that global lightning flash rate could actually decrease with climate change. They estimated about a 15% decrease in lightning strikes with climate change based on their models. But other papers have estimated the exact opposite, an increase of anywhere from 4-16% in lightning with climate change. And from what I can gather there's definitely a strong theoretical possibility that warmer global temperatures, especially in the tropics, can result in greater lightning frequency because of those warm air fronts and we know that those are the kinds of conditions under which lightning can occur. But it really comes down to it's not as simple as temperature equals lightning. And I mean climate change isn't as simple as temperature equals anything.

Erin Welsh

Right, yeah.



Erin Allmann Updyke

Other papers have looked at more of the secondary effects of lightning, right, which we didn't even get into because that's a whole other situation. But other papers have looked at things like an increasingly dry climate increases the risk of things forest fires that are associated with lightning. Lightning is a major cause of forest fires. And so even if the actual amount of lightning might decrease or not change, if the dry season is longer then that could actually contribute to an increasing risk associated with those lightning strikes.

Erin Welsh

That makes sense, yeah.

Erin Allmann Updyke

Right?

Erin Welsh

Yeah.

Erin Allmann Updyke

So it's complicated and we don't really know what's going to happen with the future of lightning. But there is so much room for fascinating research.

Erin Welsh

There is, there really is. And also better monitoring please.

Erin Allmann Updyke

Yes, definitely. For sure.

Erin Welsh

Should we do sources?

Erin Allmann Updyke

We should, I have some great ones I want to shout out.

Erin Welsh

Me too! Okay. Number one, I want to shout out again the book 'Spark' by timothy Jorgensen. So good, fascinating. Go check it out. Then I have some more multimedia sources. So I watched a great documentary called Shock and Awe: The Story of Electricity. It's by BBC, it's on YouTube. I will link to it. It's really fascinating. Then a couple of podcast episodes. The first one is by Outside Podcast and it's called Science and Survival: Struck by Lightning. That's a very impactful episode I felt that not only talked about someone's experience but also a little bit more about science and stuff like that too.

Erin Allmann Updyke

Oh it was great.

Erin Welsh

And then the last one is one that I listened to with my sister when she came to visit me and we drove up to the Tetons in Wyoming and it's a podcast called National Park After Dark and they do episodes focused on different stories and the one we listened to was about the Tetons, the Grand Teton National Park and it's called A Fatal Lightning Strike and the Jenny Lake Rangers and that is wow. I mean it was riveting.

Erin Allmann Updyke

I had a book and a book chapter that was absolutely awesome and so comprehensive focused specifically on lightning. One was called 'Reducing Lightning Injuries Worldwide', that's the book. And then there was Lightning-Related Injuries and Safety, both written by Mary Ann Cooper et al. And then there's a few others, kind of older papers that were on both electrical and lightning strike if you're interested in kind of both of those and comparing contrasting, as well as those papers on the kind of climate change projections. We'll post the sources for this episode and all of our episodes on our website [thispodcastwillkillyou.com](http://thispodcastwillkillyou.com).

Erin Welsh

Thank you to Bloodmobile for providing the music for this episode and all of our episodes.

Erin Allmann Updyke

Thank you to Exactly Right network.

Erin Welsh

And thank you to you, listeners.

Erin Allmann Updyke

You're the best.

Erin Welsh

You are the best. I hope you liked this, I thought this was a very interesting and kind of a different one.

Erin Allmann Updyke

Oh, I have a good one. I hope you found it enlightening.

Erin Welsh

Ooh, good one. Good one, Erin.

Erin Allmann Updyke

Thanks.

Erin Welsh

I mean I can't add any more than that. So thank you also to our wonderful patrons. We appreciate you so much.

Erin Allmann Updyke

So much.

Erin Welsh

Well until next time, wash your hands.

Erin Allmann Updyke

You filthy animals.