Fulminology with Chris Giesige
Ologies Podcast
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Oh heeyyy, it's your mom's neighbor who dresses up that ceramic goose on her porch – now in a tiny scarecrow costume for fall – Alie Ward. I'm back with another episode – a fiery one – of *Ologies*. This is one of those very, very many years in the making episodes, where as soon as I decided to make this podcast, *Ologies*, I was like, "I've got to hit up this expert," and I put him on a list. This interview... it's electric.

But first, let's thank everyone in the club at Patreon.com/Ologies. You're like fam. You submit questions and you find out what episodes are coming up. I love you. Thanks to everyone who's recommended *Ologies* on message boards, and group texts, and socially-distanced barbecues. Thanks to everyone wearing *Ologies* merch from OlogiesMerch.com. Thank you to the folks who press subscribe and who rate it. We're, like, number three on the science charts. It's bananas. Especially thank you to the folks who leave reviews for me to read on days when I feel like a dirty, nervous prairie dog, which is often, sometimes. I read them all, and here's a fresh one to prove it. This is from Love This who said:

> *You'd think scientists would be very serious people who get straight to the point, but nope! So fun to listen to, I learn so much. Thanks, Dad Ward. I hope you know that that's your name now and that will be put on your headstone. I hope you like it. Signed, Love This.*

Love This, I love that. Yes, I'm into it. It's an honor.

Okay, so, fulminology. Let's get into it. Very much a thing. It's a science of those streaks in the sky and it comes from the Latin word *fulgere* which means 'to shine' or 'to flash'. And, by the way, I learned this one minute ago, that 'fulminate' also means 'to publish a thundering denunciation.' So, if you're feeling pretty charged up by current events, fulminate to your heart's content, my sweet, smart babies. Kaboom.

Also, if you have a fear of thunder and lightning, you're not alone. I'm looking straight at you, my dog, Gremmie, and also my dear sister-friend Shannon Feltus. You have something that is called keraunophobia. It's also inexplicably named astraphobia, brontophobia and tonitrophobia. Let's learn a little bit more about it.

I met this Ologist probably five years ago; we were both on the bill for a 'Nerd Nite' in LA and he just dazzled this whiskey-drunk crowd with wildfire and thunderstorm facts. He studied fire science in northern California, and for the past decade has been a researcher with the WestCats Group, reviewing satellite imagery, monitoring weather patterns, and really mapping the topography of the western United States to figure out how geology and mountains interact with weather systems to better predict where lightning might strike. He is such a Californian. I love it. He's laid back, he's cool, affable, committed to protecting the land we love out here.

So, kick your boots up, lean back on your porch chair, open a beer or an organic-superfoods kombucha, and enjoy some facts about thunder, and lightning, and Thor, and storms, and pigeons, and volcanoes, and scars, and jigawatts, and sprites, and elves, and flaming tornadoes, and of course, wildfires, with lightning scientist and your favorite fulminologist, Chris Giesige.

Alie Ward: When all of this news of all of these dry lightning, and dry storms, and blazing hollow trees was coming up in the last couple weeks, I was like, "I have so many questions!" My first question I always ask: Can you say your first and last name and what your pronouns are?

Chris Giesige: My name is Chris Giesige. Pronouns: he.

Alie: Cool.

Aside: Also, Chris is about to start a new and very exciting job, but because we're so deep in infernos out here, his start time has to wait until after fire season, ironically.

Chris: It's a job as an inspector with Cal Fire. So, going to properties and places and making sure that people are ready to go in case a wildfire… not if but when, a wildfire comes through, up in the Napa County area.

Alie: When is fire season even over in California?

Chris: You know, it all depends. This year, it's looking like it's going to be high and dry until at least October-November. I'm ready to go. I mean, shoot man, I got my boots, I got my gear, throw me on there, my N95 mask. Put me out there, let me talk to some people about some fire prevention.

Alie: Yeah! You're from up there. Did you grow up with fires and lightning really on your radar, on your *Doppler*, since you were a kid or where did you start getting into this?

Chris: Well, it's funny because California, in general, a lot of people think, "Oh, California's kind of boring. Maybe they got some earthquakes here and there or two." Growing up in Sonoma County, I really don't remember a lot of fire activity. We don't really get too much thunder and lightning. It was one of those things where it was just like, [*dude bro voice*] "Oh, you know, being a firefighter would be cool. Maybe I'll do that." Kind of macho. [*laughs*] "Get out there! Yeah, bro! Firefighter!" [*laughs*]

It really wasn't until maybe the later years of high school, I started thinking it would be kind of cool, it pays well, the benefits are really good. It's all about the future. Find something that you can get all those good perks with. And then I go to college and I'm like, "Wow, actually the science of this stuff is a lot more fascinating to me."

Alie: Ah! And what kind of courses did you start taking? Was it meteorology or physics? What does a fire-lightning scientist study?

Chris: At first, it's just straight fire science. You're looking at fire chemistry, you're looking at fire behavior, you're looking at fire prevention systems, and it's both wildland and structure fire, or residential fire. You kind of pick up both, at least the program I was in. It was even things like hazardous materials, and weapons of mass destruction, and all that kind of crazy stuff. So basically, it's fire chemistry, the history of fires, fire behavior, fire prevention systems, things like hazardous materials.

Aside: He says that once you get further into college and you jump through those flaming hoops, you can specialize in how meteorology affects fire and climate, or you can study G.I.S. – which I 100% had to look up and found that it means 'geographic information systems', a.k.a. maps. Well, it's technically "a framework for gathering, managing and analyzing data rooted in the science of geography and analyzing spatial location and layers of information into visualizations using map and 3D scenes." Which means really bitchin' as hell maps.

Chris: You can even just continue into some sort of fire management. A lot of my coursework is strictly related to fire and a lot of life sciences stuff; weather and climate, physics, definitely, and calculus. A lot of people don't know, but yes, you do calculus.

Alie: What are you calculusing as a fire scientist?

Chris: So many computers and different models that help us with this. There really isn't that much calculus when you're doing in-the-field stuff, but, in terms of meteorology and fire weather, calculus is a lot of integrals and derivatives. It's all rates of change.

Alie: How much of your work deals with fire science and how much deals with lightning? Or is it kind of an equal amount?

Chris: It's kind of an equal amount. My research in particular is more lightning. We look more at the electrical magnetic properties of it. Let's say we're trying to figure out a way to build more confidence in our lightning models for prediction or projections. So, we kind of look at: What are the different atmospheric elements and conditions that are happening? And how is that interacting with the earth, creating some sort of electrical magnetic environment in that particular place, to create lightning at a certain place and a certain time? And then, we relate that mostly to a typical "fire season" which is, usually, your late spring or summer months through fall. We come up with some sort of projection system to say, "All right, these areas have high risk of lightning and because, during these months, when these certain conditions are met, lightning-caused fires could be issues here."

Aside: Okay, this is a *huge* issue and as someone who lives on the west coast, the last few weeks our lives out here have just been spent indoors. Not only because of corona but because the air is so thick with smoke, you can barely see a few hundred feet in front of you. I, myself, have had horrible headaches, a few migraines, my throat hurts, the whites of my eyes are kind of a soft, fuchsia color. And wildfires in Oregon have claimed the lives of dozens of people and counting. So this is a really big topic, but we're going to put a pin in it for a second and get to the basics of lightning. What does it look like? How does it work? And is the sky mad, bro?

Alie: And do you have a lightning storm in your mind that, when you think back, is the most fireworks one that you've ever experienced? What's the craziest lightning storm you've ever seen?

Chris: Man, there's a lot of good ones. I mean, not really here in California, per se; the last one we had recently was damaging and everything – but from my perspective, it was kind of fun – but most of the major lightning storms that have been through either Florida or Ohio. So the Midwest or Florida which gets lightning like crazy. It was actually at Disney World. It looked like the cloud-to-ground lightning strikes were hitting the bush right in front of us and it was [*thunder cracking*]. Everything rumbles, and it cracks, and you kind of lose stability for a little bit. It's *so* loud and it's *so* bright, to the point where my mom and my sister were actually covering their ears and were like, "We don't want to be here! Chris, we need to leave!"

Alie: [*laughs*] How old were you?

Chris: This was three years ago.

Alie: Oh, okay! [*laughs*] I wasn't sure if you were, like, a baby.

Chris: No, no. And me, I'm like, "Oh my gosh, this is so cool! We got to see what happens! Let's see if it's going to hit that tower, let's see if it's going to fry these people."

Alie: Ahh! Were they, like, "Chris, did you bring this with you?!" It knows that you're a fire-lightning wizard?

Chris: Fire-lightning wizard! [*laughs*]

Alie: It's going on your business card. Okay, but seeing it that up-close – I've never seen it that up-close. What is the difference between lightning striking the clouds to the ground versus the ground to the clouds? What exactly is lightning? Where is it going?

Chris: So, the story of lightning! I've actually kind of written about this. To kind of set a tone here, the way I think of the process of lightning happening is, I think about all these little molecules and particles that are happening within the cloud and happening within the atmosphere and are flowing in the earth. I always like to think of them as an emoji. Little emojis running around with different smiley faces, they're positive charge and negative charge. They have this goal in life and that's to find something of the opposite charge and connect with it and do this little dance. Then they go into the great beyond afterwards, wherever that is, whatever they're doing there. So lightning is a development of certain cloud type called cumulonimbus clouds.

Aside: If you heard Nephology with Dr. Rachel Storer, you may be familiar already, with cloud anatomy.

Chris: What happens is, within these clouds… The clouds form because we typically have updrafts of air; warm air rises, so we get updrafts, and as it rises, it runs into the altitude. So you get higher up and higher up, it gets a little colder, and as the air rises it kind of cools and condenses. Little droplets form around particulates; little ice crystals can form. They're banging around in there and having a good ol' time, hitting each other, bumping, doing whatever. At that point, you start to build up this static charge, this electrostatic charge that's in the clouds, as electrons start to get stripped or transferred from one to the other. During this process, eventually what happens is these clouds, when they're starting to get ready, when they're priming themselves for a lightning event, they separate themselves.

So, the negative charges go down towards the bottom of the cloud and the positive charges go towards the middle or the top of the cloud. This is because weather is a neutralization process. So, we're trying to get these electrons that are up in the cloud down to earth. They want to neutralize themself at earth. Bring them back to where they belong. So they separate themselves up there and then at the same time, they're separating themselves in other clouds or they're separating themselves at the ground. So on the ground level, the electrons will actually get pushed down to further layers of the ground which leaves nothing but a positive charge stuck at the surface.

This is just opposites attract. Like charges repel each other so the electrons in the cloud are going to help push those down, those electrons in the ground down even further into the ground and that leaves a nice positive charge on the surface. What happens then is once everything gets kind of built up, then those charges are going to look to connect somewhere. And so, sometimes they're going to interconnect within the cloud, sometimes they're going to connect between one cloud and another, which is cloud-to-cloud, or sometimes they're going to try and connect with the charges that are on the ground and that would be cloud-to-ground lightning.

Alie: Oh, okay!

Aside: So these ice particles are just having an airborne mosh pit. Some are losing electrons, some are gaining them, and this tension builds, and then the mosh pit divides

with the negative charges heading to the bottom. Now, as for cloud-to-ground lightning, electrons on the Earth's surface get pushed further into the ground, so positive charges are, kind of, simmering on the ground, and they have to meet each other, and then boom, lightning strikes to neutralize it. And the mosh pit goes wild. They love it. And then they're like [*sigh of relief*].

Alie: And so, which is most common?

Chris: Cloud-to-ground lightning is actually the least common. It's the one we see and the one we relate to the most, but it only makes up like 20-25% of lightning strikes. The rest are typically cloud-to-cloud or intracloud.

Alie: Oh, okay!

Chris: Crazy, right? [*laughs*]

Alie: Yeah! And so they're up there, kind of, banging around, and discharging that electricity from cloud-to-cloud a lot of the times, but we notice the ones that are ground-to-cloud because they're closer to us?

Chris: Well, they look cooler, they're more streaky, they're the ones that we see when the flash comes down. Yeah, it's like an adrenaline rush for them, really. You know, the ones coming from the cloud to the ground, what I picture is that after enough electrostatic charge is built up in the clouds, they're now ready to go, and you have something called 'stepped leaders' and 'streamers'. These are kind of the leading charges that are getting out there and ready to go.

Aside: So these are stepped leaders, that reach down toward the ground; and streamers, down below that reach up.

Chris: So I picture these little charges strapping on a helmet, putting on their goggles. [*laughs*] And the stepped leaders are up in the cloud, and they're shouting out at the streamers down on the ground, you know, [*as if over a CB radio*] "Stepped leader to streamer leader. Stepped leader to streamer leader. Over." [*Alie giggles*] "Streamer to stepped leader. Streamer to stepped leader. Copy that. Ready to engage." "All right, here we go!" And then they turn around, and they get all the other electrons riled up, "Are you ready to do this??!! YEAH LET'S GO!" Then they throw on some heavy metal music and they take off. [*cracks up laughing*]

Alie: I was just going to say, you need *Jock Jams* for this!

Chris: Yeah. [*laughs*] And the stepped leader's kind of the initiator of these lightning strikes. So they take off towards the ground, and they have no idea where they're going. They have no idea where these other charges are on the ground because there's such a distance between them. They can only really communication about 50 meters or so. That's why you start to see lightning in jagged forms, because it's these electrons trying to reach the ground that are trying to find the opposite charge, but really can't. So they shoot out in intervals, and they take this jagged path until eventually they connect with it. Then they meet together, the streamers, so the charges on the ground will actually reach up sometimes and try to meet them at a certain point.

Alie: Cool! And is it fractals at all, or am I making that up? Does it go, like, two veins split into four veins, split into… Is there anything, like, mathematic or pattern-wise about lightning strikes, or is it pretty random?

Chris: It's just, kind of, whatever path they can find for least resistance, and however they can try and find themselves to the opposite charge. But I mean, it does form a very, like, family tree-like structure, or veins of a river or stream, something like that, which is pretty cool.

Alie: Yeah. Ah! You've never been struck by lightning, have you?

Chris: I have not. [*"Knock on wood."*] I do not plan on it. I don't know about you, Alie.

Alie: [*laughs*] Mmm… I'm sayin' no on that. I'm gonna pass.

Chris: A little lightning up the butt doesn't sound too good. I don't know about you.

Alie: Nope. Gonna keep my butt right out of it, to be honest. Have you heard about the guy who was struck something like seven times?

Chris: Yeah! That'd be the old park ranger guy.

Alie: Yes!

Chris: Shoot, what's his… His name's Roy Sullivan!

Alie: Oh, nice!

Chris: Have you ever looked him up?

Alie: I have, and I've read his story. What do you think was happening with him?

Chris: Oh my God, this poor guy. So, several of the instances… I mean, he's driving away from a storm and gets nailed by lightning inside of his car. I think something like that happened twice.

Aside: Yep. It's true. Apparently, whenever he was caught in a storm he would pull over and lie down in the front seat of the truck to hide from the lightning, and he also started to carry around a can of water in case he got struck again and his hair caught on fire. Spoiler: He had to use that can more than once!

Chris: He's out working in the field, gets struck a third time. He even one time was inside of his house, just sitting there in his chair. From the way they explain it… I mean, this guy is just unlucky as shit. The way they explain it, the lightning bolt finds its way through the electrical system, into his house, ricochets off of this, like, metal container or something, and then zaps him in his chair. How unlucky do you have to be for that to happen?!

Alie: What! Do you think it's possible that he was a very negatively charged person?

Chris: You know, nothing surprises me. [*laughs*] It could be. It could be circumstances, wrong place wrong time, it could be… I don't know. Maybe he upset Zeus in some way and Zeus is just like, "Screw you, man!"

Alie: Maybe he needed an exorcism.

Aside: PS: Poor Roy Sullivan started to think that maybe there was a force out to get him and he started to fear death, which would've happened to me after the first strike, let's be honest. But like, around strike four he was like, "Oh shit. Am I gonna die? I… I…"

But Roy didn't die from a lightning strike. Sadly, he passed away from a self-inflicted gunshot wound. Proof that even a powerful shock from the sky that could kill a herd of livestock can be less painful and deadly than mental health struggles, just in case you needed another reason to be compassionate to fellow humans today.

Let's get back to fulminology.

Alie: Talk to me a little bit about the different forms, because from what I understand, there's heat, and ball, and sprites, and dry lightning. I don't know what any of those are. I just know the words.

Chris: Oh yeah. First of all, there's several things. Sprites, and elves, and… there's other mythical creature names… Trolls. Sprites, elves, and trolls. What these are is electromagnetic discharges. So you have a lightning event, and you're having a discharge of electricity, and these create electromagnetic pulses. So what a sprite or an elf might be is, the lightning itself actually discharges these electromagnetic discharges up above it into the next layer of the atmosphere. So, they happen above lightning events, and typically it's from positive lightning.

You have positive lightning and negative lightning, and it's the type of attraction that there is. Negative lightning is a lot more common. It's when the negative charges connect with the positive charges on the ground. And then positive lightning's a lot less common, but it's a lot more powerful. That's when the positive charges in the cloud connect with the negative charges on the ground. This just has to do with, one, the positive lightning usually is just proton based, so they're a lot more dense than electrons so they can pull up more electrons, and by doing that you create more energy.

So it's typically after these really intense, high-energy, positive lightning strikes that you will get things like sprites or elves. Have you ever seen pictures?

Alie: No. I'll look it up, though!

Chris: Sprites, they look like jellyfish in the sky.

Alie: [*so excited*] Ahhh!

Chris: Yeah, or if you're… I don't know if anyone out there is a *Pokémon* person, but they kind of look like Tentacruels up there. [*laughs*] Giant Tentacruel from *Pokémon*. To me, at least. That's what I see.

Aside: Yes, they're called sprites, and elves, and gnomes, and pixies, and they're upper-atmosphere lightning, or what's called 'transient luminesce events'. They look like discs, or red spots at the top of clouds, or blue jets, or kind of like jellyfish ghosts, and UFOs, and rave lights. Also, who doesn't love a well-done backronym? Like Transient Red Optical Luminous Lineament, aka TROLLs. Only trolls don't like that.

Also, a lot of folks asked about ball lightning, which has been described by one expert as, "a luminous sphere, most often the size of a small child's head." Sure, that's a unit of measurement. The United States won't adopt the metric system, but we will use standards like 'The Size of a Small Child's Head'.

But scientists still don't really understand what the deal is with ball lightning. For a long time, up until the 1990s, these were just dismissed as, like, hallucinations. So, wow. We've got a lot to learn. Future fulminologists, please figure it out. Thank you.

Alie: Now, what about, like, dry lightning or heat lightning? The kind of lightning that we've had in California lately that has been sparking fires?

Chris: Yeah. Dry lightning is basically just lightning with very, very minimal to no precipitation. What happens is, a storm comes through… For instance, the one that we recently had. We were getting a bunch of moisture dished off from that tropical storm that was down there in the southeast Pacific; shooting moisture like a laser gun into California. [*"Pew! Pew! Pew!"*]

And at the same time it's actually really hot. So what happens is you get your typical thunderstorm build up, but the precipitation evaporates before it gets to the ground, and that's when you see clouds that are called 'virga'. Virga is just a formation.

So, it looks like stuff's coming out of the cloud, but then it evaporates. You still get lightning at the same time because there's such a buildup of charge going on up there in the atmosphere. And the reason that's particularly dangerous, as we saw in California, or other states in the western U.S. might see, is that with that little precipitation, that means there's not a lot of water to come along with these lightning strikes. And if vegetation, or fuels, are extremely dry, then you get the potential for lightning-caused fires. Big events like the one we just had, where we had 11,000 lightning strikes that caused hundreds of fires at the same time, you know, within two days, that's your potential there.

Alie: Oof!

Aside: 11,000 lightning strikes! I looked this up. It's real. That's a real number.

Alie: And how hot is a lightning strike? I've read that it's potentially hotter than the Sun??

Chris: Hotter than the surface of the Sun. Yeah. It can reach up to 50-60,000°F.

Alie: OH MY GOD! How is that even possible??!!

Chris: Yeah, it's freaking crazy! That's so hot.

Alie: That's nuts. So you've got that striking a dry hillside and it's just, like, a tinderbox.

Chris: Yeah. Absolutely. Those are one of the things that we look for in fire weather, under certain types of red-flag conditions, is the possibility of dry lightning.

Aside: Okay, we're going to get back to fires in a bit, but first: There are about 8 million lightning strikes *a day* on Earth. But where are they happening?

Alie: You mentioned the western United States, and before you'd mentioned – shout out – Florida, Ohio: great lightning! Why do some areas of the globe have more lightning and others don't? Or different types?

Chris: A lot of it has to do with just the amount of moisture that they're getting. In these tropical zones, what we see is there's a lot more moisture being pumped in by those warm ocean currents. The warm ocean and moisture's a pretty good precursor to lightning because it's what helps form those droplets. In those areas and those zones, they're usually a lot warmer, so now you have the heat that is rising, convection. Warm air is rising and it combines with that moisture to help produce the charge that's up there in the atmosphere, and that's why they typically get a lot more lightning. It's just this constant flow, and this constant pump, of this warm air and this moisture. And solar irradiance, too, plays a big factor in it.

Alie: What is solar irradiance?

Chris: Those are just the little particles that we get from the Sun. It's the energy that we receive from the Sun. The Sun shoots out these photons, and big beams of photons that get transported all the way through space onto Earth. With that, you have current. So, the flow of those particles is a current, which creates heat. And that right there is a source of energy. That's why solar is so big. It's the big differences in how the Earth is heated by the Sun and how it collects solar irradiance that helps develop certain pressure and wind conditions.

Alie: Oh, okay. So you have that whole, big bag of mixed factors, and with the right conditions, with the right convection, and moisture, and ions, that is why some areas are just more lightning prone.

Chris: Yeah. Yeah, it's the climate of those particular areas. Or mountain ranges are another big one – topography. So how the topography is laid out is pretty big too.

Alie: Ooh. And what about if you're in the middle of a lightning storm, and you're in your car? Are you safe because of the rubber tires, or does it act like a Faraday cage? How does a Faraday cage even work, if so?

Chris: So typically yeah, you typically are pretty safe in your car. But that doesn't mean that there's not a possibility of getting hit, as our old friend Roy Sullivan understands and knows.

Alie: Yeah, I know. [*sympathetic noises*] Poor Roy!

Chris: But typically you're a little bit safer because of that. But it doesn't mean that it's not going to find a way of least resistance to find its way through your car and hit you.

Aside: Just an audio note. Something was buzzing in the background, and it sounds like lightning, but Chris and I have no idea what it was to be honest, so just consider it part of the lightning vibe, folks. It's not followed by thunder each time though, so don't worry.

Alie: What about counting lightning and thunder? We've seen it in a million movies: you count, you can do a calculation, you can know how far away the storm is, if it's coming or going… is that flimflam, or is that real deal?

Chris: No, typically you actually kinda can. The general rule is that you see a lightning strike, and you count, and every five seconds is about a mile.

Alie: [*surprised*] Okay!

Chris: Yeah, I used to hear a lot that you count and the number of seconds you count is the number of miles away that the storm is, where the lightning strikes are, but it's about five seconds per mile.

Alie: Okay!

Chris: Yeah. And so, if you're outside or whatever, and you want to know if it's safe to go outside, then you generally try and get to a point where you see lightning but don't hear any thunder.

Alie: Ohhhh! Good to know. So it's far enough away where it's not going to come and get you.

Chris: Yeah. It's tough, because a lot of people think, "Okay, well, y'know, it's five miles away." But lightning travels very, very far, and it can strike you from quite some distance.

Alie: How long do you think is a typical lightning bolt?

Chris: Most of them actually aren't that long, but you can be several miles out and that thing will find an area if that area's charged and ready to go for it.

Alie: Does it usually want to discharge or connect with a charge that's higher up? Like, is that why there's lightning rods, or do trees get zapped a lot? And how does that kill cows under trees, which… I don't know if that's a myth, too?

Chris: It can definitely kill animals. So the reason we have lightning rods or the reason that a very tall tree might be one of the worst spots to stand under, or isolated tall trees, is they're providing a path of least resistance. When these storms come, these charges from the

ground are able to flow up into those places and connect with the lightning that's coming out of the atmosphere. Because they happen to be tall, the charges are able to meet a little bit earlier there. And if you happen to be the cow standing underneath it, and those charges on the ground start flowing through areas, or lightning decides that it doesn't want to hit that tree, you're going to get a little spark that's going to go up one leg, through the heart, and down the other side.

Alie: [*gasps*] Wow.

Chris: Yeah, they even had the crazy… uh, a couple hundred reindeer actually, I think it was Canada, *done* from a lightning strike.

Alie: Nooooo.

Chris: Yeah, they found a ton of them dead because it had just done that: it travels up one side goes right through the heart, travels down the other.

Alie: [*gasps*] Ohhhh my gosh. I wonder if that's a painful death or if it's really quick.

Chris: Uh, I hope it's quick. I would say you could ask the reindeer, but that's not… [*laughs*]

Alie: [*groans, laughing*] Not available for comment!

Aside: PS, this lightning strike that killed over 300 reindeer was in Norway in 2016, and experts say that the lightning struck and it was the current carried through the ground and up through the hooves that killed these cervids all at once. What tends to happen to alive things – like humans – is that the jolt zips through the body and stops the heart. Which is why CPR after a lightning strike can be lifesaving. So we should all know how to do that, probably. And one adage is, "When thunder roars, head indoors." You know, unless you wanna risk being lightly toasted by the sky.

Alie: I bet it smells like burned hair.

Chris: Oh yeah. Ugh.

Alie: Can you smell weather? Are you good at that? Can you smell certain weather or is that also a myth?

Chris: No, sometimes you can, and it just has to do with the breakdown of the bacteria, I believe, in the soil. And in the air. You know, it's that chemical that you're smelling when a storm comes passing through.

Aside: Side note: if you are me, and you like to huff the dirt post-rain, the smell is called 'petrichor', and it comes from bacteria that make a scent called 'geosmin', which I want to be my pen name. And if you're like, "Dang! Smells so good! Someone should bottle it and sell it!" may I direct your attention to Etsy.com which offers petrichor-scented oils. They have candles. People make incense. Did I just spend $8.22 for a small bottle of petrichor-scented oil that smells like, "A summer storm in a bottle"? I did. I did.

Also, we are about to get to listener questions, but before we do, we're going to hear about sponsors of the show who have some deals for you. Those deals make it possible for us to throw some cash at worthwhile non-profits each episode. And this week Chris asked that it goes to International Relief Teams, whose mission is to alleviate the suffering caused by poverty and disaster around the globe, from the forgotten corners of the world to right here at home by sending volunteer teams, relief supplies, and other assistance to improve the lives of those who suffer most. You can donate and learn more about what they do at IRTeams.org.

We're also sending an extra donation to Chris's research teams at WestCats.com. This is a group of fire scientists aiming to be pioneers at the forefront of early detection and advance warnings for forest fires and Chris's work explores that. So, cha-ching! Keep doing good stuff, y'all. Now, you may hear about some sponsors who enable us to not freak out about giving away money every week.

[*Ad Break*]

All right. Questions from our loyal Patreon folks.

Alie: Okay. I'm going to dive in to… the lightning round, if you will.

Chris: Heh-heh-heh-heh!

Alie: Correct. And just whatever answers… strike you. Go for it. [*Chris laughs*] The worst? The worst. Okay.

So many patrons had so many questions, and I tried to group them, so first-time question-asker HR Bumga, as well as Liz Roepke, McKaylee Eggett, Leah, Zoe Jane, Bee Wilson, first-time question-asker Ali Reil, Kyle Ebenstein, Haley Vandewall, Dawn Zwart, Leah Pedder, they all had similar questions. Number one: Have you seen the movie, *Sweet Home Alabama*?

[*Clip from Sweet Home Alabama*]

Tabatha: *Look at these.*

Melanie: *It's what happens to sand when it's struck by lightning.*

Frederick: *She's pulling your dick.*

Melanie: *No, really. I've seen it. You just have to dig it up.*

Chris: Haha… yeah.

Alie: Do you know what this question is about?

Chris: Is it the glass?

Alie: Yes! Is that a true thing? Like lightning on sand, what does that do? HR Bumga wants to know.

Chris: Yeah, no. [*pauses*] So… that is true. What happens is typically these beaches are high in a certain type of material – silica comes to mind – and what it does is the energy from the lightning fuses sand to this material. And then you create things out of it.

Alie: When you saw that movie, were you already into lightning and fire, or were you just like a braces-faced teen being like, "Reese Witherspoon, what a babe."

Chris: [*laughs*] Yeah, kind of, I honestly was not on the route to being as involved in lightning as I was. It was kind of like, "Oh*, Sweet Home Alabama*, all right." [*Alie laughs*] "Yeah, Reese Witherspoon, she's cool."

Alie: So many people thought maybe that was not even real, so you've changed their worlds.

Okay, this next question was asked by Jessica Chamberlain, Ali, Koryn, Corrie Navis, Christen Mahaney, Nathan Wilgeroth, Ruby Johnstone, Emm, and first-time question-asker Tomena Scholze. Tomena had so many questions, but all these people wanted to know: How dangerous is it to shower or use the computer during a thunderstorm? Is it true that you shouldn't use the shower when it is thundering and lightning?

Chris: Yeah, I mean, a good rule of being outside is get the heck out of the pool.

Alie: Right!

Chris: Or the lake. Or the river. And when you're inside, for… [*stuffy PSA voice*] 'proper lightning safety measures', [*Alie laughs*] you kind of want to do the same thing. Get away from anything that's electrically circuited or water as best as you can, because that's just… electrical charges are just going to find those channels to travel through, because it's easy for it to travel through. So, you know, do your best; I probably would. I'm sure there's a lot of people out there who are like, "Ooh a lightning storm! I'm gonna go take a shower!" You know? But it can be dangerous. You're better off just not being there, in the shower or next to any sort of electrical circuitry.

Alie: Okay! Good to know! So just take a load off, take a gander, lay low. Good to know.

Jesse Markowitz, Jake, Skylar Alexander-Brown, and Jess Swann wanted to know: Is there lightning on other planets?

Chris: Oh, absolutely there is. Yeah, it's not something that I've really dove into, but Jupiter gets a ton of lightning.

Alie: What? [*squawks in amazement*]

Chris: Yeah, crazy! I mean, the dang thing's got a storm the size of another planet on it, so it's gonna produce a lot of lightning. And it's very similar processes that happen here on Earth, I believe…

Aside: Okay, just a side note, I know that Jupiter has a huge, ruddy beauty mark that is really just a whorl of meteorological chaos, but I was like, "What is that big red spot called? I feel like I know it, but I can't remember it." So I looked it up, and it's called… The Great Red Spot. That's like if you named your firstborn child The Baby Thing. It's clear. It's bold. It's a choice.

Chris: And then Saturn is kind of another big one. I'm sure someone out there is studying space lightning and sees all kinds of cool crap. But yeah, I do know that there's lightning on other planets. There's similar processes between electrical charges. It's universal!

Alie: Mhmm. I'm gonna have to find an astro-fulminologist. There's gotta be one out there!

Chris: Oh yeah. There's gotta be somebody out there.

Alie: Let's see, first-time question-asker Gianna McClain, Gabrielle Friesen, first-time question-asker Hope, all wanted to know, in Hope's words: When people get struck by lightning, they get those scars that look like lightning, so what causes those? Have you seen those?

Chris: You know, there'd probably be someone more in tune to dealing with injuries and medical… I don't know how those scars are formed. I know Harry Potter got his [*Alie laughs*] from a very high-energy concentrated spell. I don't recommend it. But exactly what's going on inside of the body that causes it to get those specific scars, I'm not sure.

Aside: Okay, of *course* I looked this up, and these raised marks are called 'Lichtenberg figures', and they're caused by blood vessels exploding from the heat and the electric discharge of those branching fractal-y patterns of the lightning. And they look first and foremost very ouchy. And secondly they're *gorgeous.* They're weirdly so pretty. Also painful. If you go to Instagram.com/Ologies this week I will treat you to a gallery. [*aaahhh of anticipation*] The scars. The blisters. The intrigue.

Alie: Do human beings walk around with a certain electrical charge?

Chris: Um… they can. I mean, our bodies are transporting electrons and stuff all the time, and our brains are constantly sending out and receiving electrical signals.

Aside: Okay, if you've ever touched something and gotten a little *zippy zip zip* spark, congrats! That's pretty much mini-lightning. But let's talk about even bigger effects like, giant, mind-blowing ones. Like, Big Bang-scale effects.

Chris: These electromagnetic discharges from lightning have actually been shown to create antimatter, which is pretty freaking cool!

Alie: [*gasps in disbelief*] What!?

Chris: These charges produce really high strong gamma rays and x-rays – so really high frequencies – and the gamma rays react with the air that's around it and produce positrons. [*intones*] Positron Prime.

Alie: Oh my God! [*laughs*]

Chris: [*laughs*] Yeah, I like to think of it as if it were a Transformer, but it creates positrons which are kind of the antimatter version of electrons. What happens is, after they produce these, and they run around, and these gamma rays are so much energy that they knock the neutrons out of nitrogen. That unstable nitrogen then releases the positrons. And then eventually they'll end up finding an electron to collide with it and then they'll annihilate each other.

Alie: Oh. My. God.

Chris: Yeah, so imagine you just walking around on the street and all of a sudden an anti-Alie comes up and you guys bump into each other! [*Alie gasps*] And then you're just gone! You annihilate each other! [*laughs*]

Alie: Is that possible on… is it possible to look at how that happens with lightning and figure out how to do that on Earth?

Chris: I don't know, Superman had some trouble with Bizarro Superman, so I'm not sure that's… [*both laugh*] But yeah, no, that's something that's really cool. These researchers in Japan are actually the ones who are like, "Yeah! Creates anti-matter! Freaking positrons!"

Alie: Oh. My. God. That's amazing.

And a bunch of listeners had a really good question – Steven Clark, Sid Gopujkar, Adam Weaver, Haley Vandewall, Kaydee Coast, Nicole Wackerle, Ross Owen Qualls, and Huw Plummer all wanted to know: Is capturing lightning a viable energy source?

Chris: Oh man, this is crazy, right? Okay, so, the thing is that lightning produces *so much* electricity. There's *so much* energy there. You're talking somewhere between hundreds to a billion volts of current possible there. And so my research associate and I have actually kind of dove into this. And what you'd have to do is… you'd have to find a way of putting up some sort of rod, or at least our idea – nobody steal this, because we're working on it! [*both laugh*] – is you take something and right as the lightning strike is about to happen, you give it a really strong charge so that it has the highest charge of anything out there, so lightning essentially is attracted to this thing. [*"You know, you're really very attractive."*]

Maybe it looks like a tree? So when lightning strikes it, what you'd have to do is you'd have to have a really, really strong, negatively charged base so that it helps kind of contain and

disseminate some of that energy. But at the same time, you would have to maybe keep that energy flowing so that what you would get is maybe a direct current. And you would have to keep that current flowing and what you would probably have to do is, it would have to go into some sort of station where it's able to be broken up, or able to be chopped up, and then distributed to other parts because you don't want a million volts going to people's homes.

Alie: Right.

Chris: [*both laughing*] That's about a million times more voltage than comes out of your little electric sockets there. So, is it possible? Man, it's really tough. I know Tesla - old Nikola Tesla, that guy - he was kind of working on it, or at least he was thinking about it. That's what he was working on when he was there in Colorado. Radio waves, just you're sending frequencies back and forth.

Alie: I had no idea that there were frequencies involved. I do remember that he was in love with a pigeon, which I know that there was so much more to his story, but um…

Chris: [*laughs*] Is that what you got out of his whole career?

Alie: [*laughs*] I know, I'm the worst.

Chris: What was the pigeon's name?

Alie: I don't know. He was so in love, though. And I really felt for him.

Chris: Fred?

Alie: I don't know; I really felt for him! I know he did so much, but that part I really connected with. I was like, "I get it. That pigeon's never going to love you."

Aside: Okay. Just because I know that we're all wondering, and we all want to name something after it. This pigeon's name was not Fred. It was a lady pigeon, a brilliant white pigeon with gray tips at the end of its wings, and Tesla once said, "*I loved that pigeon as a man loves a woman, and she loved me. As long as I had her, there was a purpose to my life*."

So it *was* requited! That changes everything. Although it did make a final visit to him in his hotel room in 1922, and by his account her eyes shone a brilliant, burning white light, and it was a message that she was dying. And he said he knew at that moment that his life's work - which involved huge, history-changing accomplishments in electricity, plasma, and radio waves - he knew at that moment his work was over.

But he also remained celibate and never married ever, partly because he thought it would interfere with those accomplishments. You know what they say, "Doves before loves."

Alie: Sean Johnson wants to know: Can a bolt of lightning actually produce [*mad scientist voice*] 1.21 jigawatts of power?

Chris: [*laughing*] Oh my gosh. That's great. I'm assuming he's referring to *Back to the Future*.

Alie: Yup. Ol' Doc Brown.

Chris: Yeah, I love that.

[*clip from Back to the Future*, *Doc Brown saying, "1.21 jigawatts! Great Scott!" Marty McFly: "What the hell is a jigawatt?!"*]

Chris: I'm not sure if it's that much or not. I think… give me a second here.

Alie: Yeah. Are you going to do some back-of-the-envelope calculations?

Chris: Yeah. [*laughs*]

Alie: Calculus is happening.

Chris: Uh, yeah. They can produce 1.21, uh… gigawatts.

Alie: Really?

Chris: Yeah! [*"Nice."*]

Alie: I can't believe we actually got to ask a lightning scientist.

Chris: I mean, there's obviously a range of gigawatts that lightning produces. But yeah, I think it could be… it's in there.

Alie: Wow, okay! We finally know that; that's amazing.

Aside: If you're mad at me right now because I said "jigawatts," and not gigawatts, please blame *Back to the Future* writers Robert Zemeckis and Bob Gale, who thought gigawatts were pronounced jigawatts, and so they spelled it with a "j" in their script. And they shot the whole movie, and then afterward they're like, "Oh! It's gigawatts." People didn't have Google!

Also, pronouncing it with the "j" sound like jigawatts *is* technically the very old method of speaking this word. So it is likely that the *Back to the Future* writers heard an older recording, or a professor, use the softer "j" sound, and that's why they spelled it wrong. And that's why a lot of us say it wrong.

It's like, uugh, if only we could ask the person who named gigawatts how they wanted it pronounced, like we can the creator of the gif, who says it's pronounced, "jif!" And don't @ me - I'm your internet dad! How dare you?

Okay. A few Patrons wanted to know about flaming spinnies, such as first-time question-askers Rachel Noble, Alyssa Royse, and….

Alie: Jamie Almodovar, first time asking a question: Are fire tornadoes a real thing? How often do they occur, if so?

Chris: Ohhhhh, shit. I love this question. Fire tornadoes: spinning, rotating, convective vortexes of terror!

Alie: Ohhh God!

Chris: [*laughs*] So, we're going to break it down a little bit here. A true fire tornado has a very specific definition. Of course, the media love the term 'fire tornado' or 'firenado' because it sounds a lot more badass than fire whirl. Honestly. I mean, come on.

Alie: Fire whirl?

Chris: The only thing more badass than a fire tornado would be a fire sharknado.

Alie: [*laughs*] Yeah!

Chris: And we haven't seen those yet, but I can't wait until that happens. [*Alie laughing*] So, most of the time what you're seeing are fire whirls. There are also fire devils, which are the equivalent of a dust devil, just with fire. But most of what you see out there in fires are either fire whirls, which are on the smaller end, or a convective, rotating vortex. In meteorology, or in any sort of weather stuff, if it's got the name 'vortex' in it, it's usually *really* cool.

Alie: [*laughs*] Okay.

Chris: So we love to call things 'vortex'. A true fire tornado - there's actually only been a couple, maybe three that we've been able to observe, at least since we've had the technology and capabilities to do so. In order for it to be a true fire tornado, you have to have something that's rotating violently. ["*Yikes*!"]

Chris: And it has to be connected to the ground *and* to a cloud - so to some sort of cumulus cloud, whether it's a cumulus formation in the sky, or a thunderhead, or a pyrocumulus cloud up above.

Aside: There was a nearby canine who crashed our recording and was very excited to chime in about this. So when you hear it, just pretend this conversation is like, happening on a country porch, on a swing, with your favorite lightning buddy. It's just ambience.

Chris: And that has to have some sort of rotation as well. [*small dog yapping in the background*] Most of what people call fire tornadoes aren't typically connected to that cumulus cloud up there in the atmosphere, so then it's usually just a fire whirl.

Alie: Oh, okay.

Chris: Yeah. So if we're going by the true definition of a fire tornado - in other words, a tornado, as defined as a violently rotating column of air that is connected to the ground and to the cloud, only one that is made from fire - there really has only been a couple that we know of, or have been able to see. The one - I'm sure you probably heard all about the one that happened in the Loyalton fire just recently.

Alie: Yes!

Aside: So just to refresh your memory: this was August 15th, 2020, near Hallelujah Junction in California by the Nevada border, northwest of Reno. Tasha Farrell, aka That1GirlTasha on Twitter, captured video of the dry, golden chaparral of the Sierras with this raging brushfire and a column of spiraling smoke in the middle. Reaction all over the world was a really unifying, "What the *fuck*, 2020?"

Chris: Yeah, that one: actually true fire tornado. And the cool thing about that is even though they might've had a little bit of warning ahead of time, the National Weather Service was able to issue a tornado warning. And I'm pretty sure that's never been done before because fire tornadoes, or fire whirls, are extremely difficult to predict. So that was kind of a steppingstone in the cool science of fire behavior and fire tornadoes, is the fact that the National Weather Service was actually able to issue a tornado warning for that particular event, which is *really* cool.

Alie: That kind of dovetails into what first-time question-asker Val Lucas wanted to know: How do the lightning tracker maps update so fast? Like, the flash out the window and then the dot popping up on the map are instantaneous. So, is technology getting better to track this stuff?

Chris: Oh, absolutely. Absolutely. And it's really cool. I mean, it's come a long way. I mean, before you used to not be able to get lightening updates for every so many minutes or so, or hours, and now a lightning map will update every 15 seconds.

Alie: How do they do that?!

Chris: It's really cool. So, when lightning strikes give out these electromagnetic pulses, the satellite systems are able to pick up on those.

Alie: Ohhhh!

Chris: Yeah. Like, pretty much instantaneously almost. So then it just gets sent back down to whatever modeling system is being used. Technology is great. Computer programmers are even better, and they're able to make this stuff work in close-to-real time.

Alie: Kaydee Coast, who does a lot of transcription for us and is amazing, says: It bothers me that they call Thor "the God of *Thunder*," 'cause that's the sound, right? He should be the God of Lightning. Wants to know: Does that bug you, too?

Chris: [*laughs*] I think he's badass either way. But yes, he should be Thor, God of Lightning, because you don't have thunder without lightning.

Alie: Right!

Chris: So, yeah. He really should be the God of Lightning! You know what? That's a good point, Kaydee! I've never really sat there and picked it apart and threw a fit because of it. But now that I think of it, yeah! He should be the God of Lightning. Why not? It's lightning that he summons and uses.

Alie: Right? Aren't you glad that you have something to be mad about?

Chris: Yeah! He's not going around going, "[*thunderous crashing noises*] Take that!"

Alie: "I'm really loud! I'm really loud and that's my power!"

Chris: "Aaaaarrrrrrhhh! [*crashing noises*]." [*laughs*]

Alie: Actually, we *did* have a few people ask… Emily A. wants to know: Is it true that thunder is the sound of lightning? And a few other people wanted to know, first-time question-askers and boot quakers Luna Lowery and Kate H: Why it's so scary. Why is thunder scary? Any idea? Is it a certain, like, frequency or is it just because it's *so* loud?

Chris: Well, that'd be perception, right? Some might find it scary; I would find it extremely fascinating and joyous, somewhat of an adrenaline rush at certain moments. But yeah, thunder is the sound of lightning because without lightning, you don't have thunder kind of like we talked about. And because lightning… there's so much energy and so much heat that is created by lightning, that energy, the air around it, cannot expand fast enough. So pressure is shot out around those areas of where a lightning strike has just gone down and produces a shockwave, and that shockwave becomes a sound wave, so that's what we hear as thunder.

It can be really scary because the ground is shaking, the air is rumbling it sounds like a war zone out there, sometimes. You have no idea when that lightning strike is going to happen, or where it's going to happen, so you run for your life and hide in a corner, or under the bed, or something like that and just wait for it to get over. So yeah, I guess that could be scary. [*laughing*]

Alie: I heard a little dog in the background. How does that dog do with lightning and thunder?

Chris: That is my neighbor's dog.

Alie: Okay. So you're like, "I don't know."

Chris: Yeah, I don't know. It's a little one, so I'm assuming it doesn't do too good? [*laughs*] I don't know. Yeah. Even big ones, man. I used to have a dog that, oooh, did not like it.

Aside: Hence Thunder Shirts, or pressure garments for pups and people alike. Who knew that consistent, gentle pressure like a hug releases anxiety-soothing hormones? Well, scientists. And also, people. But not makers of girdles. You just, you went too far with those. Reel it in a little.

Alie: A bunch of people, Sam Healey, first-time question-asker, JJ Pierce, Chris Moore, first-time question-asker, Rachael Dashiell, and Ayshia Yaeger wanted to know about hair standing up during a thunderstorm. And Sam says: My shoulder-length hair was standing completely on end once when I was standing in a field during a thunderstorm, and I found out later that was *not* a good sign. I was 14, so forgive my ignorance.

If you're around something dangerous, like a lightning storm, does your hair just statically kind of do that?

Chris: Yeah. It's a reaction to the static that's in the atmosphere. So what's happening during a lightning event is you're producing something that's electric and magnetic, and there's electrostatic that's happening before these lightning strikes are coming or as a storm is approaching. We know this because part of what we do is we go out there with something that reads electromagnetism.

[*clip from Ghost Hunters: "Dude. There's no electricity in here; we shouldn't be getting any EMF!"*]

Chris: Not to try and find ghosts or anything, or spirits, but to try and find and look at the magnetic properties of a storm that comes through or a lightning event. And you can see that the EM meter fluctuates a lot. I mean, we'll hit a high note at the time that a storm's overhead. So if there's a storm approaching, especially if there's that much buildup of an electrical charge, of static in the atmosphere, yeah your hairs are gonna rise right on up - just like the old, uh, you know, rub a balloon on the carpet, put it on your head, and watch your hair go all over the place.

Alie: But does that mean you should run for cover somewhere? Preferably not under a big tree that's by itself?

Chris: Unless those are just your spidey senses tingling a little bit, I'd probably move, because it's definitely a sign that there's something electrically going on in the atmosphere and you don't want to be around when those lightning strikes come down.

Alie: [*high pitched*] Woooo! Now, some people would want to go out in a lightning storm on purpose, and Chuong Nguyen wants to know: How true is the Ben Franklin story? The key, the kite. Is it all bullshit?

Chris: No, this actually happened. Lucky enough for you, I went back and read all the original letters that Ben Franklin was sending to his colleague about experiments he was doing with electricity. Actually, one of my favorite quotes ever is from one of those.

Aside: Quick aside, Chris sent this Ben Franklin passage to me later. It was written around April 1749, and it reads:

> *If they are driven by winds against mountains, those mountains being less electrified attract them. If much loaded, the electrical fire is at once taken from the whole cloud, and in leaving it, flashes brightly, and cracks loudly.*

And from what I gather, Franklin also sometimes referred to lightning storms or lightning bolts as thunder gusts. Which honestly is an aces term for flatulence. Anyway.

Chris: He basically was just trying to show how electricity works and how you get a separation of charges and you get a buildup of static and he went, "Okay, well, hey, guess what? There's electricity in the atmosphere and there's electricity in the sky." So, in order to show this experiment, he goes out and throws something up there. Something that he knows is going to attract the electrical charges that are in the sky. A kite is a perfect thing for that, and lo and behold, he shows, "Hey! There *is* electricity up there!"

Alie: There are several people who wrote in - this *boggled* me - saying that a lot of people in their family had been hit. Renee of David and Renee's Woodworking, Mardee Goodwin, Mae. Mae is a first-time question-asker, and so are Renee and David. I'll read Mae's question: OMG!! So my partner and my brother and I were all struck by lightning at the same time while fishing...

Chris: [*high pitched*] Aaah! Oh shit.

Alie: … all unharmed. I'm wondering about what things people who survive being struck by lightning may experience, like any long-term medical side effects? But, PS, I found out later that my mom and her brother were struck at the same time, and their grandfather and his sister were struck at the same time!

And then, Mardee Goodwin says: My family is, um, prone to attracting lightning, I guess? Two members of their family had been struck, one fatally. And then Renee and David said that multiple people on the mom's side of the family have all been struck by lightning and lived. What the hell's going on?

Chris: What in the hell? I can't believe that many listeners have experience with this. I haven't met anybody yet who's actually been struck. Holy crap!

Alie: I mean, right?

Chris: OMG. The people who are struck at the same time, obviously they're… Well, I guess maybe not obviously, sorry, I shouldn't say that. But they're in and undergoing the same electrical experience at the same time. So just like the cows in a field, or just like the reindeer, they're in an area that is highly charged and that charge wants to try and neutralize itself. So it's going to try and find a path that it can extend itself through. The fact that there were multiple people in an area during the same event that all got struck, isn't too surprising. Why it's happening to some people's family members more, that's a really good question. I would probably start to question it myself.

Alie: Yeah. I would be like, "I guess we're cursed. There's an oracle; someone pissed off a goblin." I don't know. I'll look into it.

Aside: Okay, you are in no way cursed - one hundred percent jk jk jk. You are exciting, and special, because you just impressed a professional fulminologist, which I imagine is hard to do. Also I looked for any scientific evidence that getting struck by lightning could possibly run in families or was genetic, and honestly the only thing I could come up with is that *maybe* it's hereditary to just enjoy the outdoors.

One commenter on a Quora discussion on the matter - who is not a lightning expert, mind you – said, [*pompously*] "The idea that some people have some mysterious trait that somehow attracts lightning is nonsense. A myth. Balderdash and hogwash." Okay. Impressed by the vocab, tone's a little salty.

However, really what the hell does anyone know? Scientists used to explain bird migration by confidently saying that during the winter, all the birds just went and hung out on the

MOON. We don't know anything, we're all such stupid babies - even scientists. They're just trying to figure it out. It's beautiful. Let's keep this knowledge fire a-raging.

Alie: A few people, Madeline Lewis and Marc Chavez. Madeline Lewis, first-time question-asker, wants to know about: Volcanic lightning or a wildfire smoke inducing lightning. Does that happen?

Chris: Oh yeah, absolutely. They kind of have similar components to them. They're pyrocumulus clouds, which are the cumulus clouds that are formed by fire or by lightning. And then they can later evolve, sometimes, if enough heat, and moisture, and charge is being pumped into them to create pyrocumulonimbus clouds, which are the ones that produce lightning.

What you have, during a fire especially, is fire's burning, and it's releasing a lot of energy through heat and moisture - so much energy and so much heat. And you see this more often on fires that are burning really, really hot. We get something called pyroconvection, which is eventually that heat and the moisture starts to rise - because hot air rises - and it mixes with the cooler air and kind of like a typical thunderstorm, as it arises, it starts to condense and it starts to form cumulus clouds, or pyrocumulus clouds. And the crazy thing is that the updrafts of this hot air rising, the updrafts of these suckers, can reach up to 100 miles per hour.

Alie: Oh my god!

Chris: Yeah. So there's just so much going in there. The fire's continuously pumping that heat and that moisture into these cumulus clouds, they keep growing, and growing, and growing, and you get more vertical movement until eventually a pyrocumulonimbus cloud is formed. And then you start to get the charge separation. You get the banging around of those particles up there produced from the ash and from the smoke that allow the moisture to condense on them, which then helps create the passing of charges like we talked about. You'll get lightning from that, or you can get lightning from that.

It's very similar with volcanoes because volcanoes have so much heat and they're releasing all that gas in the ash material, creating these really dense smoke plumes, they start to create a static ionization in a sense, and you get all these charged particles ready to go, all happy and excited. An adrenaline rush for them again, and they can produce lightning. So it's really cool. Pictures of volcanic lightning are actually really sick. I don't know if you or anybody out there listening has ever seen pictures of volcanic lightning, if you haven't, look it up. It's hella sick. It's hella sick, bro! [*laughs*]

Alie: The most Northern California sentence you could say, I love it.

Aside: I looked it up and it's true. Volcanic lightning pictures are hella sweet. They look like if a mountain had a midlife crisis and decided to become a heavy metal disco. Smoke machine, strobe lights, danger. If you looked through the plumes of ash, there has *got* to be a Yeti in there doing a guitar solo.

Alie: I have just a couple more questions from listeners, because I know literally we could go on for hours. Elizabeth Edwards, and Rachael, and Maria Jouravleva - Elizabeth, Rachael, both first-time question-askers - wanted to know a little bit more about what percentage of wildfires are caused by lightning strikes globally and also are these wildfires changing because of climate change, and should we be using more indigenous land management to prevent the big burns?

Chris: I've been waiting for a question like this. We know the climate is going to come into it. I'm not quite sure exactly what the global statistics are. In the US, I know roughly 80-90% of fires are caused by humans. [*Price is Right loser horns*] Then the other percent caused by lightning, so 10-20%, but that also depends on the region you're in. Some areas of the Southwest or, say, Alaska, or Montana, or Idaho might have a lot more lightning-caused fires or a greater percentage of lightning-caused fires than other places. Australia too, they get quite a few lightning-caused fires. When you look at places like Australia or Alaska, it's not uncommon for them to have what we had here: a hundred lightning-caused fires within a 24-hour period.

But overall, human-caused fires are the big one. And we actually don't mind lightning-caused fires unless they're during events, such as the one that we just had here in California, or unless it's a fire itself producing some sort of lightning activity. Because a lot of the lightning-caused fires that happen tend to happen in remote areas, where we're trying to get around to this 'if it's happening in an area far off somewhere in the mountains, let it burn, let it ravage the fuel and take over'.

Aside: So Chris says that lightning-caused fires really become an issue when they're related to an event like the one we had recently here in California where there were hundreds of them at once. Which, with new weather patterns, droughts, and warmer drier weather, may happen more often.

Chris: Yeah so, climate change is one of the big issues, obviously, as we treat fires, and even the possibility of more lightning and lightning-caused fires because climate change, or global warming, brings more extremes. We might see more extremes in heat during summer times in certain states in the Western US, and more heat is not a good scenario for fire because that also brings lower humidity and fire likes to burn in high heat and low humidity. We're also starting to see some really extreme wind events that we typically haven't seen before or haven't recognized before. I mean, some places during these fire events, you know, you'll see gusts of wind up to 80 miles per hour. And you're just like, "Holy shit! How do you even do something with that?" And you don't. That's the thing is you get the hell out of the way and let the fire kind of go. And we're just not used to this kind of change yet.

And unfortunately, we are also in a place, here in California specifically, where you typically get rain during the winter seasons and then fuel and vegetation grows, and then it gets extremely hot and dry in the summertime, and then that vegetation dries out, so there's a lot more fuel there to burn. Well, at the same time you get these extreme drought conditions that a lot of places are experiencing and that's not good because then you don't get the rain to help the fuel moisture levels. So you're kind of fighting a losing game as things start to change here. And we see this positive feedback loop with climate change.

Not only that, but the Arctic Circle. If you or any of your followers, any of you guys out there, saw the Arctic Circle reaching above a hundred degrees this year, and we're starting to see more and more fires burning out there. There's a lot that has to be taken in. There's a lot that needs to be studied.

Of course we cannot tie one single event or one single fire to climate change, but we can step back and look at the overall factors that made it possible. So yes, there is something within climate change that is adding to the extreme events that we're seeing, and if things are burning hotter, then you're going to see more and stronger fire behavior. We're going to see more extreme fire behavior. The future fire research, there's going to be so much research that's going to be cool to do in the Arctic areas, from unfortunate consequences.

Alie: This research is important and you should get some dollar bills for it.

Chris: Yeah, definitely. You know, everybody should. Something that is also very important in research is you can throw all the money at it you want, and you can get all the answers and collect all the data you want to. And it's great to have that knowledge because it might lead to something in the future. But if some of that knowledge isn't implemented at the policy level, then you have a lot tougher time with what's going on, and trying to get everybody - the local, the state, the federal, and the Indigenous people - all on the same page to work together is tough. And when things change because of climate change, that makes it even tougher.

Alie: When it comes to voting, think about which representatives might give more of a darn about it.

Chris: It's always tough, but if you're looking at something as big as climate change, yeah. Find the people who are going after it and try and get out there and vote so maybe they can help do something.

The fire industry has been undergoing a really big culture shift in the past so many years. That's because, probably you and a lot of your listeners have noticed, you're starting to hear more and more about prescribed and controlled burns, forest thinning, and indigenous or cultural burning. That is because we do need it. It's definitely become a problem; especially here in California, we have some serious land management issues. A lot of the reasons that we might get some of these mega fires or big fires is because there's such a buildup of 'fuel', or vegetation growth, that these fires are able to burn hotter. They're consuming more and there's more energy to be released by them, so you get more extreme fire behavior coupled with the wind events that are happening.

So, cultural burns along with prescribed burns is kind of a way to kind of help manage the forest so that we can take the process of burning and forest restoration and are able to bring it more in a sense of under our control. We would rather perform prescribed or cultural burns, which burn rangeland and forested areas at a lower, more moderate intensity so that they can regrow, so that wildlife can come back to areas, so that streams and rivers have a chance to reflow, so that fish can spawn, and all this sort of stuff. We would rather have that and would rather be able to help dictate where that is occurring than big buildup and large fires happening that are very high intensity because those are the ones that do more damage. Those are the ones we are trying to get away from.

Indigenous and cultural burning is something we really want to do a lot more of because it's something that they had been doing for a long time and have down themselves. Not only because preventing them from doing so can be culturally repressive, but the fact that they know what they're doing because they've been doing it for a while, really helps. There's a lot that can be learned from the way that they manage the forest and manage their lands in order to do the restorative practices.

Alie: What if we just raked the forest like they do in Europe? Can't you just rake the forest and sweep up the floors? [*Trump: "You gotta take care of the floors. You know, the floors of the forest, very important."*]

Chris: [*laughs*] You could try. It can take a while. Whatever.

Alie: [*laughs*] Yeah. Oh my god. You just gotta rake 'em.

Aside: Raking the forest: super simple, kind of just like Marie Kondo-ing the linen closet. Clean it up! Shame on California for not sweeping the 33 million acres of thick vegetation on forested lands. PS, the US is 56% woods, according to the 2016 Forest Inventory and Analysis Program of the US Department of Agriculture Forest Service, so grab those brooms and garbage bags. It's our fault!

Actually, it kind of is: since North American colonization and the genocide of Indigenous people, ecosystems have suffered a bunch from the lack of Indigenous fire stewardship, also called cultural burning. This is a huuuuuge, huge rich topic historically and currently, which we're going cover in a future Wildlife Ecology episode. But for now, you can seek out information, like KCET has a series called *Tending the Wild*. They have a whole episode on cultural burning. I myself cannot wait to talk to an expert in this and hear about the heroes who are fighting for this repressed practice. Now, on the topic of that:

Alie: Brooke wants to know: What kind of superpowers will I get when I am struck by lightning? What are we lookin' at?

Chris: [*laughs*] I don't condone it. I would say you're most likely *not* going to get them. Of course, we see this in movies and stuff all the time. That hasn't stopped me from going out during lightning storms, but I mean The Flash… lightning… yeah? Really fast, extremely high metabolism and healing rate. Can throw bolts of lightning.

Alie: Damn, good deal. Any movies get lightning right?

Chris: Yeah. I mean, well, here's the thing. Every movie that you see that's about some sort of weather event or geologic event, takes it to the most extreme you could ever imagine. So, the scenarios that they paint in those movies, are they realistic? No. But my favorite description of lightning is actually from the movie *Frankenweenie*. [*Alie bursts into laughter*] I don't know if you ever saw that. It's the Disney movie *Frankenweenie*. It's toward the beginning of the movie. The kids are in class and the teacher is describing how lightning works.

Aside: Please enjoy this clip from Tim Burton's 2012 stop motion supernatural horror comedy film about a corpse dog:

> [*clip from Frankenweenie, male teacher with heavy Eastern European accent:*]
>
> *Lightning is simply electricity. The cloud is angry, yes, making storm. All the electrons say, "I am leaving you. I go to the land of opportunity." The ground says, "Yes, we need electrons trained in science just like you! Come! COME! Welcome!" So, both sides start to build a ladder.*

Chris: [*laughs*] The kids are just frightened to death of this because of the way he's explaining it. But I really love the way that he describes it and the way he describes the process of electrons trying to get back to the motherland. Of all the movies, probably my favorite use of lightning is *Frankenweenie*.

Alie: *Frankenweenie*! Oh, I'm putting it in. [*clip of same character:* "*He does not see the invisible ladders. When the two ladders meet, BOOM! *children gasp* The circuit is complete."*] Oh my god.

Last listener question: John Worster, Ira Gray, Hannah Quist, McKaylee Eggett, and first-time question-asker Tiffany Rosales want to know: Fact or flimflam; lightning doesn't strike the same spot twice.

Chris: Well, in general, it *can* strike the same place twice.

Alie: Right? Well, lightning rods, right?

Chris: It depends on how small of a scale you want to get. I mean, when lightning strikes the ground, you're talking about electrons and protons connecting things that are tiny, tiny, tiny, tiny, tiny, tiny. So, if you want to get down to the microscopic scale, maybe it doesn't strike the same place twice. But generally, yeah, it can strike the same place twice. Yeah, absolutely. I guess it's how you define the same place.

Alie: Yeah. Get into the little, little, tiny, tiny, tiny details. Okay. Questions I always ask at the end. What sucks the most about lightning? What do you hate the most about your job? What's the, like, [*monster groan*] "Uuuugh"?

Chris: It would probably be trying to get people to realize that the research we're doing on lightning is more important than the other research out there in meteorology and fire weather in order to get the funding for it. It's not easy. Of course, everything science comes down to: how much money can you get for it? Can you do the research itself?

Alie: Yeah. What is your favorite thing about your work, or about lightning, or what just gives you butterflies?

Chris: I would have to say just the fascination of it. The fascination of trying to understand lightning in itself. Trying to get out there and do the research, knowing that there are so many questions to be answered, and seeing lightning happen and knowing that at some point we can contribute something to this knowledge base is very exciting in itself. And the fact that we're not there yet. The fact that there is more to do.

I mean, right now we're at a point where our models can get better. They can always get better. So, knowing that they can always get better and we don't have things nailed down specifically, and seeing how things are constantly changing, seeing and how it's impacting society is a big motivational factor because we know what's at risk. We know what changes might be coming about. We know that they may not be good.

So, we have a real opportunity to do something here. We have a real opportunity to help an industry seek some sort of answers. Get out there and look at fire tornadoes and fire whirls. We get to see lightning storms shoot down from the sky. We get to go out there during some of these storm events, which I know I told people you shouldn't do, but we get to go out there during some of these storm events and just fuckin' blow right through them! You know, and just get inundated with the rain and how these storms come. That in itself, even though that is a very small portion of what we're actually doing because a lot of it is sitting down and analyzing shit, [*laughs*] it's those little bits of field work, that's extremely, extremely exciting.

Alie: That's part of what got you into it, I'm sure. Right?

Chris: Oh yeah, absolutely.

Alie: I mean, what is more exciting than something that is 1.1 jigawatts 1.1… Yeah. How many… Whatever.

Chris: 1.21!

Alie: Sorry! 1.21 jigawatts, hotter than the sun, seemingly random, but science can explain it. I mean, what's more exciting than bolts of electricity coming from the heavens? That's rad.

Chris: I know, right.

Alie: Yeah. It's super rad. I mean, you're my favorite Fulminologist. You are the only Fulminologist I know, but you are my favorite, legitimately.

Chris: [*laughs*] Thank you, Alie. I appreciate that.

So, ask smart people stupid question because it might *spark* some great ideas. Also, someone just throw a dump truck full of money at climate and fire research, if you don't mind. Thank you so much.

Also, you can follow Chris on Twitter @CGiesige39 or Instagram @ChrisGiesige. He says, "If you can spell my name right, then you deserve to follow me." It's in the title folks. Plus, links to his social media are in the show notes.

You can also follow @Ologies on Twitter and on Instagram. Please do. I'm also on both, @AlieWard, on everything. More notes are at AlieWard.com/Ologies/Fulminology. That link is also in the show notes, as is a link to OlogiesMerch.com, which sells t-shirts for 20 bucks. We keep them affordable because I just really love to see y'all wearing them in the wild and making new *Ologies* friends. You can tag photos with #ologiesmerch on Instagram and we'll repost you. Shannon Feltus and Boni Dutch of the comedy podcast *You Are That* manage all the merch.

Thank you, Erin Talbert for adminning the Facebook group of over 15,000 peaceful, kind, smart people. Hello, Ologies Redditors, too. Thank you to everyone on Patreon.com/Ologies for literally funding the show and submitting such good questions.

Thank you to Emily White and the group of transcribers for getting all of these episodes transcribed for our deaf and hard-of-hearing pals. Those are up for free for anyone who wants transcripts at AlieWard.com/Ologies-Extras, alongside a bunch of bleeped episodes you can download if you have kiddos or classes to teach. Thank you to Caleb Patton for bleeping. Thank you to Noel Dilworth for helping me schedule interviews.

Thank you to assistant editor Jarrett Sleeper who cuts out all my ums, but not my swears, and of course to the Pod of Thunder, Steven Ray "Thorris," who also hosts the *Purrrcast* about kitties and *See Jurassic Right,* which is about dinosaurs. Two fine programs. Nick *Thor*burn wrote and performed the theme music.

If you stick around through the credits, I divulge a secret of some sort. This week's secret is that my favorite lightning storm ever was once in high school, my sister Janelle and I sat at the window in the living room and we just watched these wicked bolts dash across the sky for, I think, a few hours, just listening to Enya. Just in silence, listening to Enya on a boombox. It was so rad.

Okay, enjoy the thunder and lightning. Duck for cover, and hey, remember: If Roy Sullivan can live through seven lightning strikes, you can cut bangs. You can text your crush. Start your novel! We're all gonna be bones anyway. But then our bones will become plants and frogs and rocks, which is pretty dope.

Okay. Wear a mask. Be cool to each other. Berbye.

Transcribed by:

Danyella Nightingale, your bud who is either drinking chai, tending to plants, or writing on my steno machine, gratefully living on unceded lands of the Coast Salish/Duwamish people.

Anna Murray

Clara Chaisson, Cambridge, MA

Aska Djikia

Isabel Burns

Edits by Kaydee Coast the Goddess of Lightning who reminds you don't lick toads, check your crevices, and milk your thumbs. Kthxbi.

More links you may enjoy:

A donation went to International Relief Teams: IRTeams.org and WestCats.com

Weather.gov's odds of lightning strikes

What is antimatter?

Squeeze chairs, like a human thunder shirt

Lichtenberg Figures

Lichtenberg figures in wood

Jigawatts

Smells like weather

The Great Red Spot

"Tending the Wild: Cultural Burning"

How much forest we gotta sweep?

"Frankenweenie" clip

Volcano lightning

Stepped leaders and streamers

Nephology episode

Etymology of fulminology

Reindeer massacre

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