Disinfectiology with Dr. Evan Rumberger
Ologies Podcast
July 24, 2019

Oh heeey, it's the pigeon staring at you on your lunch break while you eat a salad, Alie Ward, back with another episode of *Ologies*. So, if you listened to the last two episodes you may now have quite a handle on the US Constitution. What did you do while you listened? Did you work on a macramé project? Did you drive through Kentucky? Did you watercolor a picture of a fish? Maybe you cleaned a toilet. I kind of hope you cleaned a toilet because it's apt for upcoming elections, and also, this episode will – no joke – get you pumped about glistening ceramics and crisp linens. So, dust off your brain webs. Let's get fresh!

Okay, but before I do, thank you to everyone who has told another living person about *Ologies*. Thanks to everyone wearing *Ologies* merch from OlogiesMerch.com. Thanks to all the folks on Patreon who submit questions, and to all the folks who have rated *Ologies*, and subscribed, and kept it up in the charts, and who have left reviews for me to read by flickering lamplight when I feel vulnerable. Such as PamRunsHappy who said:

> *If you've very made loved ones wait while you look under one more rock, or walked around one more corner, or read one more placard, you have found a home at Ologies. It the siblinghood of enthusiastic learners.*

Pam! Thank you muchly, from old Pappy DadWard. I'm here to give you some weird facts, and puns, and make you pancakes on Saturdays. And! To tell you why mopping floors is a great science experiment! Let's get into it!

So disinfectiology, once again, I did not make this up. It is not a commonly used word, it is a word that exists, but apparently only in Russia, by one college where there is a disinfectiology program. It's at Moscow University, but it exists, okay? So, we're going with it, because this chemist has spent over a decade figuring out how bleach works! Here's the deal. I got an email from Clorox, up in the Bay Area, my old stomping grounds, and they were like, "Hey! We're inviting some science communicators to tour our research labs. Do you want to come learn what the funk bleach is?"

And I thought, "What the funk *is* bleach? And heck yeah!" And suddenly there I was; in a lab coat and goggles, smelling things, and watching laundry under blacklights, living every social media influencer's dream. Well, it was *my* dream. I had only agreed to post a few #sponsored photos, but the facts were so great that I brought my equipment along in case I could record. But this scientist was busy sciencing and touring us around. So we got on the horn when I got back to LA, and I had him record into his phone memo app and it sounds pretty dang decent, and we talked all about things that I didn't even learn in the facility, but I really wanted you guys to know.

So, chemistry fans, clean freaks, history buffs, folks who are on a Marie Kondo-kick months later and still want sparkling surroundings. Anyone interested in potable water in emergencies, or what's in the pool you're swimming in, or anyone right now who may be staring out of a train window is wondering WHAT IS BLEACH? What is it?

Snap on some rubber gloves and get ready to fill your buckets with the perfect ratio of everyday helpful hints and some bizarre science facts with a senior scientist and, technically, disinfectiologist, Dr. Evan Rumberger.

Alie Ward: Is it Dr. Evan Rumberger?

Dr. Evan Rumberger: It is, yes.

Alie: That's what I figured. Now, would you call yourself a chemist?

Evan: Yeah, I'm a chemist by trade. I have a PhD in Chemistry.

Alie: And where did you study? Can you give me a little bit of your scholastic background? What did you study and where?

Evan: Sure. I did my graduate work down at the University of California at San Diego. My work down there was a mix of physical and inorganic chemistry, which actually has some overlap with some of the work I'm doing right now in some very indirect ways, but I think they're relevant. And after getting my PhD, I moved back to the Bay Area. I'm a native Californian, was born in Oakland, and did a postdoc at a UC Berkeley/Lawrence Berkeley labs on alternative energy work there.

Aside: So, Evan; Bay Area-born got his bachelor's and his PhD in Chemistry from UC San Diego and then headed back up to Berkeley for his postdoc; studying the sunlight gathering and oxidation of plants. Now, there are probably a lot of people in Berkeley right now, whispering into a house plant [*deep voice: "You're eating light, what is up with that? How do you do it??"*] But Evan was doing it in a lab.

Evan: My work at Berkeley was trying to make synthetic analogs of the chemical in something called photosystem II, this part of the leaf that does some of the chemistry dirty work of the energy gathered by sun. What I was attempting to do as a postdoc, what I was making some progress on, was how to make these more natural kind of alternatives to what's used in industry to electrolyze water.

Aside: Electrolysis can mean two things. One is running direct electrical current through a liquid or a solution that has ions in it. What are ions? Ions are just names for atoms or molecules, or molecules made up of atoms – not a big deal – that have some electrical charge. Electrons have a negative charge, protons have a positive one, so when this number isn't equal, you have a charged ion. A 'cation' is a positively charged; if you have a positive reaction to cats, this is easy to remember. And an 'anion' is negatively charged; think an antagonist.

When you take two electrodes and run a current through the solution, the negative ions will be attracted to the cathode with the opposite charge. What else can electrolysis mean? How does it relate to mustache hairs? Well, it can mean running a tiny electrical current via a needle in a hair shaft to kill the root of the hair cell. Do I have a couple that could benefit from this? Probably, but that's none of your business. Does anyone want an electrologist on the show? Because I kind of do.

PS if you're in Seattle and you're looking for an electrologist, you can look up a place called ZipZap, the owner's named Jake and is an ologite. So perhaps next time I'm up in Seattle electrologist Jake will let me ask them questions. This mention will probably surprise them. Hi! Anyway, where were we? Chemistry!

Evan: Water is something that is looked at as a potential energy storage system to generate hydrogen. I was making these catalysts that would help… The idea was to make that process a little bit more economically feasible, and industrially that work is done with things like platinum and other really precious metals. If you want to make headway in alternative energy, you need to be able to get scale as opposed to just getting laboratory bench stuff and

you need to remove some cost out of it. So, we turn to nature, and see how nature does it, and try to mimic that synthetically, and work from there.

Aside: What does all this science have to do with your [*slow and sensuous*] sexy, crisp, duvet cover?

Evan: As it turns out, that's actually kind of my connection to Clorox. It seems like kind of a roundabout; how do you go from doing like alternative energy resource to working on bleach? It's a little bit indirectly connected to how bleach is made. The work I was doing as a postdoc is actually what you don't want to do when you're making bleach. You want to prevent the reaction of oxidizing water so that you can productively oxidize the salt that's in the water to make bleach. It's like understanding something upside down is just as good as understanding upside up. I got recruited off of the UC Berkeley campus and have been at Clorox ever since that moment 11 years ago working on bleach.

Aside: That salt is NaCl, sodium chloride, which is table salt. Wait a second… [*chipmunk voice*] wait a second!

Alie: Do you know that I just realized right now that 'Clorox' comes from 'chloride', like right now! [*laughs*] How did I never know that before. [*half speed*] OOOH my God!

Aside: I think I told you this before in a post credit secret, but I also thought U-Haul was a Hawaiian company called [phonetic] yahu-ol, before I realized it just meant 'you haul'! Also, a lot people think unicorns are real, extinct creatures and narwhals are fantasy whales, so let's all just be gentle with each other, okay?

Alie: How is bleach made? How is hydrolysis involved? And what is hydrolysis?

Evan: How it works is it starts with, really, just two ingredients, that is sodium chloride and electricity. What happens is in passing electricity through a water solution of sodium chloride, you oxidize the chloride to chlorine, and that's one of the first ingredients that's made. Secondly, that chlorine is reacted directly with sodium hydroxide lye and the two come together to make sodium hypochlorite. So, it starts from saltwater, electricity to make chlorine, that chlorine reacts with caustic lye, the same thing that's used to make soaps and other things and like, soap boiling methods, and that combines to make the NaClO, the sodium hypochlorite.

Aside: OOOOH buckle up for a debunk, because Evan has a myth to bust!

Evan: There is no chlorine in chlorine bleach. That's kind of a misnomer and really one of those terminology things. It's all sodium hypochlorite that's in there. Although chlorine is used in its production as part of electrolyzing the saltwater, there is no chlorine in it.

Alie: I had no idea! Now, is there chlorine in chlorine pools? Or is it the same thing?

Evan: You know, it's one of those things… chlorine is one of those things that brings in a bunch of bad stuff. The analogy I like to use is water. Most people think of how water is H2O, right? And then there's oxygen gas, O2. Water has oxygen in it, but oxygen is a totally different thing that we breathe. You breathe water, you're in trouble. If you breathe too much oxygen you get in trouble as well too, but it's necessary for life. But it's how those things connect together that really make the chemicals special. So, Clorox bleach has got sodium chlorite, so the chlorine is attached to oxygen in a similar way that hydrogen is the attached to oxygen in water, it changes everything.

Aside: So, to recap; electrolysis turns saltwater; H2O plus NaCl, that becomes sodium hypochlorite, NaClO; household bleach. There you go!

As long as were talking basics, let's talk basics. The pH scale ranges from 0 to 14, with acids on the low end and bases on the high end. Bleach is around 12.6. Your blood is about 7.6. What's lemon juice? Around 2.2. Battery acid? Oohh Nelly that's a 0.3! Anyone identifying as a smelly person has heard probably the age-old ads for an antiperspirant that is "pH balanced for their swampy armpits" and been like, "Sure, whatever deodorant." But how about this alkaline water trend that claims to fix cancer and even more importantly; make your zits disappear?

Well, I looked into it, and most people in lab coats - I would wager 99.9% - have debunked this, pointing out that your stomach is a slimy pillowcase containing an acid bath, so any alkaline water you drink from the shelves, A: is usually mislabeled and is much less alkaline than promised and B: it gets nixed pretty quick by your simmering gastric contents. Anyway, water, salts, electrolysis, bleach.

Alie: Did you always love chemistry? Were you that type of person that was setting things on fire in your garage?

Evan: Yeah, you caught me. [*laughs*] Strapping firecrackers to a GI Joes and seeing what the magnifying glass will it in the sunlight to plastics and things like that. [*from a kid's song:* "*Don't play with matches, they're really not safe!"*]

Alie: At what point where you like, "How can I turn this into a PhD and a job with a lab coat?" Did you kind of always know that a chemist was going to be your goal?

Evan: Yeah, I've always known that it's. It's just been my passion. I could probably trace it back to some high school teachers. I remember very, very distinctly having a class discussion – it might've been physics or chemistry, I'm not sure, they kind of blend together – but I remember being really, really fascinated with why water is clear. Why can you look through it? Why can't you look through your desk the same way you can look through water?

I was just completely blown away with the feedback I got from the teacher, who said, "Evan, you can predict that." I was like, "What?? How can you predict that?" That just seemed so mysterious to me. It's like… Science to me, it's almost like a magic trick. If you know how things work, you can put things together and create some really awesome things.

Aside: Let's back up a sec. [*rewind audio*] We have a smart people and I have a stupid question.

Alie: Why *is* water clear? Is that easy to explain?

Evan: Yeah. That's one of those questions… Those real fundamental questions are best ones because they really get at the root of things. I've got my two daughters, you know, they're asking like, "Why is the sky blue?" Those things are, like, really tough questions that took a lot of science to kind of get the root of it. Water is clear because it absorbs light in part of the spectrum your eyeballs can't see, just like your desk absorbs light in the part of the spectrum your eyeballs *can* see. To me, in high school, that just blew me away, like, "I'm hooked. I want science."

Aside: "Well why is the ding dang ocean blue," you wanna know. Well, I looked this up for us and because light can only penetrate so far through water, what gets kicked back are the blue wavelengths. So, the reds get absorbed by the water. And I also, as long as I was noodling around on the internet, looked up "what does the Devil in the deep blue sea mean?"

It's an idiom that means to be in a real pickle, and the phrase was once, "between the Devil and the not-longer wavelengths such as red and orange sea," but that just didn't stick. (That is not true information I just gave you; it was very stupid.) Okay, anyway.

Alie: When it comes to bleach, which you can also see through, how is it made? I didn't know until, obviously, very recently when it came to tour the lab that it was like, *ze-ze-ze,* ["*This sucker's electrical!"*] like this was electrically made. I had no idea. How was this discovered? Where does this come from?

Evan: Actually, it was discovered quite some time ago. It's a rather old chemistry and it started even back in the late 1700s. It was discovered by an individual, and I'm just gonna butcher his name, [*knife sharpening*] but I'll try it anyway. A French gentleman, in Paris, an individual named Claude Louis Berthollet. [*French google translate: sounds like Ber-tulle -lay*] He had isolated the compound and initially actually repositioned it to work in textile bleaching. Immediately, its oxidative properties, it's bleaching properties were recognized as something that could be used in treating textiles. This was all the way back in the late 1700s-1785.

Aside: Of course, I needed for myself a visual image of this Frenchmen and in every old timey engraving of him; he looks kind of like Benjamin Franklin's less attractive half-brother, but his eyes are always shifted out of frame, looking away as though he just caught two people gossiping about him between bites of fruit galette. Anyway, he was a respected French scientist who left us with a legacy of much better laundry practices. Now, if you listened to the roman archeology episode, you remember in what is now, Italy; people use to pay professionals to dip their togas in urine for cleaning. So, [*in French accent*] *Merci*, Berthollet!

Anyway, by the late 1800s, scientists – including a German guy named Robert Koch, who realized that bleach killed bacteria – all agreed that it was germs actually and not airborne ghosts that caused pandemic disease outbreaks. And thus, municipal water disinfection began. I found one quote from Keith Christman, who's the Director of Disinfection and Government Relations in the Chlorine Chemistry Council – I bet he doesn't even know he's a disinfectiologist! – but he has said, "Filtration and disinfection of drinking water has been responsible for a large part of the 50% increase in life expectancy of the last century."

So, if you're bummed out about having to save for retirement, just blame it all on water disinfection for keeping us alive. That's very grim. Honestly, thank you, water disinfection systems because I just want you to know I got sidetracked reading about an 1854 London cholera outbreak, and exactly where all those cholera ghosties came from, and what they do to your boday. And I need not share with you, but I will tell you that I was eating while also researching and I continued, because I love you. Now, where else has bleach been?

Evan: One of my favorite little tidbits with respect to how, like, its long history and the funny places it ends up is that was used by the Apollo missions to disinfect the spaceship cabin after the astronauts returned from space. I believe it was also used as part of its water system inside the spacecraft to ensure that the astronauts had not-contaminated water on board.

Alie: Oh my gosh! It's been to SPAAACE! From the sewer to space; that's a pretty good journey. "Started from the bottom now we're here," right? [*clip of Drake song: "started from the bottom now we're here…"*]

Evan: Yeah. All the way from, like, some lab in Paris all the way to space.

Aside: So Clorox, started in Oakland in 1913 by a Scottish American couple, and Annie Murray had the idea to give out diluted samples at the grocery store she worked in. People went nuts for them. They're still based in Oakland. When I was growing up in the Bay Area, the company sponsored the cheap seats in the Coliseum, and it's still perhaps my favorite corporate pun ever. This section in the A's games were called the Clorox bleachers. [*ba-dum-TSH!*] So good. It gradually made its way into space and then under your sink.

Evan: It was around the 1970s, 1980s that it started becoming available as a ready-to-use cleaning product. It's been used in laundry; it's used widely as one of the most versatile and powerful disinfectants. It's a great cleaner, and it shows up in a lot of really surprising places. I think one of the biggest misconceptions around bleach is just the variety of places that it's used that are important to our collective health in ways that many of us aren't even aware of. It's doing really awesome stuff to help us. I mean, to give you an example, you brought it up earlier, it's in our swimming pools, we bathe in the stuff when we go in. That's really critical to preventing the spread of disease in pools. But most famously, polio; bleach will take care of that quite easily.

Aside: When did we start chlorinating pools? Well, in old timey days, you just go to the crick with ma and pa and swan dive into a cold soup of algae and alive turtles, but around the 1900s, people wanted fancier things with fewer sunken logs in them. The Colgate Hoyt pool, built in the name of a very wealthy donor of Brown University in 1903, had browned some, it was a little funky. In 1911, they got the idea to try chlorinating it because that had been so effective at stopping disease outbreaks in municipal water. Now, bacteria counts went from 700 parts per million to ZERO parts per million in 15 minutes after chlorinating it. They were like, "Boy howdy, hot damn! That's a lot less alive gross stuff in there!"

In case you're planning on swimming this summer. Yes, there is a bunch of human pee in pools, but one thing you can do about it is: not pee in pools. Anyone. ANYONE. Do not pee in pools. If you can drive a car, I know, *I know* you can train yourself not to urinate into a communal water supply. We can do this, America! We can do this. Also shower before you get into the pool and then shower after. Again, while eating, I did some research on why, and just trust me on this one, kiddos. Now, if you've been to a pool party and not had cholera afterward, thank bleach in some form.

Evan: One of the things that really introduced it to the practice of bringing it home, which goes back to your question of how it is made, is… really popular these days are these salt swimming pools. Have you seen those before?

Alie: Yeah, I have!

Evan: That's exactly how bleach is made. How those salt swimming pools work is they literally add a bunch of sodium chloride, table salt, to the swimming pool and then they have a device that is plumbed into it that basically zaps it, electrolyzes the water right there. It electrolyzes the chloride in there to make sodium hypochlorite on the spot. It's convenient because normally a pool person would have to go and adjust the levels and add to the pool [*"You the new pool boy?"*] This is, kind of, an on-the-spot bleach factory in the pool. That's how those things work.

Alie: Oh my god! I did not know that! I thought it was, like, a mini sea, like, "Eh, different bacteria can't grow in this much salt." I didn't know that! That's so fascinating.

Aside: Now how is bleach disinfecting things? Some research that came out only about a decade ago zeroed in on the hows, and according to studies in *Cell* magazine, the active

ingredient in bleach causes proteins in bacteria and viruses to unfold in the same way that a fever would fight an infection. Also, it's able to disintegrate the fats in bacterial cell walls.

Now, when it comes to drinking water, we've been treating it for over a century and have cut down dramatically – obviously – on infectious disease, though there are other ways of treating municipal water, like UV radiation, that's being explored; but for folks with weak immune systems, it may not be powerful enough to zap all the baddies like chlorination is. Now what about superbugs? Are we just cultivating one that is going to laugh in the face of bleach?

Evan: There is no chance of antibiotic resistance with bleach, at least nobody's observed it ever in the history of it. Whereas, you know, you hear of certain bacteria becoming resistant to certain antibiotics out there. A lot of those hospital-acquired diseases stand no chance against bleach and it's used there to treat when you have outbreaks of, like, something called MRSA, this staph, this little bacteria that's quite resilient against particular types of antibiotics. Bleach is just wonderful at eliminating that.

Alie: Same with Ebola?

Evan: Yeah, it does the same thing there as well too. So, Ebola is a virus and bleach will go in there and rip it apart, and it's quite efficacious for that. In fact, Clorox bleach was the only commercially available product that has undergone that testing and is approved for – heaven forbid that it's ever used for – controlling such a thing.

Alie: What is the difference between cleaning, disinfection, and sterilization? Those are different words, right?

Evan: Yeah, so cleaning is about soil removal. You can actually clean something and have it have great appearance, but there can be a lot of bacteria left behind. You know, these bacteria are things you can't see under normal conditions. A sanitizer, a disinfectant, and a sterilizer; those are kind of key words with respect to how well the product works under certain test conditions. For example, all of our products that make these disinfectant claims or public health claims undergo rigorous testing. We produce data that's reviewed by the EPA, Environmental Protection Agency. They look at that and when we pass and do well in that, we're able to make those claims. The terms 'disinfectant', 'sanitize', or 'sterilizer' are regulated terms by the EPA in so far as the breadth of microorganisms that the product has been tested on and how effective it is on those tests.

Aside: Okay, I looked this up, and the EPA says:

> *Cleaning is the process that physically removes debris from the surface area by scrubbing, washing, and then rinsing; it can be accomplished with soap, detergent, and water. A sanitizing product kills 99.9% of the germs identified on its label, and disinfecting product kills nearly 100% of germs identified on its label. This can take a few minutes of contact with the surface.*

But what is happening with that 0.01%? What's going on there?

Alie: Why does it usually say 99.9%? Is that just a legal thing?

Evan: Those terms come through… that's the level of which the product is able to kill the bacteria for which it was tested against, and those levels are set against what is believed to be efficacious from a public health standard. So, if you sanitize you remove 99.9% of microorganisms. If you use disinfectant it's 99.999. At some point some of those things become less and less meaningful from a consumer standpoint.

Aside: Just in case you're reading a label [*chipmunk voice*] that hard.

Alie: How does bleach lighten things? If you throw it on some sheets…

Aside: … or maybe if you have a black shirt that you splash it on intentionally. Listen, reverse tie-dyeing is a thing and it's what goths do at summer camp, okay? Don't judge me. Anyway.

Alie: How does it lift color like that?

Evan: There's a bunch of different things that are happening. When you are brightening a stain… One of my favorite things to do… I don't know about you, but I drink a lot of coffee and I've got this old coffee mug that has a bunch of coffee stains in it. If you just take a little bit of bleach in there it just takes care of that coffee stain just like magic – it's ridiculously awesome how well it removes that stain – and rinse it with water and you're good to go.

How bleach works there is the molecules in stains have kind of a connectivity, a molecular kind of connectivity among it that is unique to the color that you see, and what bleach does is it goes in there and breaks that connectivity. It's almost like snipping the electrical wire for a lightbulb. The molecules break apart and are just unable to make that color anymore. And then those broken molecules are lifted away because they are more soluble in water and they come out. So not only does it remove the stain from a fundamental color standpoint, but the rest of it just gets rinsed away with the water that you have.

Aside: P.S. I had a Latin teacher in high school, the amazing Anne Becio [phonetic], and one day, to be helpful, we cleaned her ancient, stained coffee mug. The inside looked like a rusty cave and it was a herculean effort, let me tell you, but I wished I'd known this trick. Anyway, Anne Becio, rest in peace. I hope you're sipping coffee with Jupiter; and I'll be honest, I not only typed Zeus first before remembering that Zeus is the Greek one, but I also misspelled Zeus every single time you've just heard me say it.

Anyway, clean your crusty mugs, rinse thoroughly, and then raise a shimmering toast to Anne Becio; a great Latin teacher. She was really good. [*"I saved Latin, what did you ever do?"*]

Evan: You gotta try it. It's just like… You'll want to rinse it after you're done, but it's just magic how well it'll get that stain out. You'll have, like, a brand-new cup. That's for stains, for brightening… that, kind of, shock-your-eyeballs looking at the bright white, there's two parts to it. There's getting the stain out effectively and then there's also the part about working with the detergent to make sure that the detergent is working well also, on your clothes. Think of the whitest whites, the brightest whites. Detergents contain ingredients in there that work with the light, the sunlight, and it makes those clothes look a lot brighter.

Aside: This part is so weird and cool, and during the tour we all gawked at various white t-shirt samples under different lighting conditions. It was like the Wonka factory but for laundry.

Evan: They absorb the visible light a little bit on the yellow side and they spit back a blue light. That gives the appearance of it just looking much more on the bright end of things. It's kind of similar to how if you look at an incandescent light bulb and then you compare that to a fluorescent light bulb. A fluorescent light bulb is just tack-on white, a really, really bright white, increases the color temperature, whereas the incandescent light looks a little bit yellow.

The laundry detergents that have these ingredients in there, they shift it over into that fluorescent-light looking thing. [*"So bright."*] In addition to just eliminating those stains,

snipping the stains up into things that can be washed away by the water, bleach also works with the laundry detergent to make sure that the detergent is doing its magic as well too.

Alie: Is there any flimflam that you would like to debunk? Any myths about bleach that really annoy you?

Evan: I think the big one is that there's no chlorine in bleach. We call it chlorine bleach, but that's really just sort of a historical thing. There is no chlorine in it, and that goes back to what we talked about; oxygen in water and oxygen gas. It's such a wonderful thing and it irks me that it gets burdened by its upstream cousin that has nothing to do with, you know what I mean?

Aside: We all have that upstream cousin that taints the family name. Wards, you know who I'm talking about; the one who occupied the family land with a shotgun and charges us to mow the lawn, but we love him anyway.

Alie: Are there any myths about it being harmful to the environment that annoy you?

Evan: Yeah. It's a very safe product to use. We should all just back up. Any household products, you want to use it as directed. You can always abuse anything to the point of it being harmful. But when used as directed, it's very safe. It's been used for over a hundred years. It starts from salt with some electricity, and then through its use it goes back to salt. It's processed through the municipal water system. So it gets a bad rap on that that doesn't deserve whatsoever.

Aside: By the time bleach is done doing its dirty work, it's just broken back down into water and salt. WHAT? Also, when you spray it first on the counter, you can leave it there to kick some bacterial and viral asses for, like, 5-10 minutes depending on your counter. I didn't know that; I always just wiped it right away. You just leave it there, let it do its thing, and then you rinse it off.

Anyway, when it goes down the drain, the sodium hypochlorite breaks down, like 95%-98% they said, into salt and water. Then that remaining 3-5% is either removed by sewage treatment or it reacts with stuff in your pipes and is consumed before it even reaches sewage treatment. I didn't realize that it could shapeshift like that depending on what it comes in contact with, and then it just turns back into the thing it started as. WHAT? Also, this part totally blew my mind. I was like, [*monster voice*] "NOOOO!"

Alie: And what about the smell of bleach? I learned on the lab trip that the more bleach you smell the more it's, kind of, busting up cell walls. Is that true?

Evan: Yeah, [*laughs*] that's true. Bleach smell, a lot of our consumers love it because it's a good indication of coming into a clean bathroom. I can tell you; there's nothing better than going into, like, at the ballgame and going into the bathroom. If you smell bleach in there, it's like, "Okay, okay, we can go in," or at a restaurant. That's a really good sign, just knowing how well it works at disinfecting. That smell is the smell of the bleach, kind of, fragmenting up the things that it comes in contact with. That is a little bit of what you're smelling and that's a nice cue that it's done its thing.

Alie: Is there anything that you know of in the natural world that kills germs and viruses like bleach? Or is it just, like, no comparison when you've got chemistry?

Evan: Actually, you know, this is something that I didn't know this until I got Clorox, but I'm just totally blown away by it. Bleach is actually natural as well too. Your body produces it. It's released as part of your immune defense. It's in mammals; it's in seaweed; it's also in certain fungus as well too. It will emit a very small amount of hypochlorous as part of its immune

response. So, we're not that disconnected from it. We actually have it in our body probably right now, in very small quantities, fighting off as part of the immune system.

Aside: This checks out. I read about it in that study published in *Cell*. Now, feel free to share all of this at the next dinner party, in which there is a gap in the conversation and you're afraid it's going to fill up with politics or gossip about nearby French scientists.

We're about to ask some of your questions, Patrons who submitted for this episode. But before I do, I want to tell you about some sponsors of the show. They make it possible for me to donate to a different charity each episode.

This week a donation went to Evidence Action. EvidenceAction.org and they run the dispensers for safe water program. According to their site, globally about 842,000 people die each year because of unsafe drinking water, sanitation, and hand hygiene. Clorox is partnered with Evidence Action to supply a disinfecting solution similar to the bleach in our homes, in support of their dispensers for safe water program in Kenya and Uganda. I took the donation and tripled it this week, so triple the donation will be going to Evidence Action for their dispensers for safe water.

Now a few words from sponsors who are making that possible.

[*Ad Break*]

Okay. Your questions.

Alie: Can I ask you some listener questions?

Evan: Sure!

Alie: Okay, Crystal Mendoza wants to know: Is all bleach one in the same, and can it truly disinfect all things? Can it kill all bacteria and viruses?

Evan: It's not all the same. We take great pride in the products. Those are patented technologies that we've incorporated in our product and we're really proud of that.

Aside: When I visited, I will say, it was very cute how much people working there seemed to dig it.

Evan: I mean, one of the things that springs me out of bed every day is, you know, it's challenging working on bleach. It's an old chemistry, but the changes you can make in it really affect a lot of folks in their daily lives and their daily health. We're really proud of that.

Alie: Jason Goodwin asks: Could we expect to see bacterial resistance to bleach any time soon like we're seeing with antibiotics?

Evan: It kills the bacteria and viruses we have claims for on it. So, if you're interested in whether the product kills this bacteria or that bacteria; check the label and you'll find out the specifics there. As part of that review process with the EPA, we have to provide data to prove any sort of claim like that. So, it's kind of out of bounds for us to say does all, but it's highly efficacious. I'll just say that. But check the label and you'll find it there. In terms of antibiotic resistance, there's been no indication of that ever occurring so far.

Alie: A lot of people including Dani Cav…

Aside: Hans deHamer, Chelsea Carl**,** Sierra Venus, Bruce Gordon, Allison Hughes, Andria Marsh, Kelly Breidenthal, and Abigail Huff.

Alie: … asked: Why do I like the smell of bleach? It seems like a bad thing to like. [*laughs*]

Evan: Bleach is part of this long history. To me… I can speak personally about it. Bleach has a long history. I associate it with getting that fresh batch of clean laundry all the way back to my childhood. For me personally, it's been part of my life, but maybe by association. I don't know, [*laughs*] but I like the smell of it as well too.

Aside: Quick side note: I learned recently that your olfactory bulb in your noggin can store memories. So not only is it a straight shot to your hippocampus and amygdala – the parts of the brain that processes emotion and memory – but it has its own memory. You don't have to be a neuroscientist to know that. You just have to sometimes sniff shampoo that an ex used and cry in a Target about it. Anyway, moving on. This next one was asked by Megan Dawe**,** Katie Cobb, and Ruth Anthony Vernotico.

Alie: A few people asked: What is the deal with color-safe bleach? Mac wants to know: Is it black magic?

Evan: Color-safe bleach is actually a different technology. ["*What?"*] Color-safe bleach is based on hydrogen peroxide. You can apply the product directly on a coffee stain, or grass stains, amongst others. Any particular stain that the person's after, they can just check the package of what it's good for and it delivers different benefits. The product has some fragrances in there that smell great, makes your laundry smell great. It also brightens your clothes, working with the detergent, but it's a different technology.

Alie: This kind of brings me to Kelly King's question: Is hair bleach the same as laundry bleach but in a different form?

Evan: No, it's different. This is where bleach is both a verb and a noun. So, you know, bleaching your hair, it'll lighten your hair, but they use different things for that. They usually use a hydrogen peroxide for that. One of the differences between hydrogen peroxide and laundry bleach is that they work differently on different things at different speeds. So, for your hair, maybe that product is tuned just right. It's designed for that and they use hydrogen peroxide for that. Same thing is true for teeth whitening products, they also hydrogen peroxide.

Aside: This next question also asked by Alexandra N. Castro Navarro, Sierra Venus, Meghan McLean, and Carly Katz. [*"Meow, meow, meow-meow,"*]

Alie: A few people, including Mike Monikowski and Anna Talley asked about ammonia. Anna Talley says: Because of the ammonia in cat pee, if I use bleach to clean near my cat's litter box, will I poison us at all or is that just flimflam?

Evan: No, there's no issues of some sort of exposure like that. With any cleaning products, you don't want to mix cleaning products with one another. So mixing bleach with ammonia is a big no, no. In terms of the cats; there's nothing to worry there at all. Small quantities.

Alie: Ron LeBlanc asked: I remember hearing when I was young that you can use bleach to purify water, is this true and safe?

Evan: Yeah and in fact the Center for Disease Control has recommendations on how bleach is used in emergency situations. What makes bleach important for this is that it's widely distributed, it's really easy to go to the store and get some, and it's also fairly cheap, and can be used for many things in addition to water disinfection. It just takes a couple of drops. The Center for Disease Control has specific instructions on it.

Aside: According to the CDC:

To each gallon of water, add half a teaspoon, 40 drops, or 2.5 mL of bleach. If the water is cloudy, murky, colored, or very cold, add double the about of bleach, let stand 30 minutes before drinking.

Evan: But yes, it can. In fact, kind of goes back to the salt pools and the how bleach is made. You'll see there are some camping water purification kits out there that, you bring along a little salt, and with some batteries you can electrolyze the brine to get you a little bleach to add to your water to make it potable in dubious situations.

Aside: That's some serious DIY business right there, and you can find kits like these at camping stores, probably at doomsday prepper birthday parties, I'm guessing on at least one of those. Anyway, this next question was also asked by Natalie Crinklaw, Diana Staresinic-Deane, and Isabelle B. Holper.

Alie: Emiliy Foisy said: I had a contractor recently tell me that bleach does not kill mold, is this true? And why doesn't it kill mold? And then the next person asking a question was Isabelle B. Holper who says: What makes it the kryptonite for mold? Is that flimflam? Can bleach kill mold?

Evan: Yeah, it can kill mold. In fact, it's actually routinely used by roofers to remove mold off of roofs. So it not only helps with the removal, but it can kill it as well too. When used as directed… We have a product called outdoor bleach, which is great for doing that. It also kills the mold that causes athlete's foot as well too. If you've got people that are suffering from that, cleaning your bathtub and shower with it will help control that.

Aside: Several patrons asked this including Caitlyn Carter, Amanda J., Jessi Crast, and Ducksfloat.

Alie: Bryan McIntosh says: As an alternative to bleaching a surface to disinfect it, what concentration of acetic acid would one need to be to be as effective as bleach? Is that vinegar? Is this a vinegar versus bleach thing?

Evan: Yeah, vinegar is remarkably ineffective as a disinfectant sanitizer, in comparison. I think it can work under certain scenarios, but it is not even the same ballpark with respect to how well it works. Not even close.

Alie: Wow! That's funny because I think there was a Pinterest trend a few years ago where it's just, "Something dirty? Clean it with vinegar!"

Evan: It'll do some, but not anywhere close.

Aside: This was a personal curiosity:

Alie: How do you feel about the Nirvana album, *Bleach*?

Evan: [*laughs*] Oh, that's funny. That comes up every now and then. I love Nirvana. I've always been a fan of them. I was born in the '70s, grew up in the '80s, and you know, Nirvana came out when I was in high school with its *Nevermind* album and I always loved that. So yeah, that's cool. [*clip from Nirvana's "Blew", "Is there another reason for your stain?"*]

Alie: What's the hardest thing about your job? What suuucks the most? Is it the commute, or not having the right sized lab coat? Is there anything that is just the worst thing about your job, or just the worst thing about chemistry or research in general?

Evan: I think this goes back to just my own personal inspiration. I think the hardest part is also the best part. Science, product and development, R&D, it's all a process and it's hard stuff. If it were easy, we'd be coming up with new stuff all the time. Particularly when you're working

on something that has such a long legacy, how do you continue to innovate in that area? It's so inspirational to me that we are continuing to innovate in that area. Doing the right work, having the conviction to find those little nuggets in the forest and getting there. So, it's both very hard, but also just incredibly, incredibly rewarding. I love it, but it's also to your point it's also the hardest thing.

Alie: Do you have any advice for anyone who's either intimidated by chemistry, or struggling with chemistry, or maybe has run into dead ends on experiments? Any advice to future chemists?

Evan: I'd say embrace the curiosity. Science is not something that is separate from the world, it's part of the world. Asking 'why' is one of the most important questions, and to me, one of the most satisfying things. "Why is that? Why is the sky blue? Why is water clear? Why is this? Why is it that?" That's an insatiable thing. Follow that passion. It can come through chemistry, physics, medicine, writing, a lot of different places where it shows up, but science to me is just one output of just insatiable curiosity, one way to express it. Do it, have fun. It's cool stuff.

Alie: What's your favorite thing about your job?

Evan: My favorite thing about my job is working with the folks here at Clorox. We've got a small team of folks that design products for millions of people and it's a tight team. The stuff doesn't all come together on any individual's back. It's all of us working together to make it happen, and doing great science, and making great products that can literally change the lives of people out there. It's just one of the most inspirational, fun things to do. I love it.

Alie: Aww, so you love your coworkers! Thank you for making the world a less germy place. Every time I go to a hospital, I'm very glad that there's not *C. diff* everywhere, and Ebola, and flu. Thank you so much. I literally look at bleach so differently now.

Evan: That's cool.

Ask some smart people some stupid questions, and if someone offers you a lab tour, you should take it. It's kind of like backstage access at a concert, only usually no one's on drug or taking selfies, and thank you again, Clorox. Now, if you want to regale your friends and family with more facts about bleach you can go to FactsAboutBleach.com. It's just sitting there waiting for you. This episode was kind of a rare pitch from a company, but it truly interested me and charmed me, and I was like, "I wanna share this!" I'm glad I can share of this stuff with you. Next week we're going to hear all about coral and, oddly, coral bleaching, which has nothing at all to do with bleach. We're gonna dive into that next Tuesday.

To follow along socially we're @Ologies on Instagram and Twitter. I'm @AlieWard on both. Ask questions for ologists at Patreon.com/Ologies. You can join for a dollar a month. You can find us on Facebook at Ologies Podcast. Thank you, Erin Talbert and Hannah Lipow for all the adminning you do there.

Thank you Boni Dutch and Shannon Feltus of the comedy podcast *You Are That* for being merch queens. If you just like wonderful ladies with mouths like sailors and quips like your best friends from college, go listen to *You Are That*. They are amazing. Thank you to Jarrett Sleeper of the mental health podcast *My Good Bad Brain* for the editing help, and of course to the electric current that runs through these salty waters, Steven Ray Morris, for stitching all these clips and bites together each week. The theme music was written by Nick Thorburn of the band Islands. Listen to them.

Each week you know I tell you a secret, and this week's secret, well, it's one bonus fact; that you should wash your sheets weekly and even more often if you sleep nude because let's just say: underpants mean cleaner sheets. So, bonus fact in there.

Also, I downloaded this app called Plant Nanny to help track water consumption. It's a digital plant you have to water throughout the day by drinking water yourself and I realized, "Wow! I care more about this digital plant's health than my own. This is a real eye opener." Also, it took me at least five minutes to choose a style of pot to put my plant in even though the pot doesn't exist and I can change it anytime anyway.

Clorox may have paid me to learn about bleach for a day, but I only agreed because it was some legit cool fascinating science, but Plant Nanny did not pay me a dime. Also my plant is dying today, I have to go water it. Speaking of water, please promise me: don't pee in any pools this summer. I believe in you.

Okay. Berbye.

Transcribed by Lisa Zhan your friendly neighborhood mad scientist to the north.

Final touches by Kaydee Coast, who cares more about bleach now in March of 2020 than she did back in July of 2019. Stay safe, wash your hands, check your crevices, don't lick toads. Kthxbi

Some links which may be of use:

A donation was made to: evidenceaction.org

For more facts abut bleach, go to, well… FactsAboutBleach.com

What does ph Balanced for a woman even mean?

Bleach as a protein buster

Salt water pools

Some water treatment history

Thanks, water disinfection!

Mmmm cholera

Le Claude du Bleach

Why is the ocean blue?

Gross sheets: change em, kiddos

Hair electrolysis: how does it work?

A wonderful electrologist in Seattle

Alkaline water flim flam

How bleach is made!

CDC advice for cleaning dirty classrooms

Cleaning guidelines in general

How to make water safe for drinking

Fancy water filter: bleach on the go, essentially

Safe Water Project

For comments and inquiries on this or other transcripts, please contact OlogiteEmily@gmail.com