Environmental Toxicology with Dr. Kimberly K. Garrett
Ologies Podcast
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Oh hey, it's the bouncer who comments on your out-of-state license because he has a cousin who lives there, Alie Ward, back with a fresh and a timely episode of *Ologies.* As an episode and as a species, this one is really long overdue. But it was finally driven by some recent events in Ohio. Jarrett and I went to our neighbors' to eat dip for a quarter or two during the Superbowl and we were pretty shocked to learn how few of our neighbors' friends had heard of this train derailment in eastern Ohio. Same thing with my family chat; everyone's like, "What derailment?" So, I said, Ward, let's talk to an environmental toxicologist about their whole life, and this. So, we did.

So, I asked around for the best person to chat with and y'all delivered. So many arrows pointed right at this ologist, who did an undergrad degree in environmental science; got a master's in public health in environmental and occupational health, including a very fancy environmental health risk assessment certification; and then earned their doctorate in environmental and occupational health. They're now doing a postdoc at Northeastern University's Social Science Environmental Health Research Institute in Boston. They've studied anthrax in Alaska, potential antidotes to lethal phosphine poisoning, sneaky PFAS, much more on those later, they studied how climate change impacts epidemiology and mitochondrial poisons. Their work is just this beautiful soup of environmental toxicology, public health, and environmental justice. They are perfect for this.

But before we get to the interview, a quick thank you to everyone who is sponsoring on Patreon at Patreon.com/Ologies, I love you. A dollar or more a month lets you lob questions at our guests, it also keeps the show running. And for zero dollars, if you like, you can just help us out by telling friends, or reviewing, or making sure you're subscribed, or leaving a rating or a review. I do read all the reviews and as a thanks, I highlight a fresh one each week. Like this one from NikkiDrinks who wrote:

> *Alie ward puts her whole ologussy into this show. I tell everyone I know about it, I'm obsessed, much love to you, queen.*

NikkiDrinks, I would like to buy you a drink for that. Ologussy, god I hope I said that right, I loved it. Also, AnnaKThor, hugs to you.

Okay, environmental toxicology and a little bit of fun trivia. So, toxicology comes from the word *toxin* which means 'poison', which was from a Greek word for 'poisoned arrows,' which came from an older word, *taxa* meaning 'archery,' which came from an older word meaning a yew tree. Which, in a weird roundabout way, there's a compound from the Pacific yew tree that was approved in 1993 as a chemotherapy called Taxol for breast cancer among other cancers. And chemotherapy is a type of well-administered poison to tumors. So much more on that whole philosophy coming up, you're going to love this.

So, I made this ologist get on the horn to talk about their work and chemical spills, historical disasters, water quality, airborne toxic events, clear gasses, white noise, dead fish, dark clouds, chemistry tests, raincoats, lawsuits, and lead. So, take a deep breath if your air is fresh and get ready to love environmental toxicologist, Dr. Kimberly K Garrett.

Kim: Sure. Kimberly Garrett, she/they.

Alie: And Doctor, right?

Kim: Oh, yes, yes. [*laughs*] And you can also call me Kim, so that's fine too. It's been quite a week in toxicology land.

Alie: It has been quite a week. Dang, is there any part of you that's like, "Well, people finally care about environmental toxicology."?

Kim: Oh yeah, absolutely. I'm sad that it takes an emergency or a disaster for people to be interested in the field that I love so much but, you know, there's room for everybody in the toxicology train, so welcome! [*laughs*]

Alie: Ah, no pun intended on the train thing.

Kim: Oh nooo!! That's true, oh my gosh.

Alie: We have trains on the brains, what can we say?

Kim: Well, I'm from Pennsylvania, and my partner who is not from Pennsylvania is convinced that every Pennsylvanian has a genetic disposition to love trains. I can't escape it.

Alie: And how did you decide what to do your PhD in?

Kim: Well, when I was an undergrad, I became really interested in chemical toxicology. I initially wanted to go to undergrad for chemistry, but I have really bad test anxiety so the testing of the weed-out classes at the beginning, they weeded me out. So, I ended up going into environmental science and I'm so glad that I did because I took a toxicology class and I learned about all different kinds of ways that chemicals impact our bodies. And from then on, I was like, "If it's a chemical, I want to study it and how it impacts our health."

And so, I really got into the laboratory science side. I did a lot of spectroscopy, spectrophotometry, very molecular analytic methods to start to learn about how chemicals impact our bodies and how chemicals interact with each other. So, even though I didn't have that official chemistry background, I really learned a lot through hands-on research and learning from other colleagues. And then I wrote to a professor at Pitt who was teaching an inorganic chemistry class and that professor was very wonderful and supportive and that class really, really impacted the way that I do my work.

Aside: And so, this professor, Dr. Jill Millstone at the University of Pittsburgh's Department of Chemistry, ended up changing the course of Kim's life. And on the topic of the past, let's go way back environmentally, toxicologically speaking.

Alie: What about when this career took a turn, I imagine that we've been using way more human-made chemicals and forever chemicals, and we have better technology to study them. Was there even a thing called environmental toxicology before the 1900s? Did anybody even care?

Kim: Well, there definitely was toxicology throughout history. One of the founders of toxicology, a guy that we call Paracelsus, he was an alchemist and had some pretty bonkers ideas about how the world worked. But he had some good ideas about how chemicals work and how poisons work. So, we think of historical toxicology as very poison driven, you know, mercury in alchemy operations, and cyanide in drinks of rich men by their future widows, and things like that. But I mean, the environment is around, and it's always been interacting with our bodies and even if there wasn't the language to talk about it the way that we do now, people knew about associations between what was going on outside and what was going on inside.

Aside: So, toxicology has existed for thousands of years, before the Egyptian hieroglyphs that warned of poisons and before Socrates's death by hemlock. But toxicology had its official start on the books in the 1500s with yes, the Swiss-born physician and alchemist, Paracelsus,

whose birth name was actually Philippus Aureolus Theophrastus Bombastus von Hohenheim, which I fucking dare you to name your next cat, Philippus Aureolus Theophrastus Bombastus von Hohenheim. [*giggles*] Please.

Anyway, but Paracelsus was actually a pen name for his non-science writing but it kind of stuck after his death like Madonna, or Rihanna, or Beyoncé, or Cher, or Adele. But his hot jams included hits like figuring out that miners' disease or silicosis was caused by inhaling rock dust and was not, according to the prevailing medical opinion of the time, "A punishment for sin administered by mountain spirits." He's like, "No, that's from dust, guys." But fast forward a few hundred years to the late 1700s into the mid-1800s and there was a revolution, mechanically and toxicologically.

Kim: That really gained attention in the Industrial Revolution when we saw really gruesome working conditions in factories and people were being exposed to chemicals in confined spaces. We can think about things like coal mining too as a huge start of environmental toxicology and environmental science. But a lot of the industrial chemicals that we used during the Industrial Revolution made people very, very sick. And so, throughout public health history, people have been looking at the ways that those chemicals lead to death and tabulating workers' deaths and things like that. Really, the environmental movement in the 1960s really spearheaded the EPA and the formation of some of the occupational safety groups in the US, so it kind of follows the general environmental movement, I guess.

Aside: So, a few things that contribute to the environmentalism movement were not, as what I assumed, was just absolutely tripping balls in a park in the '60s talking to squirrels. Rather, it was renowned marine biologist and conservationist Rachel Carson. She released the 1962 book, *Silent Spring,* about the dangers of DDT and other synthetic pesticides. And plus, there was a massive oil spill off the coast of California, and apparently a river in Ohio was so polluted in the '60s, it straight up caught on fire. Plus, astronauts started taking photos of the Earth from the Moon and people were like, "Yikes. We're on a planet in space and it's really pretty from there and it's just a shame to garbage it."

So Boomers, who were like the Gen Z of their time were like, "Boy howdy, it would be so groovy to save the planet." And so, in 1970 the EPA officially launched under history's favorite president... Nixon. So, to this day if you ask the EPA website, "What do you do?" it'll tell you that among its duties are working to ensure that Americans have clean air, land, and water. And that all parts of society, communities, individuals, businesses, local and tribal governments, have access to accurate information, to manage human health and environmental risks. They make sure contaminated lands and toxic sites are cleaned up by the potentially responsible parties and they review chemicals in the marketplace for safety.

Although, in a pretty big surprise, in June of 2022, the majority conservative US Supreme Court voted 6 to 3 along political lines in the West Virginia versus the US Environmental Protection Agency case and the Supreme Court blocked the EPA from making future broad regulations on greenhouse gas emissions from coal-fueled power plants. So, environmental lawyers say that that ruling in June set back renewable and clean energy efforts by 5 or 10 years. 9 people in America make decisions that affect the world. Oh life! What even is it?

Alie: Who do environmental toxicologists answer to? Who is keeping an eye out on this stuff to make sure that there's not just, like, asbestos falling from our Christmas decorations, you know? Like there used to be.

Kim: Right. So, in the United States, the government authorities on environmental and occupational safety, which environmental toxicology and occupational health go hand in hand because chemical exposures at work are very, very important to monitor. In the United States, there's the National Institute of Health has NIOSH, which is the National Institute of Occupational Safety and Health. There's also OSHA which is the Occupational Safety and Health Administration, but also the EPA. The EPA looks at a lot of environmental toxicology.

Alie: And when you are an environmental toxicologist, do you get to decide, "Am I going to study forever chemicals like PFAS? Am I going to study gasses? Am I going to study microplastics?" What kinds of stuff are y'all looking for?

Kim: Oh my gosh. [*giggles*]

Alie: It's a big question.

Kim: Literally. So, I guess this goes back to some of the principles of toxicology. So, our boy Paracelsus, problematic fave, he came up with this, I guess, this saying of, "The dose makes the poison," which I actually have tattooed in Latin... [*Alie admires*] I have a poison plant tattoo. [*laughs*]

Alie: Holy shit! What kind of plants are in there?

Kim: So, I have foxglove, and there's poison hemlock, and daffodils, which are my favorite flower.

Alie: Are those toxic?

Kim: Yeah, the roots are really toxic.

Alie: I didn't know that!

Kim: Yeah, the bulbs. But they're also being studied for different medicines and things like that. So, all of these plants also have active ingredients that, in the right doses, can be used medically. So, I think those are all the ones that I have on there. It also says, "*Sola dosis facit venenum,"* which means, "The dose makes the poison."

Alie: Wow!

Kim: I was like, "I'm going to be a toxicologist, it's going to be great, everything will be fine."

Alie: It's gorgeous. You also could never get away with poisoning anyone.

Kim: Yeah, absolutely.

Alie: You've got to find a different way to kill someone if you've got an enemy, you know?

Kim: [*laughs*] Yeah, they would never suspect...

Alie: But yeah, when it comes to deciding, I mean... Gosh! You could study plants, you could study plastics. How do you know? Do they roll a pair of, like, 20-sided DnD dice and that's how you figure it out?

Kim: Basically. So, the idea that the dose makes the poison means that anything can be a poison. And there are lethal doses for every chemical and sometimes those adverse effects come at such high levels that you get sick before you can reach that level and you no longer ingest it or things like that. So, that means that the limits… there aren't really any limits as to what you can study. [*"The limit does not exist!"*]

Aside: So, Kim was interested in endocrine disrupters and also took a liking to inorganic chemistry, which means carbon is not involved. Organic chemistry just means there's carbon,

all living things have carbon. Inorganic chemistry thus involves the study of things like metals. So, organic; carbon. Inorganic; no carbon. But don't worry, you can study danger and not necessarily work in a chem lab at all. There's danger everywhere... [*softly*] Yay!

Kim: Really if you're interested in a chemical or even a non-chemical exposure, you have things like noise, exposure to sunlight, exposure to workplace violence, there's a place in risk assessment for all of those kinds of things and toxicology being just part of that risk assessment.

Alie: What about something like this week... I mean, I believe the train derailment out of East Palestine, Ohio was February 6th, I want to say?

Aside: It was actually around 9 PM on February 3rd, 2023, and the train of 150 cars, which is nearly two miles long, was headed from Madison, Illinois to a railyard in Conway, Pennsylvania. So, it crashed on the 3rd, but the controlled burn came on February 6th, which is when most people may have heard about it.

But I wanted to do this episode because so many people I knew, family members, and neighbors, and friends hadn't heard a word about this crash at all, which kind of mystified me. And then a reporter was arrested which caused some people to panic but it turns out it was for speaking while the governor was speaking at a press conference. It just felt like I needed to get a professional's opinion on what is happening.

Alie: When did you first hear about it?

Kim: So, I subscribe to an environmental newsletter called "Above The Fold" and it comes into my inbox every day. And I received one on Monday and it said something like, "Train derailment in Western Pennsylvania, Ohio region." And I grew up in that area and I lived in Pittsburgh for the past few years, and I was familiar with the compressed natural gas trains that go through the city multiple times a day. And some of my colleagues and my friends and I have always said this would be really, really dangerous if there was a derailment. So, I was afraid that a compressed natural gas train had derailed in the urban center of Pittsburgh.

It turns out it was closer to where I grew up than Pittsburgh. So, I was familiar with the area, and so I read about it and I, you know, called my parents because they were fairly close, and made sure everything was okay. And then I looked into what kind of chemicals had spilled and I had seen reports that it was carrying phosgene, which is not true. So, at first, I was like, "Why are they carrying phosgene?" But it was vinyl chloride.

Aside: More on those in a bit. But meanwhile, Kim had tweeted a thread about the hazards of the crash, and it opened with:

> *As an environmental toxicologist who makes a point to hate on Pittsburgh's daily compressed natural gas trains, the East Palestine Ohio Vinyl Chloride Train Wreck is breaking my brain.*
>
> *We know that vinyl chloride is associated with liver cancer after chronic exposure. That's important to consider with any environmental release, but the more acute risk in this case is exposure to hydrochloric acid and phosgene, which are produced when vinyl chloride burns.*
>
> *Vinyl chloride is the main concern right now because it's explosive.*

So, after the derailment, as dark gray plumes filled the skies, about 2,000 residents within a two-mile radius of this Appalachian Ohio town were evacuated.

Alie: Tell me a little bit, in this particular case, what that area of Ohio is like. Is it really rural?

Kim: Yes. So generally, western Pennsylvania and eastern Ohio are fairly rural. They were more populated during the Industrial Revolution and the steel boom up until about the 1980s when steel left the area, leading to a little bit of an economic depression. But I know the train infrastructure is really central to the region and, like I said about Pennsylvanians and their trains, I think the same could be said for Ohioans.

And it's also an area that had a lot of industry that is associated with a lot of environmental pollution. So, Pittsburgh has some of the worst air quality in the country, they have high rates of air pollution-associated cancers and it's a big environmental justice issue because those risks aren't distributed evenly. There's this history of industry coming in and polluting and then the community is left to clean up the ruins. And so, this is, unfortunately, just another case in that very rich history of industrial pollution in the area.

Alie: Yeah. And now, phosgene versus vinyl chloride. Can you tell me a little bit, because these are words that most of us are not familiar with, but as an environmental toxicologist it's probably like 101 for you. [*laughs*]

Kim: Yeah, absolutely. So, vinyl chloride is really volatile, it burns at, I don't want to say a low temperature, but on the scale of temperatures that things can burn at, it's a pretty low temperature. So, when it's exposed to air and heat it will combust into a variety of combustion products. So, the train derailment started a fire, and the heat was rising, the pressure was building in the tankers carrying vinyl chloride. So, when vinyl chloride combusts, it produces a couple of different products like carbon monoxide and carbon dioxide but there's also hydrogen chloride, which I can talk about in a minute, but there's also phosgene.

So, phosgene is famous for being a chemical weapon used in World War I and it was used purposefully in high concentrations because of its toxicity. It disrupts the interaction between the lowest parts of your lungs and your bloodstream so oxygen doesn't get in and so you can't breathe. It's also denser than air so it stays closer to the ground. So, if you're ever around phosgene, you want to get up to higher ground. This was really important in the context of World War I where people were fighting in trenches. So, if you have something that stays low to the ground then it gets stuck in trenches and so people can't escape. And so, unfortunately it was used as a chemical weapon and so that's how people know it now.

So, that's produced when vinyl chloride combusts. But it doesn't last very long in the environment. Its half-life in the laboratory scale is under a second. So, it really depends on how much there is, how long that's going to last. But my suspicion is that it was gone from the area after the controlled release within a few hours to maybe a day and a half.

Aside: We'll talk more about that controlled release in a bit because the decision to do it has left people, well... fuming.

Alie: And now, everything else that was a product of combustion, did that rise?

Kim: For the most part, yes. So, that was the other interesting tidbit about the controlled burn. There was a thermal inversion coming in. Can I geek out about thermal inversions for a second?

Alie: Yes, 100%.

Kim: Okay so, as a loyal Pennsylvanian, I love our environmental history and I like to talk about it whenever possible. So, thermal inversion is when there's warm air on the ground but then a layer of cold air comes over top of it and acts like a blanket, and it keeps all the warm air down on the ground. And usually, that warm air would rise up to the atmosphere but because

there's that blanket overtop, things that are close to the ground don't escape and so they're stuck down at the ground. And that happens fairly frequently in the Western Pennsylvania and Eastern Ohio area. Anyone in Pittsburgh is probably very familiar with the air quality warning days and the word 'inversion'. But it was really, really important to the establishment of the environmental movement in the United States.

Aside: So, the year is 1948, 25 miles southeast of Pittsburgh in a small mill town called Donora, which had a zinc smelting plant.

Kim: They were off-gassing all kinds of contaminants. It turned out there was a thermal inversion that day, this was in Donora, Pennsylvania. There was a buildup of the contaminant in that thermal inversion, and it lasted for days. So, people were exposed to this ever-increasing concentration of toxic chemicals coming from this industrial plant. Unfortunately, a lot of people were sickened, and people died, and it got a lot of national attention.

[*clip from Donora Smog News Reel:*]

A death-bringing fog settles over Pennsylvania's bustling industrial town of Donora. Residents have difficulty in breathing the murky air as the town is plunged into darkness. Oxygen tanks care for sufferers in the local emergency hospital. 20 people die, 400 others are stricken with respiratory ailments. Investigating the cause of the sudden catastrophe, health officials close the local zinc plant suspected of emitting poisonous fumes.

This was also what caused the London Fog, which is another example of an inversion causing contamination to stick around in the air.

Alie: I had no idea! I thought London Fog was a type of trench coat! I had no idea.

Kim: Yeah! It feels a little insensitive, honestly. I guess London having water fog is normal. But for me, you know, [*laughs*] I think of the London Fog as the environmental disaster.

Aside: Okay, so in 1952, there was a five-day inversion event known as the Great Smog of London that killed around 4,000 people. But this metropolitan air pollution, it wasn't uncommon, this was not new to them. "London fog" was a long-used term for this yellowish or pea soupy, thick, sulphureous industrial smog that occurred in the late 1800s and the early 1900s in industrialized cities. Back then, everyone, like, smokes six cigarettes with breakfast, who cares? "Look at the air, you should even see air but look at it, here we are in this poisonous miasma of airborne waste, so cheerio!"

But what about London Fog the coat manufacturer, what does it have to do with anything? Well, it was established long before that fatal London fog, 1952 event. They started actually selling trench coats in 1923. And also, surprise, London Fog is an American company. They were founded in Pennsylvania too. And I spent at least two hours digging into the research of London Fog coats this week, my brain would not permit me to stop. So now, you have to carry the burden of trivia that trench coats were named because soldiers in the First World War would wear them in the literal trenches, hence trench coats.

But London Fog really made a name for themselves during World War II; they made like 10,000 coats for the US Navy, people loved them. And the style that the London Fog founder, Israel Meyers, preferred, was kind of a less inspector Gadgety double-breasted look and favored the sleek, single-breasted style based on a Scottish coat called a balmacaan. And Israel liked to call his stylish rain jackets main coats and not raincoats because he was like, hey, even though we worked with DuPont to make these raincoats waterproof, you can wear this shit no matter what the weather, and you can look good. So, let's call them main coats, baby. And so,

London Fog coats became wildly successful. [*"Name another raincoat."*] But yes, given the historical inversion events of London fog, perhaps London Fog's slogan of, "London Fog lets you laugh at the weather," was like… nnhh, a little too soon.

Alie: Oh dear!

Kim: Yeah.

Alie: And so, with these types of concerns with regular weather patterns mixing in with brand new chemicals we're not used to, where does remediation even start? When I see pictures from this Ohio derailment there's a plume; it's like a column of dark, dark grayish-blue smoke and then it rises and covers so much of the sky. Why is it such a column and where is that cloud going?

Kim: So, the difference between the controlled explosion versus the other options made it so that, even though it doesn't look like it, it's basically, if you shook a can of soda and you opened it a little bit at a time and let the air go out rather than puncturing the side of it.

So, the images from the controlled burn are really striking and that shows how much energy is contained in those molecules. That plume is because of the energy that was released when those molecules broke up. The height of the plume is unsurprising because of the amount of energy that's in there. If you went in with a spectrometer you could look at the plume and see what colors show up so we can see which kind of gasses are in there. But the really interesting thing about those images is that you notice it stops at the top, it flattens out. That's the thermal inversion.

Alie: Ohhh.

Kim: Yeah, so they were trying to do the controlled burn before that inversion got lower to the ground so they could maximize the amount of dissipation and minimize the amount of contaminants that were close to the ground when the inversion was coming. So, shoutout to meteorologists for being aware of what was going on and probably making things a lot less disastrous.

Alie: And now, the vinyl chloride, I understand, when it mixes with water vapor, does it become hydrochloric acid?

Kim: Yes. So, vinyl chloride combusts forming hydrogen chloride, and that, upon contact with moisture, becomes hydrochloric acid. And so, if you inhale hydrogen chloride, you have a lot of moisture in your mouth and your lungs, and it unfortunately will become a liquid in your lungs when it reacts. So, that's something to stay away from. But that reaction happens really quickly and if people are evacuated from the area, then with the first rain or just with reaction in the environment, that suffocation or drowning risk is no longer an issue.

Alie: Is that what's been happening to people's chickens, and dogs, and foxes, and stuff?

Kim: Well, I can't give individualized risk assessment or health advice and I'm not on the ground to do an autopsy, but from what I've read, unfortunately not all the animals were able to be evacuated so were likely exposed to phosgene and hydrochloric acid. Those reports make me very, very sad and I wish that every living thing in the area could be evacuated.

Aside: So, there have been reports of pets and livestock dying from chemical exposure, and scientists estimate that about 3,500 fish have died in the streams and the rivers nearby, so far, which has left kind of a greasy, fatty, dead fish rainbowy film on some of the local waterways that has been misreported as an oil spill. But why did all those fish go belly up?

Kim: I'm not super sure about the fish. I think that would have been a change in oxygen in the water upon contamination. But my guess is, for the animals that were unable to evacuate, exposure to those respiratory toxins is probably the cause. Now that the vinyl chloride and the immediate explosion risk is gone, it's important to still monitor your pets if they do become sick. So, there's definitely a few phases of the environmental disaster; we had the acute explosion phosgene risk and now we're looking into more long-term consequences.

Alie: Did your parents have to evacuate at all?

Kim: No. No, luckily, they didn't. But my mom smelled it the day after they did the controlled burn.

Alie: Yoikes.

Kim: Yeah, yeah. But I'm very glad that they were safe.

Alie: Oh my gosh. Now, what about long term? How long will it affect the environment?

Kim: Well, that depends on a few important components. So, number one is, what chemicals are there? PFAS for example lasts a long time in the environment, and I'm speculating, but from what I know about firefighting, fluorinated foams were probably used to put out the fire. Which I don't knock any fire department for using those because they're what's available right now and it was a dangerous situation, but those chemicals are probably in the environment now and we need to be able to address that.

Aside: Let's talk about PFAS. So, PFAS stands for perfluoroalkyl and polyfluoroalkyl substances. But unlike me in one minute, you're never going to have to say that aloud, probably ever, so don't worry about it, just call them PFAS. But also, do worry about it because they're known as 'forever chemicals' because their carbon-fluorine bonds are so strong, nature just cannot break them down, and that means that they can bind to protein and they can bioaccumulate in your sweet, soft, body.

Do you touch PFAS? Do you think you've been in contact with any? Oh sweetie, yes. So much, so much. They're in everything; nonstick pans, clothing, carpets, fireproof materials, bottle caps, anything waterproof. Remember that raincoat and the DuPont collab from the 1950s? Mm, well, a cancer victim, testicular cancer twice, just won a $40 million lawsuit against DuPont for dumping PFAS in a river in West Virginia. Kind of makes you want to run to the middle of nowhere and just subsist on only natural foods and just be naked. But I have some bad news for you; polar bears already had that idea and PFAS have been found in their brains. Everyone's got 'em, everyone's got 'em in them.

Now, what is the danger for all of this human-made convenience? So, a 2020 paper published in the journal *Environmental Toxicology and Chemistry* was titled, "Per- and Polyfluoroalkyl Substance Toxicity and Human Health Review: Current State of Knowledge and Strategies for Informing Future Research." And this paper reports that:

> *Epidemiological studies reveal associations between exposure to specific PFAS and health effects, including altered immune and thyroid function, liver disease, insulin dysregulation, kidney disease, increased cholesterol levels, adverse reproductive and fetal development outcomes, and cancer.*

Yikes. Why isn't anyone doing anything about this?

Well, ologists are, including Kim, who is currently doing her postdoctoral studies at the Social Science Environmental Health Research Institute at their PFAS Project Lab at Northeastern University. And they are helping assess PFAS contamination, they're analyzing the

governments' rules about it, they're working on community activism and environmental justice, among other things. She's also working in collaboration with the Silent Spring Institute, marine biologist Rachel Carson would be proud. And Kim is also a co-author on two 2022 papers, one, "Improving governance of 'forever chemicals' in the US and beyond," and "Presumptive Contamination: A New Approach to PFAS Contamination Based on Likely Sources." Ah! Another reason to love her, she's on the PFAS case.

Kim: So, those chemicals can last a really long time. But other things like the butyl acrylate, that was found in some of the downstream areas a few miles from the explosion site, those get broken down by enzymes in soil and in the water, they're in bacteria. So, those are probably being chewed up. And there's a lot of photodegradation, so breaking down through the sun and oxidation, so exposure to oxygen. All of those factors act to break chemicals down in the environment.

Alie: You know, do you feel like the Lorax a lot? Do you feel like you environmental toxicologists are screaming from a tree stump like, "Someone pay attention to this please! [*"I speak for the trees! Let 'em grow! Let 'em grow!"*]

Kim: Umm, yes. Yes, absolutely for a lot of chemical contaminants. And on the other hand, I find myself screaming for people to consider toxicological nuance, which is a thing that I complain to my friends about a lot. So, I guess this kind of gets into some flimflam. The idea that something natural is inherently safer than something that's synthetic is something that I yell a lot about.

Alie: I know whenever an environmental toxicologist sees something that says there's no chemicals in it you must, [*Kim laughs*] just absolutely wants to hit yourself in the face.

Kim: Oh yeah. I take pictures of all the labels, and I have a little album on my phone where I'm like, "That's not how it works, my dude." [*Alie laughs*] That's... [*exasperated sigh*]

Alie: Water's a chemical.

Kim: Yeah. [*Alie laughs*] Everyone who has ever died has had H2O in their bodies.

Alie: Yeah. [*laughs*] You gotta watch out for it. [*"I wasn't drinking water."*]

Aside: Don't actually worry if you have H2O in your body, anything that's made of matter is technically a chemical; water is a chemical, oxygen is a chemical. So, not all chemicals are bad and to say that something doesn't have chemicals in it is like saying food doesn't have ingredients. But also, if it's a manufactured chemical maybe, I don't know, maybe we should test it before selling it; this seems like common sense. But when dollars are at stake, sense kind of goes out the window and straight into a stream. And Kim says that there's a whole area of study and a theoretical framework that environmental toxicologists use, and it's called the Precautionary Principle.

Kim: I'm a big proponent of the Precautionary Principle, and it basically says "assume something is dangerous until proven safe" and it's really hard to prove safety. There's a lot of complexity in environmental toxicology and risk assessment. And the Precautionary Principle basically states that we shouldn't prioritize innovation at the cost of public safety, human safety, environmental safety, remembering that people are part of an ecosystem; We're not some entity that's separate from the environment around them. The built environment is still part of an ecosystem, and things like that. So, the Precautionary Principle prioritizes safety and knowledge gathering before willy-nilly chemical spraying.

Alie: And how do they test the safety of things? Because couldn't it be 30 years before something starts to affect you? Do you think with quantum computing, there will be better molecular models? How do we know how it affects animals and humans?

Kim: Right, so there are so many different methods that you can use to study environmental toxicology, and they happen at so many different scales. So, if we think really, really tiny, we can look at how molecules are interacting with each other, and that's what I did a lot in grad school. We can look at the way that they're absorbing light or emitting light and see what that means about the molecular shape. And then you can go up to cells and you can look at how it impacts the cells, their respiration rate, any kind of health impact we have pretty good methods to assess.

And then all the way up to population level, so environmental epidemiologists look at towns, cities, geographic areas with high rates of a certain health outcome or exposure to something. They look at health data there, if a lot of people are getting sick all at once, that's something that you want to investigate, so you can go and ask about people's exposures. If they all smelled a weird smell in their town, that's maybe a clue and you can look into that.

But you can also do, with animal models, and cellular models, and molecular models, you can look at specific toxins and how they work. And when we do that, we typically do what's called a dose-response curve and so that goes back to the principle of toxicology, the dose makes the poison. And when you do a dose-response curve, let's say you're going to give cyanide to a bunch of cells and study how their respiration rate goes, so how fast they're turning over oxygen. Cyanide inhibits the ability to turn over oxygen. So, you can measure the amount of oxygen that's in the plate with the cells as an indicator of inhibition. And you can increase the dose and you can plot it on an X and Y axis with the X being the dose and the Y being the response. And the shape of that curve tells us a lot about the poison of interest. Something that's really toxic is going to have a really steep dose-response curve and something that is not so toxic, we consider to have a very gentle dose-response curve.

I am biased to saying negative outcomes because I love to study poisons but that's the same principle that's used in drug development and medicines. The response could be something really good, could be an increase in oxygen use, things like that.

Alie: And are there different levels of toxins? Some that might affect your immediate respiration versus others that fuck with your DNA?

Kim: Yes, absolutely. There are *so* many of those. So, that's when we get to acute-versus-chronic exposure. A lot of our information about acute exposures and chronic exposures come from the occupational settings. [*"I'm at work doing work."*] So, if there's an industrial accident like a train derailment, that's a one-time incident. Let's say for instance, the workers who were on that train were right next to it when it crashed. So luckily, I haven't heard any reports of any injuries from the derailment, but that's a one-time acute exposure. But chronic exposure we can look at, at a workplace. So, if people are going to the same place every day for a series of years, being exposed to the same chemicals, then that might be a little bit different. So, you are exposed over time.

We can think about that with sun exposure. There's an acute outcome after sun exposure unprotected, which is a sunburn. You can see that, and you can feel it, and medical professionals or researchers could see that. But after a long time of sun exposure, sometimes there's a misprint of DNA or a miscopy of DNA, and then skin cancer arises, but that's after a

long-term exposure. Sun's a good example of something with a multi-exposure level health outcome.

Aside: And for more on this you can see last week's episode on Melaninology, in which we discuss this very thing and what kind of sunscreen you need.

Alie: What about toxicology movies? Did *Erin Brockovich* get it right?

[*clip from Erin Brockovich:*]

20 million dollars is more money than these people have ever dreamed of. These people don't dream about being rich, they dream about being able to watch their kids swim in a pool without worrying that they'll have to have a hysterectomy at the age of 20! By the way, we had that water brought in special for you folks.

Kim: I actually have not seen...

Alie: You've never seen it! I haven't either. But still. Do you have any interest in seeing it or are you like "No, never, can't do it."?

Kim: Oh no, it's absolutely, it's on my list of movies to watch, for sure, I just have not gotten to it. Let's see, it's a TV show. So, *Breaking Bad* in the first few episodes does the best and maybe the only example of phosphine toxicology or phosphine toxicity that I have ever seen.

So, phosphine is a byproduct of methamphetamine production, and it's one of the reasons that meth labs explode. So, there's a scene in one of the first few episodes of *Breaking Bad* in which they're making meth and this adversary of theirs comes into their trailer, [*"Move it, homes. Ain't got all day."*] and they very strategically release a gas, and that gas is phosphine. So, it's an explosion hazard and the reaction is pretty spot-on for a mitochondrial disruptor, so inability to breathe [*sounds of gasping for air, coughing, and struggling*] turning all red, it's pretty good. I definitely point that one out.

But also, more recently, the movie *White Noise* on Netflix, which it turns out some of the extras for that movie live in the area of Ohio impacted by this. So, basically, it tells the story of an airborne toxic event of undisclosed toxicity chemical makeup. But what I think the movie does really well is it shows the existential uncertainty that comes with toxicological complexity. So, I really related to some of the characters who are at this kind of shelter site. And Adam Driver comes up and says, "They said that I've been exposed to this thing for 3 minutes, am I going to die?" And they very calmly say, "You may die in 30 years." And he's like, "But that's not good enough!" But in that kind of event, no one has any idea. But you know, we can say things on a population level but it's really, really difficult to bring that down to the individual level and I think that that movie really summed it up. My review on Letterboxd was something like, "Finally, one for the existentialist academic toxicologists." [*Alie laughs*] [*clip from White Noise: "I wish there was something that I could do. I wish I could out-think the problem."*]

Alie: I haven't seen it yet, but the timing is... impeccable.

Aside: So, *White Noise* was released about 6 weeks before the Ohio train derailment and it was shot just a few hours away in several different Ohio locations. Some of the film's extras actually live in East Palestine. And if you look up the trailer for *White Noise* on YouTube, one of the top comments reads, "This aged well." So, what does Dr. Garrett say?

Kim: I recommend it, it's a fun one plus it has a new song from LCD Soundsystem which I really like.

Alie: Oh, that's good to know. Did you ever listen to the band The Airborne Toxic Event?

Kim: No, I didn't. [*laughs*]

Alie: They're great.

Kim: I feel like I'm a bad media consumer.

Alie: They were great, they were an LA band and the lead singer ended up being like a *New York Times* Bestselling author and journalist and stuff so I'm like, "Wow, this whole week has really been right up his alley". Can I ask you some questions from listeners?

Kim: Oh, absolutely.

Alie: They know you're coming on.

Aside: But of course, before that, let's give some money to a good cause chosen by the ologist, and this week Kim selected the southwestern Pennsylvania nonprofit, Group Against Smog & Pollution, which has the genius acronym, GASP. It was founded in 1969 and GASP has been a diligent watchdog, educator, litigator, and policymaker on many environmental issues, with a focus on air quality in the Pittsburgh region. You can find out more about them at the link in the show notes. So, keep up the amazing work, y'all. And that donation was made possible by sponsors of the show.

[*Ad Break*]

Okay, I know it's on your mind. Let's do it, let's ask, let's get back to Ohio. I don't know, if you're with kids, turn it down for the next 30 seconds so they don't hear me swear so fucking much.

Alie: I'm going to ask this one that is the most asked question. How fucked are we? V.E. Griffith: Are we just fucking done for? RJ Doidge: So, how totally fucked is the region? Rachel Casha: My only question, what the fuck? There's a lot of fucks, a lot of fucks to be given. Is it Chernobyl scale?

Kim: No.

Alie: Okay.

Kim: Well, I will say there are a lot of unknowns and I want to recognize and sit with the uncertainty that we have in a situation like this. As for "how hecked are we," I cannot say as an individual risk assessor or… you know, I'm not directly associated with the situation. But the data that I've seen is… I am not running around screaming very, very scared. [*laughs*]

So, what we do know about some of the chemicals that were released there is that they don't last very long in the environment. And the EPA had a press conference last night where they explicitly said where the plume is moving, where they've detected it, how fast it's moving, and some of the chemicals that are in it. And they also really importantly mentioned the points at which they're registering non-detect.

So, if we think of a plume kind of like, a perfume, a perfume cloud. If you're in the perfume department of the department store, you can start to smell it at maybe the entrance of the department store and then finally when you get to the perfume counter it's very smelly. [*"That's a lot of perfume bro."*] So, the non-detect area would be where you can't smell it anymore, so at the entrance where you can't smell it anymore. So, that really indicates that it's being either bioremediated by those little enzymes eating up all the chemicals, or oxidized, or degraded by the sun by the time it gets to that point. And that, of course, is to the limit of detection, so how good the technology is at finding that. But for most chemicals, the limit of detection is far below any kind of concerning health level. So, I'm fairly confident in the data that I've seen from the EPA about those kinds of things.

As for individual impacts, you can say, how bad is it? But we can qualify how bad is it to human health? Or how bad is it to economics in the area? Or how bad is it to people whose houses are filled with soot? That's bad. And so, risk can be really individualized, and I don't want to say one way or the other that this is really bad, or it isn't really bad because that's kind of up to an individual's definition.

As far as the comparisons to Chernobyl and to some other historical contamination events, I think those are fairly inappropriate because Chernobyl was a radioactive event, for example, and so there's a lot of differences between these kinds of events. And general fearmongering doesn't really lead to action, I think it causes a lot of negative outcomes where people feel really, really scared. There are lots of scientists working on this and there are a lot of things that we do know from historic events, and we can learn from those mistakes, and we really have an opportunity.

Alie: Some people, Anna Elizabeth, Suzy K, MB, Nana from Canada, and Courtney Kudera wanted to know how this might affect the water quality? How does something go from an airborne toxic event to a poisoned aquifer, for example?

Kim: So, that has to do with the water cycle and the weather cycle. So, if there's ash up in the sky it might dry deposit, so fall down from the sky or be carried by wind. You have dust in your house, that can be a similar kind of thing; your skin particles float around and get on your stuff. So, the same thing can be said for combustion products. But there's also wet deposition, where things react in the atmosphere and either dissolve into water or become something that is rained down from the sky so that's how it really gets into the water system and the soil.

As for preventing and remediating that kind of contamination, there's drinking water and then there's groundwater, like, surface water that people don't necessarily drink. And so, on the drinking water level, municipal drinking water systems have a lot of filtration in place. And in this case, I really hope that the state and federal government and Norfolk Southern, when they're found responsible for this contamination, I hope that they pay for improvements in the technologies in the affected areas. Because what we've seen with PFAS, when a community realizes they have contamination, the water authority says, "Okay, we'll get this new technology to help take it out," and then they don't get support for that funding, so the cost comes back to the bill payer. And the community absolutely should not be responsible for paying for the negligence of a company.

Alie: Yeah, I saw that $25,000 for the 5,000 residents and I could not believe my eyes.

Aside: So, the railroad company, Norfolk Southern, is worth over 50 billion dollars and has now upped the relief to locals at one million, which is less than the cost of a condo in LA. Okay. But initially, they pledged $25,000 to the Red Cross, to cover the whole town.

Alie: Like, that's not even a sandwich at a gas station. As someone who eats a lot of gas station sandwiches, I can tell you.

Kim: I feel like for a little audio in that, you could get Lucille Bluth saying, "It's a banana, Michael." [*"What could it cost, $10?"*] [*both laugh*]

Alie: Seriously. That, to me, is just like, they really should have held off and come up with something better because that's horrible.

A lot of people had questions about impacts on wildlife and plants. Whitney, Liliana Ramirez, Riley Axel, Finlay Mullen, Natalie J, Curly Fry, Chris West. Curly Fry wanted to know: What are the effects of disasters like these on wildlife habitats and what can we do to help?

Kim: Okay, let's see. So, this is kind of more of an eco-toxicology question, but I will answer it to the best of my ability. I tend to veer on the public health side of things. But the environmental contaminants are sometimes taken up in the soil and they can be taken up in plants. So, I've seen a lot of people saying, "Don't eat food grown in eastern Ohio," and I don't think that that is the answer. But I think that farmers in the region should consider getting crops tested for heavy metals, PCBs, VOCs. Because a lot of environmental contaminants get transformed into other things which, for the most part, those tend to be less toxic, less harmful. And they also get taken up into plants.

Aside: Just a side note, a PCB is a polychlorinated biphenyl and they're human-made chemicals, they can cause cancer, and immune system, and reproductive harm. They were banned from being produced in 1979, but that doesn't mean that they're not still around. And VOC is a volatile organic compound, that is a gas that arises from a solid. Either way, Kim says that when it comes to environmental toxicology, the party responsible for contamination should pay for testing, it's only polite. And if you're in an area where there's been an accident or potential exposure, document as much as you can; go to the doctor, report symptoms, take notes, take photos... Document, document, document.

Kim: I know in Pittsburgh we have a lot of lead in the soil so it's an issue where people who are trying to do urban gardens tend to get raised beds with soil from elsewhere because the lead can be taken up into the plants.

Alie: Oof.

Kim: Generally, that's what I would look for in agriculture. For plants generally, I really don't know what the impacts will be on the plants and, of course, for wildlife in the area, I think the initial acute issue of phosphine exposure has already passed, and unfortunately that did take a toll. But moving forward, there are ways that communities can come together and monitor these kinds of things. In some of the historical examples, we've seen communities come together and map where they notice maybe fish are dying. Or even with things like West Nile, if you see a dead bird, you report it to someone. For the east coast, sometimes we get West Nile virus outbreaks and birds die from it, so you report them. Coming together and doing community science can be really, really valuable in these situations. So, I'm definitely recommending that, and I hope that if people do community science, I hope they don't find anything bad.

Alie: Yes. A lot of folks, circling back to the whys of Emily MacLeod, Paul Smith, NanoNaturalist, Jackie, and Isabella wanted to know: Why burn it? NanoNaturalist says: I'm a chemical engineer and I want to know who in the FRESH HELL decided it was okay to set VINYL CHLORIDE on fire. (I live in Ohio, can you tell I'm mad?) Was setting it on fire done deliberately, did it just burn at very low temperatures?

Kim: From my understanding, there were three options… well, I guess there were four options. The ideal situation would have been if there was no fire and just these tanks of vinyl chloride just took a little tumble and nothing happened, then hazmat crews could come in and ship those tanks full of vinyl chloride to a facility where they can appropriately dispose of them. That's option number one.

Aside: Which didn't happen.

Kim: Option number two is, puncture the tank when there's no fire which would leak vinyl chloride out into the environment, and as we've seen with "Cancer Alley" in Louisiana and it's one of the chemicals of concern on Camp Lejeune, where you may see TV ads asking to participate in lawsuits and studies. It's very persistent in the water and the soil if it is not broken down. So,

vinyl chloride is a carcinogen. And when we think of carcinogens typically, we think of chronic exposure, so that would be something that's of concern with chronic exposure through drinking water. So, that's really, really hard to remediate. So, you can think of that as spilling something into a river and the river takes it far away, it takes it far and wide, so that's a lot harder to clean up than some of the other options.

The other two options had to do with fire. From what I understand, there was fire already happening around these tanks because of the derailment, right; big train accident, unsurprising that there might be a fire. And as that heat rose, the pressure inside of those tanks rose and they knew that the risk of explosion was so high. So, that's why there were calls for evacuation, right, you don't want to be around a train tanker full of anything when it explodes. And so, that's the other option, just wait around and see if it exploded. Another component that went into that decision, I assume, is the thermal inversion coming in. So, you wouldn't want to wait around and see if it was going to explode and then have it explode during the thermal inversion.

So, what they did is they punctured smaller holes in the tankers… So this is the fourth option and what they did. They punctured holes in the tankers to do what's called a controlled release. And controlled, it didn't really look controlled, it looked very, very... just so intense. Knowing the burning rate, there's a lot of math that goes into these kinds of things to determine how far something is going to move or how fast something is going to react. So, they cleared out the area, so that's one thing that they were able to control, is getting everyone out to a safe distance away from the immediate risk of phosgene in the exposure and just general explosion. So, they were able to control that, and they were also able to control the time that they did that. So, they didn't have it waiting around for the thermal inversion to come in.

Aside: So, remember the 1948 Donora, Pennsylvania disaster and the Great Smog of London in 1952, right? So, one reason they had to move quickly in this case, is to avoid more pollutants getting trapped and blanketed low. So, the inversion in Ohio only let the billowing fumes go up so far and then it started to flatten. That's why the plume over East Palestine looked like a horrifying atomic mushroom cloud.

Kim: The other component of the burn-off that's really interesting and I think saved a lot of grief from later… I don't want to say officially that this has been a really beneficial thing, but the breakdown of vinyl chloride turning into some of those other combustion products, those break down in the environment really easily into less toxic products. Vinyl chloride doesn't break down as fast when it's not combusted. So, by burning off a lot of that vinyl chloride, they reduced the amount that got into the waterways, so it was transformed into other products which were acutely very toxic but didn't last long in the environment.

Aside: So, that's the good news, that definitely made me feel better. And Kim was interviewed in *Newsweek* a few days ago and explained to them that yes, a controlled burn might have been the best of two bad options and that the health risk of vinyl chloride is greater once it's in the water supply which is likely what nudged officials to burn it before the weather inversion and before it leaked into the water.

But once a hazardous chemical is out and about, how does one un-ring that bell? So, patrons including Cate Muenker, Joe Porfido, Alaina Cruson, Shelby Mills, Meg Shooter, Esohn, first-time question-asker Ross Banerjee, Eleanor Stephenson, and EdNoGG all wanted to know about bioremediation. And some folks asked about pharmaceuticals in the water supply and for that I'm going to direct you to the Environmental Microbiology episode about testing

sewers for COVID and we also discuss pharmaceuticals in the water, so I'll link that in the show notes.

Other clean-up questions were asked by Geena Grim, Omexamorph, Kristina Kunze, Lisa M Rich, Buhbrie, Katherine Fox, Emily P, Kelsy Simpson, Alicia Henning, Leah Anderson, Dara-Mae, Marxe Orbach, Mia, Haley Kenerley.

Alie: What about other ways to clean things up environmentally, things like sending fungi that want to gobble certain chemical compounds that we don't want in there? What's the best way to clean this up?

Kim: Yeah, so that again depends on the chemical. [*laughs*] I'm very tentative about the specifics of toxicology but it really depends on the chemical. I'm glad that Norfolk Southern and the EPA released the manifests, so we know what chemicals were there. And even if those chemicals break down into other products, you can look up data about that. There's a really cool resource called PubChem where you can type in the name of a chemical and find out more information than you would want to know about it. It's my favorite website. [*both laugh*] So, you can look those up on there but it's also important to take into consideration, how much was there?

One thing I see that's missing from the manifest and some of the other documents is, how much was released? The EPA documents that have been made public for the environmental sampling, but it would be really, really interesting to know much was released and so then we can start to look at things like how fast is it being degraded? If we started with this much, and we're this far away, and this amount of time from that release, that can tell us a lot about what's happening in the environment.

Aside: Kind of like one of those math problems where if Tommy boards a train from Pittsburgh at 64 miles per hour, and Suzie's train is headed east, what time will they meet in a combustible ball of cancer smoke? But also, where is that plume headed, with how much vinyl chloride? But really, the fallout from the crash is being tracked through the Ohio River and experts say that it's flowing at a rate of about a mile an hour.

And as for that oily sheen on the creeks that we mentioned earlier, the jury is still out. Some say it could be natural or bacterial from the fish gills. But the Pennsylvania Department of Environmental Protection was quoted as saying that a bacterial sheen will typically break into small platelets when disturbed, while a petroleum sheen will quickly reform. And another way to tell them apart, they say, is by smell. Natural sheens don't smell like petroleum. But as a precaution, Cincinnati and other locations that draw water directly from the Ohio River are using different intake systems for a few days or urging water customers to use bottled or filtered water.

Kim: So, with that in mind, I think that one of the best ways is going to be through municipal drinking water filtration, so things like granular activated carbon, reverse osmosis; those technologies are very good at getting your everyday contaminants out of your water. As for maybe airborne dust things, when you go back to your house, you might find a lot of soot on your items. I had an apartment fire a few years ago and luckily nothing was damaged but there was soot everywhere and it lasted for so long.

So, when you're looking at soot you want to make sure that you spray it down with a little soap solution with water because those dry particles are respiratory irritants and they're larger particles. So, the N95s will help with the soot exposure, they might not help with really small molecules that could get through that very small filter. But with the soot, you'll probably

sneeze less and be able to smell less while you're cleaning your house with the soot but be sure to spray that down before wiping it up.

Alie: Am I asking for early death if I burn incense while I work?

Kim: I am of the opinion that breathing anything other than air is not ideal.

Alie: Okay! That's good to know! That's really good to know.

Kim: So basically, the idea is, if it's not air, don't breathe it. Your lungs are so cool and so good at their jobs. The lungs are incredible, they're my favorite organ, they have all these really cool defenses to keep things that are not air out of your body. So, we have something called a mucociliary escalator, which is a bunch of tiny cells with tiny little hairs on them that move up all the time and they're controlled by your neurologic system. And if they encounter something that shouldn't be there, they move even faster. They're also cells that secrete mucus. So, mucociliary escalator comes from the midpoint in your lungs, all the way up and it is why you cough, why you get phlegm, and the mucus traps inhaled particles and carries them up so you can cough them out. Mucus deserves our respect. [*Alie laughs*]

Aside: Ah yes, our friend mucus. I used to bleep the word mucus in previous episodes, but I don't anymore... I've grown as a person; I hear it, it still grosses me out, but I have a new appreciation for it. And Kim asked if she could possibly rant about vaping, and I gave her the floor.

Kim: So, clearly your body is saying, "please don't put weird stuff into your lungs," they're so sensitive, there's a direct link to the bloodstream down in the alveoli, which is the smallest little part. So, the idea that vaping is safer than cigarettes is a false comparison in my opinion. Cigarettes are one of the only things that we have that we know is a direct link to cancer, to specific kinds of cancer, where if you get lung cancer and you smoke, that's basically the causative agent.

Comparing that to vaping, there are very few things that are more dangerous than smoking. Vaping, again, you're inhaling things that are not water and they're fairly unregulated in the United States. So, when I was going through grad school, there were fewer regulations on vaping and it was seen as this big, you know, revolutionary thing. But the issue is that you're inhaling vaporized particles, your lung doesn't want any liquid, you don't want to put liquid in your lungs. Even a vapor, you can get dermal exposure to things, you can get it stuck on your lips and get burns and different things that way.

But the real issue is the flavoring agents. So, the tobacco that's in cigarettes has a little dangly atom coming off the molecule that irritates the back of your throat. So, that limits the amount that you can smoke comfortably, right? Vaping tobacco has been developed so that it doesn't irritate so you can get a much higher dose with fewer immediate adverse effects. So, that's a problem that we see with kids and teens vaping, they're getting these huge amounts of nicotine, which is a carcinogen and really, overall, really bad. And then you get the flavoring agents and there's a chemical called diacetyl, which is a really good example of this; it gives butter its flavor, it's also produced when coffee roasts, and it is associated with something called popcorn lung. So, are you familiar with that?

Alie: I eat way too much microwave popcorn, or at least I used to. So, I was familiar with people who worked in popcorn plants, right?

Kim: Yes, so workers in popcorn facilities were coming down with this very specific lung disease and it was attributed to the butter flavoring, which is fine to eat– So, this is another principle

of "toxicology is exposure" root. So, it was fine to eat but to inhale was a huge problem that resulted in this really bad lung disease. And so, there have been cases of diacetyl being in vape juices, butter-flavored vapes. There's also a cinnamon flavor called cinnamaldehyde which is of concern for a very similar reason. And so, I would be very, very careful with vaping and I do not condone breathing anything other than air.

Alie: This might change my, "light some incense right as I sit down to work" habit.

Kim: Yeah and of course that's an individual risk thing. I have asthma so I wouldn't do it.

Aside: So, in a 2021 study titled, "The Adverse Impact of Incense Smoke on Human Health: From Mechanisms to Implications," my heart was broken. As researchers reveal a shitshow of health problems that can come from habitual incense burning including lung disease, eye issues, throat irritation, lead poisoning, disrupted fetal development, dementia, heart disease, and cancer, all kinds of cancer. It also noted that burning a lot of incense is just comparable to secondhand smoking. So, there goes my hobby.

What about candles? Well, the wicks may contain lead and the soot is bad for your lungs and for your house but if you're burning paraffin candles, those are made from byproducts of the petroleum processing industry. And one 2013 Polish study concluded that sitting next to a burning paraffin candle is like being adjacent to a combustion engine. So, I guess we've got to slow our rolls on the candles, maybe open a window at least, look into an air purifier. Try to find joy in something else, as impossible as that sounds. And yes, I am as sad as you are.

But listen to the 2022 recap I did around New Year's, maybe get an LED lantern on your desk, we talk about those. It's visually pleasing, I use it as a productivity tool. LED lanterns: they flicker, they're worth it.

What else can we do in the future? Patrons Rachel Gentile, Timothy Hwang, Noel Dietz, Chris Brewer, Jennifer Piacente, Curly Fry, Buhbrie, and Isabel all asked about environmental toxicological prevention.

Alie: What about, for the future, what are some things that people can do to keep themselves safe in general from environmental toxins? What should they worry about, what shouldn't they worry about?

Kim: Well, I guess it's kind of my duty to say don't smoke. Don't smoke, don't vape. But a lot of our chemical messaging is very individualized and the chemical regulation in the United States puts the burden of proof on communities and individuals to bring these issues to attention. So, precautionary regulation, especially of new and emerging chemicals is really important and we really need to reassess whether or not we should give companies free rein to put these chemicals into the environment.

But on an individual level, I really recommend checking out the Green Science Policy Institute's consumer resources.

Aside: So, a wonderful site for the cautious consumer, this Green Science Policy Institute's site. It warns against furniture manufactured before 2015 because it may contain added flame retardants; older immersion blenders because they may leak chlorinated paraffins, which is a type of chemical found in flame retardants; they advise to look for fragrance-free personal care products since the ingredients "fragrance," or "perfume" or "parfum" often mean phthalates are present. And I was like, what's a phthalate? I don't even know. Those have been linked to testosterone disruption and liver toxicity.

And we mentioned this in the Melaninology episode last week but be careful too with imported skin-lightening or anti-aging creams unless you're certain that they don't have mercury in them. You can avoid food that comes in contact with grease-proof packaging, because that may have PFAS like microwave popcorn and some fast foods. This fact makes me very sad and also hungry. To avoid PFAS you can use cast iron, glass, or ceramic cookware rather than nonstick Teflon. And so, for the patrons who asked about PFAS, you're welcome, Kathryn Brignac, Annalise De Young, Emily Stauffer, Boreal Becca, Rob Hover, Marijke Decuir, and Wells Howe.

Kim: I use their PFAS guide to pick out new outdoor equipment. So I got a new rain jacket, and I used their little tool to figure out which one was PFAS-free.

Alie: Oh good!

Kim: Other than that, I want to emphasize that just because a chemical is associated with adverse health outcomes in one particular setting, doesn't mean that we need to be really, really afraid of it. Or, on the other hand, just because there's no evidence available that something is dangerous, we shouldn't assume that it's safe. So, it's really important to consider that nuance.

I think paying attention to exposure root is important and I think that the Tide Pod Challenge actually exemplifies that. So again, kind of similar to diacetyl, laundry soap, unless you're allergic to some of the ingredients, it's usually pretty okay to get on your skin, you can wash it off, your skin has a whole bunch of defenses that protect the insides of your body, just like your lungs do and your GI tract all have different defenses. And so, getting it on your skin, no big deal. However, you don't want to eat it. You don't want to eat it because your GI tract has totally different defenses compared to your skin and your respiratory system. So, it's really important to consider what the chemical is and the exposure root.

Alie: Good advice from Dr. Garrett. And what about the hardest thing about your job, the hardest thing about being an environmental toxicologist?

Kim: I honestly think it's the amount of flimflam that's everywhere. [*Alie laughs*] You know, I think there's so much misinformation and it's easy to be very scared about chemicals. There's a lot of examples of very terrible things happening after people are exposed.

Alie: What about the best thing?

Kim: Oh, the best thing I think is to get to solve complicated puzzles and also help people understand what is going on around them, and how their body interacts with the environment, and how we're not so separate from the environment, as we'd like to think.

Alie: Is that… Behind you, is that a periodic table?

Kim: Yes. I have that, I have an estradiol molecule, and yeah...

Alie: I love the notion that you like to solve puzzles when the periodic table is just kind of one assembled puzzle as it is, right?

Kim: Yeah, absolutely. Yeah, it took a lot of problem solving to figure out where each molecule goes, or each atom goes.

Alie: Do you think you'll ever get a periodic table tattoo? Any elements you would get tattooed on you?

Kim: It's so hard to pick. I don't think I have a favorite element. I also have equilibrium arrows so I feel like I maybe shouldn't get more chemistry and toxicology tattoos, [*Alie laughs*] but you know.

Alie: Did you have to search for any kind of nontoxic ink for that? Or were you like, "That's fine."?

Kim: No, I was just like, "I'm accepting this risk." [*both laugh*] I definitely have the little thought each time I put on lipstick I'm like, "There's probably lead in here." But you know, you can have a little lipstick as a treat. [*laughs*] Though lead exposure is one where there is no safe dose. So, you can't just have a little lead as a treat.

Alie: Dang it!

Kim: I don't want anyone to think that I'm advocating for that.

> **Aside:** And yes, apparently there is lead in a lot of lipsticks. But you can go to the FDA site which I'll link on my website, and you can see which lipsticks and which shade have the highest amount of lead. And topping the charts from an FDA study was Maybelline's Color Sensational shade 125 in Pink Petal. I'm going to look that up right now and tell you what it looks like... A wonderful pinky nude shade, versatile, anyone could wear this as long as they don't mind 7.19 parts per million of lead. L'Oréal owns Maybelline and they had some of the highest rates of lead on there. But it's not just the drugstore goodies either. NARS also clocked in with a few high ones. But even Burt's Bees lip shimmer has some lead in it. So, do some research.
>
> The FDA says it should be safe at the levels they're at, anything under 10 parts per million should be safe, but also remember that the world is imperfect in so many ways and our generation and your children have a lot of survival bonuses that our ancestors couldn't ever dream of. Like, for the most part, plumbing, and walls, doors, soap, antibiotics, dating apps. So, at the end of the day, people you will never meet are working hard to keep you safer among some environmental toxins we're learning about. So, thank you to all the ologists listening for making the world a cleaner and safer place, including Kim.

Alie: Oh my gosh, this has been such a joy. I'm so lucky that you answered our bat signal. [*laughs*]

Kim: Oh, thank you, I hope that the things that I said make sense. [*laughs*]

So, take calculated risks, ask smart people not-smart questions, and keep your eye on the sky Ohio, and everywhere. You can follow Dr. Kimberly Garrett on social media at the links in the show notes. As well as the charity of her choosing, GASP. We are @Ologies on Twitter and Instagram, I'm @AlieWard on both. I'm @Alie_Ologies on TikTok, you can say hello.

Smologies are shorter, kid-friendly versions of *Ologies*, they are cleaned up of my filth. Those are up at AlieWard.com/Smologies, that's linked in the show notes. Erin Talbert admins the *Ologies* Podcast Facebook group with assists from Shannon Feltus and Boni Dutch. Noel Dilworth does the scheduling; Susan Hale handles the merch and they both do so much more. Emily White of The Wordary makes professional transcripts which are up for free at AlieWard.com/Ologies-Extras; that's linked in the show notes alongside bleeped episodes. Kelly R. Dwyer works on the website and assistant editing was done by Jarrett Sleeper of Mindjam Media with *Smologies.* And lead editing done by Mercedes Maitland of Maitland Audio which is linked in the show notes. I accidentally just texted, "I love you," to Mercedes on a group thread with Jarrett, but I meant it honestly for both of them. Nick Thorburn did the theme music.

And if you stick around until the end of the episode, you know I tell you a secret. This week, it's one of my favorite places in the world is a willow structure in the gardens of the Natural History Museum in LA. It's been there for almost a decade; it was made by an LA artist named David Lovejoy. And it's just a beautiful little willow home, just sitting in the garden, you go in there and it's

like a dark little nest of twigs. And it had to be rebuilt once before and I got to go help David rebuild it. And when Jarrett and I got engaged, the NHM let us take photos in the museum as well as in the willow hut, which was magical. And not to be too sad, but my dad also knew that I loved the willow hut, and he was making me a small model version out of some willow branches that grew at the edge of the river my parents lived on back in 2020 but then he got sick, and he never got to finish it. And that little model my dad was working on is at my sister's house and my summer project this year is to finish it up.

But I got an email from the NHM a few weeks ago saying that the willow structure was to be dismantled and removed but they knew there how much I loved it, so they saved me a branch. So big thanks to Diana Saldana at the Natural History Museum of LA County for letting me know and for saving me a twig from it. SarahMackAttack McAnulty was visiting LA and visited the museum and brought this branch back to my house. So, this willow twig is not mounted on my wall, and I stare up at it wistfully every day. For more photos of the willow hut, you can go to Instagram and look up the hashtag #WillowHutWednesdays and you can see it in all of its glory when it existed. So, I hope you get to cozy up in whatever your favorite place is, it's nice to have a favorite place, even if it's just in your mind. [*sighs*] Okay, berbye.

Transcribed by Aveline Malek at TheWordary.com

Links to things we discussed:

Visit Dr. Kimberly K. Garrett's website and follow her on Twitter

A donation went to Group Against Smog & Pollution (GASP)

Follow GASP on Twitter

History of Toxicology

Her Twitter thread

History of Taxol or Paclitaxel

Paracelsus history

The Origins of EPA

Rachel Carlson's 1962 book, "Silent Spring"

Donora Smog event of 1948

Deadly Donora smog via Smithsonian

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Breaking Bad Pilot: Phosphine Gas Caper

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Phthalates on Wiki

NIH's info on Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

The Adverse Impact of Incense Smoke on Human Health: From Mechanisms to Implications

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Lead in lipsticks – FDA report

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Meteorology (WEATHER & CLIMATE)

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Secrets, Advice + AMA (LANTERNS, ETC.)

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