Getting Curious with Jonathan Van Ness & Marsha K. Allen

JVN [00:00:00] Welcome to Getting Curious. I am Jonathan Van Ness and every week I sit down for a gorgeous conversation with a brilliant expert to learn all about something that makes me curious. And today's episode is so good. We are joined by Marsha Allen, where I ask her: How important is groundwater? Everyone, you may remember in our first season of Getting Curious for Netflix, we filmed an episode about skyscrapers. It was then that I became obsessed with what was going on, like, under New York City, like, the bedrocks, the waterways. So today, at long last, we're going deep on everything just below the street level. So welcome to the show, Dr. Marsha K. Allen, who is an Assistant Professor of Earth Science at Mount Holyoke College. She specializes in the field of hydrogeology—how cool, right?—and specifically fractured rock aquifers. And she conducts her work on the island of Tobago. Welcome, Dr. Marsha K. Allen, how are you?

MARSHA K. ALLEN [00:00:56] Oh, my God. I'm so excited to be on your show, Jonathan! Ah!

JVN [00:01:01] Y'all. I really wish that this was an episode of the TV show, though, speaking of, because the glasses that Marsha is rocking today, so chic. It's giving 50s in 2022.

MARSHA K. ALLEN [00:01:12] Yes!

JVN [00:01:13] And the texture on your beautiful hair with these white headphones. You guys, we typically don't post, like, shots from the podcast, but we may need to take a screenshot today because the look is looking, it's serving. You look amazing.

MARSHA K. ALLEN [00:01:25] Oh, thank you!

JVN [00:01:26] And also I know that beauty pageants can be controversial. I get it. However! 1998, Miss Universe, she is from Trinidad and Tobago. I will never forget watching that year, Miss Universe. It was the year of the Nagano Olympics. Michelle Kwan, honey, she had just won silver. This was a big year for us.

MARSHA K. ALLEN [00:01:47] Yes!

JVN [00:01:48] Miss Trinidad and Tobago was the most stunning, fierce ass Miss Fucking Universe. She literally took my breath away. My mom and I used to make little, like, pre-scorecards, like, we were really into it. And the second I saw her, I was, like, "This is a wrap because she's going to win." And she did. Wendy Marcelle Fitzwilliam.

MARSHA K. ALLEN [00:02:09] Wendy! Wendy is life. And I just love her elegance, her grace. And she's actually brilliant. She's a lawyer. She did so much for—as me, as a young Black woman growing up at that time, oh my goodness. Ah! She was so radiant and I just wanted a piece of that.

JVN [00:02:26] Oh, my God. Okay, but we're going to focus, like, I'm sorry I freaked out. I just, I had to get out of my system, and now I'm so ready to talk about the, like, Earth. So let's start with the inside out. Like, what's the structure of Earth? Like, what are the basic layers?

MARSHA K. ALLEN [00:02:39] Let's talk about our solar system first. Imagine this huge cloud of plasma and dust and it starts to swirl, collapse because of gravity, and then the sun—in the center it dances—the sun ignites. And that's how we got our sun. Then it got so hot it started melting all of the dust particles and other things that were in that cloud and the first rocks formed in our solar system. These rocks form at extremely high temperatures and high pressures. And they are called calcium aluminum inclusions. Fast forward, time passes. These rocks are creating other rocks in, you know, big interactions, become larger in size and then we have planets and so forth. Earth, now, over time it cooled. And because of density and gravity, the center of the Earth is core, dense material like metals, heavy metals. The mantle is in between the surface layer and the core. The lightest material is actually on the surface of the Earth, the crust. Think about the Earth as a ball of chocolate cake. The more you go towards the center, the richer it is in chocolate.

JVN [00:03:52] Oooh! I'm obsessed with that analogy. Oh, my God, it's giving me Matilda. It's giving me Bruce Bogtrotter. It's giving me fucking gorgeous cake. So we got our core, we got our mantle, which is like the Dr. Evil liquid hot magma. And then we got the crust.

MARSHA K. ALLEN [00:04:09] Yes. The core is super hot, too, but the mantle, it's pliable. It's, like, semi-solid, semi-liquid. And that's why we can have the plates on top move on top of them.

JVN [00:04:20] Oh, yes! I love that.

MARSHA K. ALLEN [00:04:22] There's so much pressure in there, you know, the temperature, as we increase towards the center, it's going to get hotter.

JVN [00:04:29] The layer that you study is the crust?

MARSHA K. ALLEN [00:04:31] The crust, yeah.

JVN [00:04:32] So, do we walk on the crust?

MARSHA K. ALLEN [00:04:35] Yeah, you'd be walking on the crust. [JVN BANGS TABLE]

JVN [00:04:38] So it's just right the fuck there, like, that top layer is just the crust. Like we are on it!

MARSHA K. ALLEN [00:04:43] Unless you're in Manhattan and you know, you have buildings, you have subways. But beneath that it's solid rock and yeah, it's Earth!

JVN [00:04:52] So as a hydrogeologist, you're really giving, like, rock, paper, scissors, trio, but of groundwater, soil, and rocks. Like, there's the groundwater, there's the soil, and there's the rock. Is there other stuff?

MARSHA K. ALLEN [00:05:04] So the first thing you should know is that any medium underground that can store or transmit groundwater is called an aquifer.

JVN [00:05:10] Ah!

MARSHA K. ALLEN [00:05:11] So hydrogeology is what's happening underground with different types of aquifer systems. And so you can have a big deposit of sand that can hold water, you can have gravel. But then we have these very, very complicated ones that are in solid rock. So for example, picture a huge mountain of granite, and this granite has huge fractures and it has really good potable drinking water in it. We call them fractured rock aquifers. So they are basically an untapped source of drinking water. And we are trying to answer all of the unknown questions about how they function, especially now with climate change happening.

JVN [00:05:55] Ah! Because climate change, it just affects everything.

MARSHA K. ALLEN [00:05:58] And it's a lot of chemistry. So I use chemistry to figure out how old groundwater is, what direction it's flowing underground because we can't see in these fractured rock aquifers. I also try to figure out when we're pumping, how, how connected is that aquifer to other areas or locations? Does it go beyond the regular catchment size or is something else happening underground that it's sourcing water from far away through these fractures? And then finally, I take all of that data over from those chemical analyses. I use data from climate scientists like climate precipitation projections, and I input it in three-dimensional models to predict the change in charge or storage in the aquifer system.

JVN [00:06:49] Okay. Obsessed. So basically you're taking, like, data from other scientists and then you take that from what you know about your background in geology and you're fusing that with, like, groundwater, soil, and, like, other, like, materials that can transmit water because really anything that can transmit water underground is considered an aquifer.

MARSHA K. ALLEN [00:07:09] Yes, yes. Any medium that can store or transfer water.

JVN [00:07:14] Okay. So how do we get our water now?

MARSHA K. ALLEN [00:07:17] It's all dependent on where you are in the world. So for example, Tobago, it's a very tiny island. It doesn't have surface reservoirs, lakes and so forth. So it's predominantly using groundwater to provide for all of the residents and businesses. This is government-controlled and they do all the repairs, maintenance, the pumping schedule, and so forth. So some people in America, I know for a fact they have their own well in their backyards.

JVN [00:07:49] Yeah.

MARSHA K. ALLEN [00:07:50] Because there's no, like, local situation where they can actually, you know, get water from the town and so forth. So they have their own personal wells. So it's all dependent on, on where you live and what's, what's available.

JVN [00:08:04] If you were to, like, do a cross-section of, like, Manhattan or, like, a place with a subway, there's, like, the ground that we walk on and then, like, where is the groundwater in relationship to, like, subways? Is it below us? Is it all around us? Is it above us? Like, what's a cross-section of a goddamn city with a fucking subway?

MARSHA K. ALLEN [00:08:26] I lived in New York City for a long time. I actually go often. So as far as I know, New York gets its water from the Catskills upstate, very pure water. New York has good water, good drinking water.

JVN [00:08:39] Yeah, good ass water.

MARSHA K. ALLEN [00:08:40] [LAUGHS] So I'm pretty sure the water is coming through pipes.

JVN [00:08:44] So the pipes are just, like, underground?

MARSHA K. ALLEN [00:08:47] Yes, and they come to your building. [JVN HUFFS] Don't look so disappointed. Do you want to have a well?

JVN [00:08:53] On that episode of Getting Curious on skyscrapers, I got to see, like, these, like, cool places that, like, not everybody, like, gets to walk to, like, down there and there's, like, all these different pipes. But I guess I just assumed some of those are electric, but some of those were carrying water?

MARSHA K. ALLEN [00:09:06] There are many pipes underground. Some take in sewage, some take in water, some have electrical wires. I think this might be a whole new episode.

JVN [00:09:15] Holy shit. Okay, yeah.

MARSHA K. ALLEN [00:09:16] Because I want to know!

JVN [00:09:18] So when it comes to groundwater supply.

MARSHA K. ALLEN [00:09:20] Mhm.

JVN [00:09:21] In a place like Tobago, where do we find groundwater most often? Or does it really just vary?

MARSHA K. ALLEN [00:09:26] So first thing you need to know is as precipitation falls from the sky and it hits our land surface, once it can penetrate, some of it is going to penetrate into the soil, then into the aquifer. Some of that precipitation is going to run off on the surface of the Earth following the gradient of the hill on the lands, it's going to go from high to low because of gravity, and it may flow into rivers and so forth. And then we also have water leaving through evaporation and evapotranspiration from plants.

JVN [00:09:59] Ooh.

MARSHA K. ALLEN [00:10:00] Any particular land mass except for deserts, some places just have minimal water. But let's just take New England for example. The water table is the level of the water underground from where we stand. It's normally a couple feet underground.

JVN [00:10:16] Okay. Fuck me. I'm so sorry. I'm obsessed. Water table. Everywhere has a water table? Except for, like, deserts? Or just, like, if there's just, like, not very much groundwater, it might be, like, super, super deep or just, like, almost nonexistent?

MARSHA K. ALLEN [00:10:28] Yes, yes, yes. So it's really based on what's happening underground with the geology, what's happening with the climate. And this is why you have to study every single region with water issues or who's trying to make water plans to see what's happening. And you have to plan based on what situation you're presented with. Does that make sense?

JVN [00:10:47] Yes. So basically, like, the water falls and then it either, like, flows to the ocean or it flows to, like, a river or a lake, if it's, like, downhill from that. Some of it absorbs, like, into the plants in the soil. But then it's, like, whatever is left over and does not flow into, like, a river or a lake and doesn't get absorbed by soil. That's, like, the water table. And that's kind of always, like, just a few feet typically below the ground.

MARSHA K. ALLEN [00:11:10] Yes.

JVN [00:11:12] And then so does that mean that, like, seasonality would affect it because, like, especially, like, a New England place, like, when, like, the snow is melting like in springtime, like, does it kind of raise?

MARSHA K. ALLEN [00:11:21] That's right, yes. Yes. You get it. That's, that's it right there. Now, the funny thing is, that's New England. But in Tobago, because it's all fractured rock aquifers. My advisor Dr. David Boutt, when he studied my research, he found that the island is losing over 60% of its fresh water through these fractures underground. And it's going straight into the ocean and the ground. And it was verified by fishermen who said, "Out in the ocean, there's pods of, like, freshwater." And they know that because of the type of, you know, fish and so forth living in it. This is why it's so important to do local studies. Based on what's happening, you can figure out what the issue is and how to adapt our methods to rectify it. So losing 60% of potable water is a lot of water to lose, especially in a drought.

JVN [00:12:11] Okay. You also just had a word for the second time that I was, like, obsessed the first time, and I was trying to act, like, fierce, like I know stuff, but "potable water"?

MARSHA K. ALLEN [00:12:21] Potable water just means drinking water. We can drink it.

JVN [00:12:24] Okay. I'm obsessed. Okay. And how does seasonal changes affect groundwater in Tobago?

MARSHA K. ALLEN [00:12:31] So both Trinidad and Tobago have a tropical climate. So for, like, six months of the year it's super dry and then the other half is super wet. And the rainy season is really, really important because during that period of time is when we get our recharge, which is supposed to, like, last us through the entire year.

JVN [00:12:55] I think what we haven't really laid bare yet is that, like, there's, like, a water shortage, like, currently or, like, we see one in the future looming for Tobago?

MARSHA K. ALLEN [00:13:04] Well, we had the most recent really bad drought was called the Pan Caribbean drought, and it affected all of the islands, even certain parts of South America. When you say you have a drought that affects the daily lives of people, children not being able to go to school or farmers not having enough water. We should be concerned because we need to figure out, why is it happening? How can we fix it? And the last drought we had was pretty serious. Based on climate change projections, the regions that are getting drier now are projected to be much drier in the future. And the other regions in the world where we project that's going to get wetter, they're going to have a lot more rain and more flooding and so forth. So that's the thing about climate change, it's just not all about drying. There's also wetting happening too. So we'll have these extreme floods and so forth. So that's why I'm worried. We need to move faster on understanding our aquifer systems and know how to budget and use it sustainably and also use it as a mechanism to plan for the future.

JVN [00:14:16] And especially when you think about, like, just, like, what you just said, like, livelihoods, farming, schools, like, you can kind of figure out, like, how much water someone would need through, like, years of observation. So this is really necessary to figure out, like, how people can move forward in the presence of drought or, like, the opposite of, like, drought, which is like, you know, too much water. So it's important to figure out, like, how this works. So then, like, does that ocean in Tobago need, like, that water? Like, because if you try to harvest that 60%, could that fuck up the fresh fish that, like, go there? Or is that part of the controversy? Like, do some people want to figure out, like, how to harvest that, but then other people are like, "No, you can't, like, mess up what it's doing down there" or whatever?

MARSHA K. ALLEN [00:14:59] But that's the purpose of groundwater modeling. If it is, we have all of these measurements and chemistry results. We can model systems so that we can take water sustainably without causing harm. And that's, that's why my research is so

important, how to use it sustainably, how can we all benefit from it and not mess the Earth up more. We need water every day, and we use water so much. I don't think we consciously realize how much potable water we waste. I feel in the future, we're going to have to do a lot more recycling of our used water and just save the potable water for drinking. And that's the direction I think we're going in if this continual drying and droughts continue to happen at such intensities.

JVN [00:15:55] So, like, sinkholes. What the fuck? [MARSHA LAUGHS] Is that just, like, there's so much rain? It's, like, the opposite of drying out? Like, there's so much rain or something, and, like, the groundwater table gets so high that everything's just kind of, like, getting a little soggy and then it collapses, or is that totally not what it is?

MARSHA K. ALLEN [00:16:12] Now we're going to go into some geology, Jonathan.

JVN [00:16:14] Yay!

MARSHA K. ALLEN [00:16:15] So you see a lot of sinkholes—

JVN [00:16:18] Florida!

MARSHA K. ALLEN [00:16:19] Yeah. So Florida, certain parts of Florida have underground karst systems, which means limestone rocks. The thing about limestone, you know, it, it can dissolve in water. And if it is, you have a ton of water underground washing through this deposit, it's gonna be hollow after some point in time. And that hollow hole beneath your house will cause instability. And at some point in time, things disappear in that hole.

JVN [00:16:52] Mmm. Scary.

MARSHA K. ALLEN [00:16:55] So you need to know where you're building your house, what type of rocks you're on. You know, buying a home is a very big investment but people don't realize you need to check the geology.

JVN [00:17:07] Shit, fuck, oh my god I just moved. How do I find that out? My house is in Texas. Oh, my God. Okay. I'm just texting my husband really fast. "Must check, must check geology," texting.

MARSHA K. ALLEN [00:17:19] One more thing. Also, check to see the flooding history. There are maps on there that you can find.

JVN [00:17:24] Oh, fuck. Shit. Oh, my God. So you guys, do that before you sign the dotted line. You know what I'm saying? Do that beforehand, you guys. That's really good advice, Marsha. That's, like, really, really good advice. So you also mentioned something earlier that's, like, really fascinating, and I guess I just didn't realize. You said that you can, like, date water. So, like, water has an age?

MARSHA K. ALLEN [00:17:43] Okay. So yes, technically. We call it the apparent age of groundwater. And what it is, is when you take a sample from a well, that sample is actually a mixture of multiple precipitation events dripping in through the rocks over time. We use something called environmental tracers. I particularly use two. One is called sulfur hexafluoride. It's an inert gas. They use it for making metal products. And that's how it gets into the atmosphere. Now, sulfur hexafluoride has been in the atmosphere since the 1950s and a few organizations actually measure the sulfur hexafluoride in the atmosphere so we know how much it is in the atmosphere each year.

JVN [00:18:32] Okay wait. Why has it only been since the fifties? Like, was that the result of some scary, like, fossil fuel burning or some, like, 1950s fucked up fuckery?

MARSHA K. ALLEN [00:18:43] I think they just decided to check it, but what happened in the 1950s was nuclear testing. So I think you're talking about that.

JVN [00:18:49] Oh!

MARSHA K. ALLEN [00:18:50] Yes, I use that too. That's called tritium.

JVN [00:18:54] So you use, like, the sulfur hexafluoride. And it's not necessarily that it started in the fifties, it's just when we started testing for it. So maybe it did exist beforehand?

MARSHA K. ALLEN [00:19:03] Yes, yes. So yes, it's actually very tiny amounts of sulfur hexafluoride is naturally occurring in the atmosphere from the weathering of the mineral fluoride. So it can happen naturally in very minute amounts, but the majority is from industrial processes.

JVN [00:19:20] Okay. So it is, like, mostly a manmade thing?

MARSHA K. ALLEN [00:19:23] Yeah. Yeah.

JVN [00:19:24] Got it.

MARSHA K. ALLEN [00:19:25] So they started measuring it in the fifties. So every year we have a number that represents that year, how much was in the atmosphere. And we also found the trend since then that it increases by 7% each year. So when I get a sample of groundwater and we check for sulfur hexafluoride, based on the amount that's in the water, we can backtrack and see which year it probably fell into that aquifer and has been there.

JVN [00:19:54] That's so fucking interesting. So what's—, is the other one that you use to measure that nuclear one?

MARSHA K. ALLEN [00:20:01] The nuclear one is more drama. Tritium? She's just all drama. It has three different versions of hydrogen, one, two and three. The third one,

which is called tritium, is radioactive. And what that means is every 12.32 years, she just changes into helium three.

JVN [00:20:20] Mmm.

MARSHA K. ALLEN [00:20:21] And the beauty about that is, if I get a sample of water from the well, and I test. I get the amount of tritium and helium. The ratio between that can tell us how many times helium was produced. And we know each event is 12 years. So it gives us an average, like, an average apparent age of the groundwater. So, for example in Trinidad and Tobago. Tobago, normally small islands, are supposed to have very young water. It's supposed to be, like, less than 25 years. The oldest water I found was 60 plus years and 60 being the minimum amount. So it can be 100 or 1000 years old. But all of the groundwater in the north is, is younger. It's 20 to 25 years.

JVN [00:21:11] Okay. So you just said that the minimum was sixty years, but it could have been, like, even way older. Why is there, like, such a variance?

MARSHA K. ALLEN [00:21:17] Because each environmental tracer can only give us a certain age range. So the cheapest method is, thus far, is stuff like sulfur hexafluoride and tritium. And then after that, for example, that sample, that particular well, it has the 60 year old plus water. Now we know it has old water. We take that and use another method of age dating to get up all age.

JVN [00:21:44] Oh. So it's at least 60, but it could be more. Like, we use things like tests for, like, that third sample. Okay. That makes sense. I'm obsessed.

MARSHA K. ALLEN [00:21:50] Yes, yes.

JVN [00:21:51] So then is that the whole—like every 12 years—-when it goes from the tritium to the helium? Is that, like, the half-life thing when they talk about like, "Oh, like, this has a half-life of whatever?"

MARSHA K. ALLEN [00:21:04] Yes. Helium three is the daughter isotope of hydrogen three.

JVN [00:22:09] Do we know or do we have any predictions for how long that's going to be in our water, like, period? Like, is there going to be, like, hundreds and hundreds of years that we're going to be able to measure that? Or is it almost gone?

MARSHA K. ALLEN [00:22:18] Well, this is the thing: we started testing using this method after nuclear testing and there was a lot of tritium in the atmosphere after that testing in the fifties. Based on the historical numbers I've seen thus far, we're getting very close to whatever the tritium was in the atmosphere, pre-atomic bomb testing. So it's quite possible you might be able to figure out another way to use tritium since most of those tritium that formed in the fifties has now decayed away, over time. But yeah, innovation, we can figure out how to do it.

So the beauty about what I do is if you need to figure out what's happening with your local groundwater supply, we could apply these exact same methods to figure out water quality. We can figure out the age of the water. How far out of the catchment is it sourcing water from? Residence time, how long does that water normally stay underground? And then from that data, we could do those models and come up with relatively decent pumping schedules based on what we have in storage and manage that sustainably.

JVN [00:23:28] Okay. I'm obsessed with that. Okay, so then let's talk about Tobago. So, I think we've learned what a fractured bedrock aquifer is.

MARSHA K. ALLEN [00:23:39] We missed a very big part.

JVN [00:23:41] Welcome, class. This is what a literal fractured bedrock aquifer is.

MARSHA K. ALLEN [00:24:45] So, what people don't know is that rocks and minerals are very special. And when we have precipitation that trickles in through that soil layer, there's a layer that's between the soil and the un-fractured bedrock. Layer between the soil and a fractured bedrock, that's called saprolites. So first you have soil, then you have saprolites, then you have fractured aquifer bedrock. And then you have un-fractured bedrock at the bottom of it. Now, the beautiful thing about minerals and water when they get together in aquifers is that the water starts to equilibrate with the rock type and the mineral type, and it starts to reflect the chemistry of that rock. [JVN EXHALES] Yes. So we can use those signals to track the mixing of different types of rock water as it flows through an aquifer system. So it can show you which waters are more probably contaminated or potentially can be contaminated with seawater. It can tell you what direction flow is coming, especially from regions with high elevations. We can calculate the distance and time traveled for that water droplet that came on atop that mountain to the well far south. And these are all methods that already exist. What I try to do is use existing methods to find the answers to the current unknowns. So these are all methods that already exist, and we're using it to solve these questions. [PAPER SHUFFLING]

JVN [00:25:25] Okay. So I just drew this little picture.

MARSHA K. ALLEN [00:25:27] Okay.

JVN [00:25:28] So basically you have, like, soil up here. And then you have this, like, little layer of, like, sac…. Yeah, that, that s-word.

MARSHA K. ALLEN [00:26:36] Saprolite.

JVN [00:26:38] Okay, and then you have, like, the fractured aquifer bedrock, and then you have like the un-fractured one.

MARSHA K. ALLEN [00:25:42] That's it! That's it! [CLAPS]

JVN [00:25:43] Is every place, like, have varying thicknesses? Like are some places like a mile thick of saprolites and then, like, five miles of un-fractured, like, aquifer bedrock? Like, how thick are they?

MARSHA K. ALLEN [00:25:56] So what I can say for sure is based on your latitudinal position, your saprolite thickness changes. So here in New England, we have saprolites here, maybe three, four feet. But in the Caribbean, where you have all that rainfall, much more weathering, the saprolites could be maybe 8 to 10 feet. So it's all dependent on that specific location and that specific rock type you're looking at where it is. It's so different. Nothing is uniform underground. This is why there's so much work to be done.

JVN [00:26:29] And then is saprolites where you would find, like, diamonds and, like, sapphires and, like, emeralds and stuff, like, from all the special minerals, like, or like, is that, like, way deeper?

MARSHA K. ALLEN [00:26:40] Well, actually, you, you should come to visit me on campus sometime. I'll take you out to an outcrop where there are, like, garnets on the side of the streets. [LAUGHS]

JVN [00:26:48] There are?!

MARSHA K. ALLEN [00:27:49] Yes! You can have minerals just showing up in a regular rock. Yeah! *[A note from Marsha: Gemstones are rare minerals and rocks!]*

JVN [00:26:57] But are there minerals that live in the saprolite layer or no?

MARSHA K. ALLEN [00:27:01] Of course. Because remember, saprolite is a weathered rocks and all the rocks have minerals in them. But if it is you're talking about gemstones, I don't know which saprolites will have them.

JVN [00:27:10] Okay, so this is, like, a different episode of Getting Curious but that's how curiosity works. It just takes you different places. But it's because I was just in Australia and I was learning a lot about opals because there's all these, like, opal museums, [MARSHA GASPS] cause, like, opals are, like, maybe it's, like, black Australian opal. There's some kind of opal that's, like, only there. So that's where I came from. And I was learning that, like, it takes millions of years for an opal to form. So gemstones are probably, like, deeper, unless it fell off someone's finger, like, and then, like, got in the soil.

MARSHA K. ALLEN [00:27:37] I've heard of people going to locations that have gemstones and it's, like, they have land, they know they have really nice stones or quartz or whatever. If they know this area has gold or whatever mineral, you just go and pan and see if you can find something.

JVN [00:27:52] Where I'm from, like, it's, like, right near, like, Hannibal, Missouri, which is like, you know, it's like Mark Twain, Huckleberry Finn and like the caves and like you would go there on field trips when you were little and you would just like you would get to do

that in the fucking creek, like, with the little net thing on the bottom and, like, sift through the shit for, like, you guys, it's so fun. I need to do that. Okay.

MARSHA K. ALLEN [00:28:09] I want to do it, too!

JVN [00:28:10] It's fun! So basically going back to Tobago, the different ways that we're studying water from there, there's a lot of untapped potable water in these fractured aquifer bedrock. So in the research that you've done and what, like, the environmental tracer analysis, we've learned that, like, some of the water is, like, a lot older than what we had originally—*you* had originally guessed—I'm, like, "Jonathan, you're not a fucking groundwater researcher, okay? Like you did not know about this until 3 minutes ago, so let's not say 'we.' Okay, you know what I'm saying?" [MARSHA LAUGHS] So but, it's, like, *you* have [LAUGHS] you have found out that some of this is, like, a lot older than what we thought. So what are we finding so far, of, like, the state of the research that you're conducting in this state of the study?

MARSHA K. ALLEN [00:28:56] So what have I found thus far? I have found that there is a lot of interbasin flow happening on that tiny island. And what "interbasin flow" means is that these conduits, these fractures on the ground, are cross-cutting topographical boundaries and allowing water to transfer from one region of the island to the other. And because that is happening, some of the sub-catchments in the south of the island is producing 100 to 1000% more groundwater than the calculated recharge. So those conduits are bringing a ton of water from the, the sort of midcenter range of mountainous range in the island to the south. Imagine. Think about this, you have precipitation falling on a certain spot on the island and we can calculate how much the recharge is going to be. So let's say the recharge is 50. You're pumping water and you're realizing you can get 5000 gallons of water instead of what you calculated, 50.

JVN [00:30:08] So where's all that water coming from?

MARSHA K. ALLEN [00:30:10] That's what I figured out. The water is coming from the fractures, traveling long distance. The old age has just validated it because the longer the distance the water traveled, the older the water is going to be because time is passing. Tobago has a lot of water in the south, very good quality water. With reference to the wells that are in, you know, hard rocks like granites and basalt. Very good water quality. And then I also found that the wells that are located in the limestone and coral, they tend to have more seawater intrusion because remember I told you earlier, limestone can dissolve in water so that ocean water in contact with that limestone. And that limestone is also in contact with the freshwater. So we have freshwater that's now being mixed with the sea.

JVN [00:31:00] Brackishy.

MARSHA K. ALLEN [00:31:01] Brackish, yeah. We can't use those. So for that island, stay away from the limestone. Most of them are closed anyway, but it tells you, like, which wells are susceptible to seawater intrusion. And then finally, once we have an idea of the distance traveled, volume, and so forth, we can literally create pumping schedules. You

know, because remember, it's easy in Tobago because the government already have the wells and the distribution already done to the homes. So all we really need to know, right now, is how much in the aquifer, how can we use the water sustainably? How do we manage it in droughts? So, for example, in the drought where the wells that have very young water. It means that it's not staying there very long, it's being pumped out much faster. But what about tapping into those wells that are, you know, connected to that old water that's traveling all those years? So it might give you an idea which wells to tap into during severe droughts if you have to and so forth.

JVN [00:32:12] Yes, it really helps you with a sustainability plan.

MARSHA K. ALLEN [00:32:15] That's correct.

JVN [00:32:16] And so that's why this research is so important, because it's, like, it's not like you can just do that cross section of the ground, like, at any old time and be, like, "Oh, yup, there's the water. That's how much there is." Like, you need these projections and calculations to figure out how old the water is, to figure out, like, how long has it been there? So you can deduce, like, from all the different times that it rains, you're, like, "Okay, so with this much rain and we can say that this water has been here for, like, ten years or eight years or two years or 25 years, or however you can start to figure out, like, how much untapped water is there."

MARSHA K. ALLEN [00:33:47] The local water management companies are doing a good job. But I feel as if once I complete this study, they will have everything they need with reference to knowing how much is in storage, even if they get a significant amount of rainfall, how much do we estimate will be in storage? And we can calculate, you know, based on how much water each person on the island needs. We'll see if, if the storage amount is sufficient and it actually gives them even insight into planning their future. So, for example, desalination. If it is population growth , we know we can probably put in a plant that provides the extra water we need. But I also feel as if we have so much space for innovation. And I do feel as if some of that water that we're losing to the ocean we can still use some of it. So if we're probably looking into technology, into tapping into those spots in the ocean where fresh water is coming out of these conduits, maybe cutting water from those conduits, it might even be cheaper with reference to desalination costs because it's less salty. I love innovation. I feel as if to innovate, we have to have the foundation and we have the foundation, we have the science. We just need innovative ideas and funding to get them done and we can be okay. I'm worried about the future, but I think if we prepare, we'll be fine.

JVN [00:34:20] So, I mean, this is, like, really important to understand this, because I'm sure that Tobago isn't the only place that has untapped, like, potable groundwater and there's so many places that are struggling with drought. This is, like, really important science that can probably be replicated other places.

MARSHA K. ALLEN [00:34:36] Yeah. So my plan is to replicate this in Trinidad now because we have a huge fractured rock aquifer and move my way up the islands. Because first

things first, who would have thought tiny islands would have old waters? They always said, "No, we can't." We do. All because of fractured rock! They are amazing.

JVN [00:35:00] Okay, I'm obsessed. Okay, wait. I have another question that's kind of, it's not spelled out so far, but I just, I always go to doomsday. I think it's because of, like, life or something. So, you know how, like, water erodes rocks? Right? So if there is, like, fractured underground aquifers, like, is that ever going to make, like, places that have them a lot? Like, is that ever just going to collapse and we're, like, going to sink or something?

MARSHA K. ALLEN [00:35:29] Oh, no, no, no. Think about, you know, granite countertops. It's solid. You always want your house to be a house on a solid type of rock. You don't want limestone. You don't want gypsum. You don't want sand.

JVN [00:35:42] But, like, Tobago, like, that's mostly made of…?

MARSHA K. ALLEN [00:35:46] Hard, old, old rock.

JVN [00:35:49] So it'll be perfect. It's like a millions and millions of year thing. Like, so it's fine. We're fine, like New York, fine. Tobago's fine. Like we're all fine?

MARSHA K. ALLEN [00:35:56] Mm-mm. Ah, we are fine until… unless sea level rises.

JVN [00:36:02] Oh, geez. But as far as, like, collapsing into fractured aquifer bedrock?

MARSHA K. ALLEN [00:36:06] Oh no, we're good, we're good.

JVN [00:36:07] We're fine for that?

MARSHA K. ALLEN [00:36:08] We're fine, we're fine.

JVN [00:36:09] So we're not going to, like, have, like, a huge sinkhole because that's where my brain was going, as I was, like, "Is this underground water going to, like, erode our base?"

MARSHA K. ALLEN [00:36:15] Rocks like granite and basalt, these are hard rocks. They don't dissolve in water.

JVN [00:36:21] Ah, okay. Okay. I'm obsessed. Okay. Okay. So. Okay, and we talked about that. Okay. And then obviously, like, if it turns out that the groundwater is an untapped source of potable water, which it does seem like that's kind of happened in Tobago already, you're, like, "Okay, we're having this like interbasin water. Like, it's old. Like we just need to figure out, like, how to harvest it and, like, how to get to it." The impacts are, like, better planning, better urban planning, like, less vulnerability to drought, like, better crops, better, like, all the things that water would bring, which is just, like, better health, better public stuff, like just better everything, right? Yes.

MARSHA K. ALLEN [00:36:57] Yes.

JVN [00:36:58] So were you just, like, minding your own business and you were just, like, a little baby girl and you were, like, in Tobago, and you were just, like, "I love rocks." Because now obviously you're a hydrogeologist, but, like, you said earlier that you, like, got into geology first. Like, when did you, like, become obsessed with geology?

MARSHA K. ALLEN [00:37:12] You know, I was thinking about this the other day, and I realized. My sister told me I always sat on the front step chewing rocks. [JVN LAUGHS] And she told me she asked why, and I wanted to taste them. So I have very clear memories of me being six just eating rocks. I can remember looking at, like, mica and schist, I was, like, "Ooh, shiny, let me see what you taste like." So it started there.

JVN [00:37:36] Okay. I also, like, was, like, always obsessed with collecting. Like figure skating, gymnastics, but then also, like, collecting stuff. Like I collected rocks, stamps, like I liked to collect stuff when I was little. And, like, I really feel you on that, like, a lot of times wanted to lick the rocks, not, like, eat it, but lick it. And I think it's because this one time I licked one that was, it was, like, salt. Like, it tasted like salt. It was like a salt rock or something?

MARSHA K. ALLEN [00:38:02] Yes, halite, yeah.

JVN [00:38:03] Yeah, I'm just saying, you're not alone. Like, it's, like, not weird. Like, I think a lot of us want to eat rocks when we were little. But it did start for you when you were young?

MARSHA K. ALLEN [00:38:10] Yeah, and my dad and I, we would always be outside in the garden. I was his mini me. I just have a love for growing food and rocks and plants from since I could walk. I think my memories is just me following him around.

JVN [00:38:24] And I have one more, other question for you just because I just think your story is, like, really cool. You had said that you, in college, you were majoring in…

MARSHA K. ALLEN [00:38:32] Economics.

JVN [00:38:33] Yes. And so, like, there's a lot there for, like, following your passion. I think, like, I had that at, like, that age where, like, I was in school for like political science, but really I wanted to be a hairdresser. And I need to be interested in what I'm learning about, or I just don't want to do it. But it takes the leap of faith to, like, do something that's, like, more passion driven. Were your parents, like, "Oh, maybe stick with economics," or what did that take for you to personally, like, switch and, like, what was that like?

MARSHA K. ALLEN [00:38:59] Can I tell you something? From the moment I was 16, my father told me to become a teacher. I had a mouth on me. I was, like, "No, I don't want to deal with anybody's kids." And he, every year since that, he was like, "You should teach," because I used to teach my little brother every single day and he's, like, "You should teach

and you get summers off." But I never really thought about teaching until I came to the U.S. and I realized, "Oh, this could actually be a job." "Oh, people become professors." I didn't even know what a Ph.D. was until three years living in America. I had a mentor, Dr. Peruji. One day I think she knew I wasn't happy with my major. And one day she asked me, "Why are you studying economics, Marsha?" And I was, like, "Dr. P., I want to make money. I want to take my family out of poverty. I need to make money." And then she looked at me. She was, like, "Now it's just, like, the only way to make money is to follow your passion. What is your passion?" And that was my first semester at Mount Holyoke, that conversation stuck with me. And I literally switched my major to Geology and minored in Economics. The faculty and staff at Mount Holyoke Geology/Geography Department were so supportive. It always felt like home. And it made learning about, you know, all of these intense topics so much easier because I really loved learning about it.

JVN [00:40:28] And now you're a literal Ph.D., fucking literal doctor teaching there, like, full circle realness. I love that part of the story.

MARSHA K. ALLEN [00:40:37] I have Freaky Friday moments where I will be walking, like, a couple of days ago I was walking on campus. It was raining out, I had my raincoat on, I had, like, a déja vu, but it couldn't be because maybe it was. I was like, "Oh, I remember walking and I had bought that jacket my first year at Mount Holyoke." So I still have my exact same rain jacket. And I was, like, "Oh my God, I'm back home with my jacket."

JVN [00:41:00] Aww! That's so cute!

MARSHA K. ALLEN [00:41:01] [LAUGHS] And I see them screaming and running and having a good time. I'm, like, "Oh, my gosh, I miss being able to have enough energy to scream and run at the same time."

JVN [00:41:12] I know, the other day I was just, like, doing something that wasn't that hard, and I was, like—, oh, I was at the airport! and I remember how my grandma would, like, sit down and, like, take a really deep breath, like, in the airport or whatever, just because it was, like, [JVN AND MARSHA SHARPLY EXHALE], "That was a lot." Like, I find myself doing that now. I'm, like, "Oh my god, I turned into my grandma!" Okay. So you have, you have personal ties to Tobago. Now you're working to prevent water shortages there. So, like, has your relationship to the island changed or, like, how does that feel as you've, like, learned more about it?

MARSHA K. ALLEN [00:41:40] I spent a lot of time in Tobago and in the forest with my friends, like, we were always doing something. You know, it has a beautiful natural forest with birds and very exotic creatures, coral reefs. So from a very young age, I was always, like, obsessed with Tobago. So much nature and life, and I'm really into nature. But then when I started to do the geology and the geology of the island, it just showed me how much more magical that place is. It's home. It's. It's exotic, it's beautiful. The people are so kind and warm. I feel very blessed to be able to give back to my island. I also feel extremely blessed that, you know, I grew up in a very poor area in Trinidad and Tobago and I'm so excited for other young people to see it doesn't matter if you come from the hood,

you know, your humble beginnings are good and they make you into who you are. So I will always be Trini to the bone.

JVN [00:42:52] Aww, well, you're amazing, I love you so much. Soit really is so cool that you did your studies at Mount Holyoke. From when you were a student there to now that you're a teacher, do you feel like there is more awareness and more urgency on climate change and environmentalism? Or does it just feel like Jennifer Lawrence in Don't Look Up, like, the whole time? Like people were panicking then and people are still panicking now and we're, like, not moving quickly enough because I know you mentioned earlier, like, we need to move faster. What's it, like, like, being, you know, on the, on the kind of the front academic lines?

MARSHA K. ALLEN [00:43:24] The spirit of Mount Holyoke is the same. Same energy. But in the ten years that I haven't been here, I've noticed something. I've noticed that this new generation of college students, they are fierce. And they are determined to fix problems. They are brilliant. And this is the first time in maybe ten, 15 years. I feel hopeful for the future and I feel for those we continue to support and help the youth, Earth and everything in it has a chance to be happy, loved, and prosperous. I really, really believe we have to focus on our young people right now. And that's my plan.

JVN [00:44:15] What values are you hoping to kind of instill in them?

MARSHA K. ALLEN [00:44:21] Mm, in general or just science wise?

JVN [00:44:25] Both.

MARSHA K. ALLEN [00:44:26] Oh. Okay. So. Value number one: be your authentic self. She might be a little extra. It's okay.

JVN [00:44:37] Just enough, I think.

MARSHA K. ALLEN [00:44:39] Just be yourself. And when you're yourself, your village will come. Your friends, the people that need to be in your life, they will show up. Hold on to that village, village of people throughout your journey. Secondly, life is short. Nothing is promised to us. Go for your dreams. Dream big and go for it. There's no reason you shouldn't do it. Actually, the more people told me, "I can't do this or I can't do that." I did it just for spit. People will underestimate you but don't underestimate yourself. Go for it. I want them to also enjoy being young. Because your youth goes so quickly. I feel as if if you don't experience the things you want to do in your youth, you always wonder what would have happened if you did that. So I want them to experience life and travel. Meet new people, try new things. I also want them to be gentle on themselves. We have had a really rough three years and, you know, the pandemic and everything else that's been happening in the world is, is really, really stressful. And I want my students to know that I am aware of that. And we need to be soft with each other while we heal from this.

JVN [00:46:12] Yeah, it's yes, yeah, it's beautiful. One of the aspects of your story that I just think is so beautiful and really amazing was that you pursued your passion for science. So what advice would you have for other people who want to pursue the sciences?

MARSHA K. ALLEN [00:46:25] First things first, make sure you choose a topic that you would always have your passion for. If everything else is going wrong in your life. You have to be excited to do your research. I think that's what kept me going. Secondly, have a mentor for every aspect of your life. You're not going to get a full mentor in one person. Have your mentor for, you know, your life goals, have a mentor for speaking training, about your research, multiple mentors about writing. I have about six or seven different mentors. And thirdly, don't be afraid or ashamed to ask people to, to be your mentor. A lot of students are functioning in fear. Do not function in fear. The worst you can get is a no. And guess what? Nos are not bad. You're going to get a yes someday from the right person. Right?

JVN [00:47:19] One of my mentors tells me that—because I, like, really struggled with rejection and it would cause me to have, like, really kind of intense, like, reactive self-destructive behavior. And once she taught me that, like, "Nos are actually just, like, feedback," it's just, like, research. Like, if you view your whole life as, like, research, "no" is just, like, feedback.It's not a reflection on you or, like, who you are. It's just research. And then you know how to make better choices, like, based off of the feedback or based off of your research but you don't have to, like, take that on as, like, a reflection of, like, who you are as a person, which, like, helped me a lot.

MARSHA K. ALLEN [00:47:55] Yes.

JVN [00:47:56] I love.

MARSHA K. ALLEN [00:47:57] And then finally I want all, even you, Jonathan, always take a moment to sit in nature. That's where you get most of your answers. Your gut speaks to best when you're in nature.

JVN [00:48:10] Ah! As I sit inside of a closet in Manhattan. So I'm obsessed with you. I feel like we learned so much. How can listeners learn more about groundwater near where they live? Like if we are just like fully bitten by our inner Erin Brockovich, like, groundwater bug or, like, Dr. Marsha groundwater bug, rather, how can people learn more?

MARSHA K. ALLEN [00:48:30] Okay. So you can literally just go to Google and type in, "Where does my sort of town receive its potable drinking water?" And normally you have three or four links telling you from your own region, where it's from, what's happening. If you want something in particular, you want to get your water sample analyzed and stuff. Most universities or colleges, we have people doing water science and you can send them a sample and so forth.

JVN [00:49:02] Interest. And then what about if, like, advocating for more sustainable water use speaks to you or, like, you want to know more about that? Like how can people advocate for more sustainable water use?

MARSHA K. ALLEN [00:49:13] Well, there are already some pretty powerful organizations that are currently advocating for the protection of water rights and sustainability. One of them is called the Waterkeeper Alliance Group. Another one is called Standing Rock Water Protectors Profile. Another Earth. There's a whole bunch of organizations protecting water rights and, and learning about the water in their regions.

JVN [00:49:43] Now, if like me, you've just, like, completely fallen in love with you over the last, like, hour and change. How can we follow you in your work? Like, where are you most active and what's next for you? Like, where can we keep up?

MARSHA K. ALLEN [00:49:55] So I'm active on Twitter @hydrogeotrini.

JVN [00:50:00] Yes!

MARSHA K. ALLEN [00:50:02] That's my handle, yeah. So I normally post, just really cool information about water or science. And then I recently started something. Well, so, let me just tell you about my class, Jonathan.

JVN [00:50:15] Tell me!

MARSHA K. ALLEN [00:50:15] I got the opportunity to create my own new classes, but one of my classes I decided to integrate art, an art component. So my poor students each have to do two pieces of art. And the art is going to reflect what's happening with our climate atmosphere. I wanted them to make it by hand: paint, drawing, poetry, crafting, and I decided to do it, too. I'm really big on diversity and inclusion, and I have this hope that I can have students try fieldwork on campus in a safe environment just so they can see if they like it or not. So I'm really excited about going into these new forms of teaching science where we can have science expressed in so many different ways.

JVN [00:51:10] I love that. If you could share with people that artwork on Twitter, I think people would really love to see that. So get on the Twitter. I just feel like there must be, like, a really cool, like hydrogeology, like, geology community on TikTok because there, like, a community for everything on TikTok. I feel like I want to see you, like, making video content on there. You're just, like, so charismatic and charming and I just, like, loved watching you. You're just, you really are just, like, really engaging. Like, I am just been so, like, this whole time I learned so much. So I just would love to see more of you. Maybe we're going to take a screenshot from this episode of Getting Curious and then you're going to simultaneously get, like, awarded a modeling contract because the academia, but, like, the modeling prowess at the same time. I mean, you're just giving me, like, angle, angle, angle, like, honey!

MARSHA K. ALLEN [00:51:55] Jonathan. I can't help it, my sisters, they made me extra. Oh, my God.

JVN [00:52:02] Look at these gloves.

MARSHA K. ALLEN [00:52:03] Yes!

JVN [00:56:04] She's giving us glam academic. I just love this girl so much I can't even stand it. But the gloves are really—, the glove, necklace, headphones, hair, combo, glasses, just all of it. The sensory game is just really like came to absolutely fucking slay is, like, coming for the jugular today. We're so grateful for you coming, Getting Curious. I learned so much. Thank you so much for your time.

MARSHA K. ALLEN [00:52:23] Thank you for having me.

JVN [00:52:24] You're the best!

MARSHA K. ALLEN [00:52:25] Please come and visit me.

JVN [00:52:27] We will! You've been listening to Getting Curious with me, Jonathan Van Ness. Our guest this week was Marsha Allen. You'll find links to her work and the episode description of whatever you're listening to the show on. Our theme music is Freak by Quiñ. Thank you so much to her for letting us use it. If you enjoyed our show, honey, please get on that Facebook. I mean, the Meta, honey, the Instagram, the TikTok, the YouTube. Let the folks know what you're listening to, what you're loving, and how they can listen. You can follow us on Instagram and Twitter at @curiouswithjvn. Our editor is Andrew Carson. Getting Curious is produced by me, Erica Getto, and Zahra Crim.