

Microbiology with Dr. Elaine Hsiao

Ologies Podcast

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Oh, haaay. It's that friend who never carries a purse, which must feel sooo liberating. But also, she always asks you to keep her lipstick in your purse, and you're like, "Well, okay. I mean, sure.", Alie Ward. Back with another episode of *Ologies*. Boy howdy, hot damn, y'all. This one is super exciting. This is like introducing someone to their future spouse. Like, you're about to not know what hit you.

Okay. First I'm gonna hit you with a thank you. Thank you to everyone on [Patreon.com/Ologies](https://www.patreon.com/Ologies) who supports the show so I can keep making it, and for submitting all of your excellent rapid-fire round questions to the Ologists. Also thank you to everyone tuning into to the new Netflix science show I'm on called *Brainchild*. It's really weird. It's really funny. You do not have to have kids to like it. Feel free to tweet about it using the hashtag #brainchild and hopefully we'll make another season. Let's just make a little noise.

Okay. Also, thank you Ologites for exchanging your money for merch at [OlogiesMerch.com](https://www.ologiesmerch.com), and for spreading the word. Thank you for \$0 support just telling your Instagram and Twitter friends or the lady who drives the ice cream truck about the podcast. Rating, reviewing, subscribing, keeps this thing up in the charts.

Every week, I read you a very piping hot tongue burner of a review. Fresh off the press. This week, PaintedNovis [phonetic] says:

This podcast is the cloaca of science facts. It's got a little bit of everything going on. I can't stop talking about trees and squid arms and the long, long, lifespan of sharks. I'm putting a solitary bee house in my yard and fighting to overcome my fear of snakes and legless lizards.

Thank you, PaintedNovis. I think a snake would love to have you as a friend, to be honest.

Okay. Microbiology. The workings of alive, tiny little things. You're about to get to know yourself in a way that will shatter how you think of yourself as a beast, and as a human. I'm so excited for all of us. Now, I had emailed this Ologist repeatedly. Creepily. Over and over for the better part of six months. I thought this would never happen. Honestly. I'd pretty much given up hope, until we finally found a time we could both sit down in her office on the UCLA campus, where she runs her own microbiology lab. Also in her office on a couch: a pillow in the shape of the poop emoji, but with hearts for eyes. True story. The Ologies Instagram has proof. Seek it out.

Okay, so this Ologist has authored so many papers about the inner drama and triumphs of the critters that live in our guts and ostensibly make us, us. And I'm in very unsubtle very, very obvious awe of her work. I was freaking out.

I was also very sweaty and frazzled. Because even though I got to campus half an hour early, the parking was a hellscape, and I walked into her lab 15 minutes late. Did you do the math on that? 'Cause that means it took me 45 minutes to park. You're correct. So that was mortifying.

But as you will soon discover, she is chill as hell. She wasn't even mad at me. So please pat your belly and let the trillions of tiny invisible friends who control your mind get ready to listen to gut biome expert and microbiologist Dr. Elaine Hsiao.

Alie: Once again, I'm sorry that I'm so sweaty.

Elaine: No! No problem!

Alie: I like to arrive moist to my interviews. Just dewey. And what is your title?

Elaine: It's Assistant Professor in Integrative Biology and Physiology. A lot of -ologies there.

Alie: I know! I was gonna say, do you think that you are a molecular biologist? A microbiologist? Physiologist? What would you call yourself?

Elaine: I am a crisis-ologist. I do many things. Our work touches on microbiology, but we also use molecular biology approaches, and it also touches on neurobiology.

Aside: Eh... We'll go with microbiology. We're just— We're going with microbiology.

Alie: You're like one of those D&D dice with all of those different facets. You're a 20-sided D&D dice. Pretty much.

Aside: Oh, man. That was too nerdy too soon.

Alie: When did you decide that biology was for you?

Elaine: I did choose a biology-related major, so I had to make the decision in high school. To be honest, at the time it wasn't that informed. I wasn't one of those kids that just loved science forever. Nobody in my family does science. I was really into other things like performing arts and music.

But I just thought that I had to choose something practical, and I'd just taken biology in high school, and I thought it was neat. So that's my little choice at that moment. Thankfully, it turned out well, so I stuck with it.

Alie: Now, you have your own lab, which means that you're the boss, which is pretty dope. What was it like... Do they have a ribbon-cutting ceremony, what happens when you get your own lab?

Elaine: There was no ribbon-cutting basically! You get faced with an empty space, and then you have your pot of money, and then you just go. And there's no instructions on how to set it up, so different labs will have different styles and different structures. So it's really up to you.

Alie: I mean, that's SO boss.

Elaine: It's fun! It's really fun.

Alie: Did you think when you started out in biology that you would go this far with it? Did you think that you'd be heading operations like this?

Elaine: No. No. Actually I first decided to enter grad school because I thought I really enjoyed teaching, and that's all I wanted to do. And in the first half of grad school I seriously considered dropping out. I was not doing well.

Afterward, things started rolling. I kind of got the hang of doing research and really got sucked in and I really love it now.

Alie: That's interesting that there was kind of a hump to get over, and then you were like, "Oh wow. I'm really good at this." You see people who are so successful in what they do, and you think, "Oh. It must've just been a straight path," y'know?

Elaine: And not at all for me. But what really kept me in it is that science is a lot of fun. There's a lot of room for creativity. You get to decide what you want to study and you get to decide on what the important questions are. And then you get to decide on how you're going to try to answer those questions, so I find that it's really fun.

Aside: Elaine studied microbiology during undergrad. And at that time the program's focus was really on the so-called 'bad bugs' that cause infectious disease. But then, she became fascinated by the somewhat neglected study of... for drama's sake, we'll just say, the good guys. The helpful bugs.

Elaine: I was just watching this new field develop where more of the focus now is on good bugs rather than bad guys. Bad ones turn out to be a super small proportion of all the bacteria that are out there. That's how I became interested, is just watching the field develop and wanting to help explore.

Alie: And so we focus on these bad bugs because can they can take us down. But meanwhile, how many things do we have living on and in us? Because there's always that number you hear that's like 10:1. For every cell of yours there's maybe 10 microorganisms. Is that total bullshit, no pun intended?

Elaine: The actual numbers are a little bit fuzzy. It gets down to the nitty-gritty. It depends on what you count as a cell. There are some cells that don't have a nucleus. They don't have the DNA that you're thinking of.

Alie: If you had to give someone a dinner party estimate of how outnumbered you are, what would you say, roughly?

Elaine: I would stick to the 10:1. I would actually also just reference the raw number, the actual number that people have found based on sequencing is 100 trillion bacteria in your gut.

Alie: [*Alie's mind getting blown*] Just in your gut?! What about your nose and your eyes and your hair and your mouth and stuff?

Elaine: They're everywhere. They're EVERYWHERE! [*laughs*]

Aside: Quick aside: Why do we call bacteria bugs, anyway? So the etymology of the word 'bug' is ancient Welsh for 'ghost' or 'goblin,' which, in this case, kinda makes sense. You figure invisible, scary things that can exert mysterious forces on us? I mean. Yeah. It tracks.

So Elaine is essentially a ghost hunter who's just out looking for Caspers.

Alie: And so what makes a good bacteria versus a bad bacteria?

Elaine: That's a good question. On a very superficial level, "normal" is that they don't actually cause disease. And now people are finding that the bugs that are in and on us, that some of them play really important roles. Like, there's some bugs that help us digest things that we wouldn't otherwise be able to digest. There's no way... Like, the complicated fibers in your granola bar, there's no way our cells could actually digest that ourselves. We rely on bugs to help us do it.

Alie: So if there are certain foods you can't eat, do you think you just need better bugs?

Elaine: That's a good question. I think some people are actually studying that. I think's an active area of research.

Alie: Interesting. Going back to your research a little bit: Was there anything at the intersection of biology and psychology that really intrigued you? How are you studying all these different ways that our stomachs, and our guts, our intestines, affect our brain, that's nuts. That's so cool. What was it that intrigued you about that?

Elaine: The same thing you are mentioning is what really sucked me in. I started grad school not really intending to study bacteria at all. We were studying in my lab, my mentor's name was Paul Patterson at CalTech, and he kind of pioneered these animal models for studying autism, and also animal models for studying schizophrenia. So we were just studying these really difficult neurological diseases, and it was really just noticing that, at the time, if I change the microbiome somehow that these mice started behaving differently.

Alie: Oh my god!

Elaine: And it was just like, “Oh! This is really weird! I can’t stop! I’m getting sucked into this! I need to know why!” [*laughs*]

Alie: So we’re puppets to a bunch of strangers—friendly strangers—that are living in our colons, essentially.

Elaine: You could put it that way. But the lines are getting blurred. Like, do you count them as strangers, or do you also count them as self? There’s no animals that exist without microbes. So, some people prefer to count them as part of yourself.

Alie: I mean, they’re definitely close collaborators. I’d have to say it’s a team effort over here.

Elaine: Definitely. I think that’s the idea now is that there’s this, maybe, what people like to say, like, a co-evolution. We grew together, and they do some things, and we do some things, and it’s this symbiosis.

Alie: It’s so bizarre, and it also makes you feel never lonely.

Elaine: A hundred trillion friends at least.

Alie: It’s a big party! You’re a party bus, is what I like to think of it as. [*party music and crowd of people partying*]

Can you explain to me a little bit how the things that are living in your guts, how they affect your brain?

Elaine: That’s a great question. At this point the field is really excited just by acknowledging that they do affect behaviors. Most of this work comes from animal studies. If you study mice, or rats, or flies, or fish, if you get rid of the microbiome, they start behaving differently. Or if you change the microbiome then they’ll behave another way.

And now labs are trying to figure out how that happens. What are the signals that microbes are sending to us? Are they sending these signals to neurons? Are they sending these signals that just float around and enter your brain, or are they sending signals to immune cells? All of these different possibilities.

Alie: So they might be putting out some kind of chemical, some kind of signal, and your brain’s like, “Oh. [*clicks tongue*] Got it. 10-4. I’ll do that.” Or they might just be pooping out things and our brain is receiving them being like, “Oh. I think I’m gonna go in this direction,” just from having them pass a blood-brain barrier? Is that how that works?

Elaine: Yeah. Exactly. That’s a really good reference. Some molecules that bacteria make can cross over, can get absorbed into the intestine, can get into the bloodstream. And some of them can enter the brain across this blood-brain barrier.

Alie: I don't even know what a blood-brain barrier is, but I just said it because it sounded like I knew what I was talking about.

Elaine: Oh really? It sounded nice. It was perfect. It's basically that not everything that is in the bloodstream enters the brain, and so there's this barrier, like, sandwiches of many cells that are there that are the gatekeepers of what can enter.

Aside: Real quick: So, I looked into this. So the blood-brain barrier is this semipermeable situation that happily lets in water, some gasses, glucose, which is delicious, sugary think fuel.

And in some cases like with neurological disease or trauma or inflammation, this blood-brain barrier can become more lax. Kind of like a bouncer who gets distracted by their phone and starts admitting douchebags, like toxoplasmosis, Lyme-causing bacteria, syphilis, and other party ruiners.

So, you want the blood-brain barrier alert and only letting in those folks on your guest list.

Alie: Oof! Okay. So when you're looking at 'hooman' beings, are you like, 'we are all maybe a little bit off of our rockers just gently, because our diets are maybe so different than they would be in the wild'? Is there a really big correlation, like the fact that we're eating Honey Crisps for breakfast and a venti frappe for lunch, like, is that really screwing us over a lot?

Elaine: That's also a huge area of study in microbiome work. Other scientists have done these huge, amazing studies. For example, there's one... Maria Dominguez-Bellow, and Rob Knight and a bunch of their colleagues where they sampled microbiomes from indigenous tribes of people that have not had any exposure to any modern medicine or what we consider western lifestyles, and they basically find that they have these extremely diverse super-rich microbiomes with bugs that are there that are not seen in any people here in the US, at least in what they sampled. So there's this idea that maybe we've lost the diversity of microbes over time through things like our lifestyle and practices, our hygiene practices here, and that maybe it's a bad thing could contribute to more chronic diseases.

Alie: Is there any truth that our serotonin is made largely in our intestines?

Elaine: That work was from Michael Gershon and he first published this finding that about 90% of the body's serotonin is made from gut cells.

Alie: 90%?!

Elaine: Yes!

Alie: THAT'S SO MANY NUMBERS! That's so much! It's made in our guts?! It's just simmering in these big hoses full of poop down there?!

Elaine: Yeah! Well, the gut is so cool. It's not just a container. It's really important that they hold poop, but they're really cool. There's actually a lot of neurons that are in there. Maybe, like five times more than in the spinal cord. So, there's a lot of neurons that are there. It's one of the few organs that if you sever it from the brain it could work by itself.

Alie: Oh my GOD. So, if 90% of your serotonin is made in your gut, what cells are pumping it out? Or is it the bacteria that are pumping it out?

Elaine: There are these endocrine cells that are basically cells that are in the gut lining, and their role is to make lots of serotonin and some hormones. They do things like control your appetite when you get full, when you feel nauseous, things like that. What we found a couple years ago is that bacteria are really important for communicating with these cells to control how much serotonin is being made and released.

Alie: Oh my god.

Aside: My colon is blowing my mind right now.

Alie: Do you ever look at the way we treat depression and anxiety, and are you ever on the sidelines being like, [*high-pitched*] "We're doing it wrong!"?

Elaine: We wonder how much the gut plays a role. Even in side effects. It's known that antidepressants have a lot GI-related side effects. It's important to study how these systems interact. That being said, there are dedicated neurons in the brain make the remaining 10% of serotonin of the body, and those are really important for depression, too.

Alie: But, gosh, that sounds like when you think that someone's the boss, and then you find out that, like, their assistant does all the work, y'know what I mean?

Elaine: Yeah!

[*Gary Cole as Bill Lumberg, the boss from Office Space: "Yeah. If you could just go ahead and make sure you do that from now on, that would be great."*]

Alie: Because you'd think the brain - thanks for the serotonin, you're doing your job, but downstairs is just a serotonin factory! [*whirring factory machines*]

How does serotonin even make us happy?

Elaine: That's a really good question. So, in the brain serotonin is a really important neurotransmitter and it's only made from certain neurons, so a very select few of neurons make it. It's thought that the serotonin will activate these circuits that are really

important for things like reward and happiness. That's how people think that works. And so with antidepressants, there's this way that when serotonin gets secreted it will get recycled, it'll get taken up by the cell that secreted it, and antidepressants will block that re-uptake. So basically you've got more outside that will keep activating this circuit and it's thought that's how antidepressants help boost activity of these circuits that make you happy ultimately.

Alie: And are animals or people who are depressed, do they have less serotonin than people who maybe aren't depressed?

Elaine: I think that's one thing that could happen. I feel like there's probably many different pathways that contribute to depression, but yeah, decreases in serotonin are associated.

Alie: Man, I feel like we're all going to look back, and be like, "Oh my gosh, it was so obvious what caused certain things." You know when you look back at medical practices of yore and you're like, "*That's horrifying.*"

Elaine: How did we do that? [*laughs*] That might apply with the fecal transplants now maybe.

Alie: It'd be like, "Remember the days you couldn't go to a Jiffy Lube type of situation where you just pop in, 'I'm just going to pop in for a quick fec trans.'"

When you describe your job to someone who's never met you, how do you talk about it? Like, what do you say that you do?

Elaine: That's a good question. I would probably give a boring answer about how I'm a professor, I run a research lab, and I teach. But to lab members I often tell them that I'm the hype person of their work.

They make really cool findings. I communicate the findings. I pitch the findings to try to get funding, more funding for their work, and so I'm kind of the hype person for what they discover.

Alie: Your job is just so fascinating. I mean, you know that I have been kind of mildly stalking you on email for a long time, I'm like, "Hi can we record? Hi can we record?" I'm just so fascinated by this field. How do you describe the importance of what you do to people?

Elaine: That is a really good question, because I'm still not good at it usually. You know when you're on an airplane and you have the couple of minutes to talk, I'll give an explanation that'll shut down the conversation. [*laughs*]

Alie: Like what?

Elaine: Let me think of a cooler way. I'm taking recommendations. Maybe one way I should explain it is that we study how gut bugs control brains. [*clip from DJ Snake and Lil Jon song: "Turn Down for What!" airhorns blasting*]

Aside: So, allow me to be the hype man for the hype man. But holy actual shit. Elaine's studies have involved some truly wonderful and very important things; the microbiome's effect on neurotransmitters, how it relates to autism, and even how the microbiome can affect seizure occurrence in epilepsy. It's *big* stuff.

Elaine: The most recent stuff we were studying is really whether we could use microbes to replace dietary effects on the nervous system. So we chose this diet, you may know, the ketogenic diet. It's kind of a fad diet right now, but it's been used for almost 100 years to treat epilepsy.

Aside: This ketogenic diet is high-fat and very, very low-carb. Like, max 30 grams a day or lower, depending on how you do it. And your frame of reference may be Joe Rogan proselytizing like a shredded pastor. Or maybe you have a co-worker who drops a dollop of coconut oil into her coffee and only eats the toppings off of a pizza.

But research shows that keto can reduce seizure occurrences by half in half of the patients. And a third of patients report up to a 90% reduction in seizure frequency, which is huge. But it can be hard to stick to. Especially for kids who are already struggling with epilepsy and just want a frickin' apple, or a piece of birthday cake. So Elaine explains:

Elaine: In kids that don't respond to normal medications that are out there, as a last-resort treatment, they'll often get enrolled in the hospital and put through this really severe diet. And so we wondered if we could study whether the microbiome changes and whether the microbiome is important for how the diet decreases seizures.

Our most recent findings were basically, yes, the microbiome changes and we could pick out the very specific bacteria that basically replace the diet in terms of protecting against seizures.

Alie: So instead of doing the diet, would you maybe be able to increase that proportion of microbes to affect seizures?

Elaine: That's the idea. The caveat is we've done that all in-mouse first, to start. Who knows if it'll work in people? But that's the pie in the sky. [*ba dum tsshh!*]

We'll either be able to have, say, a very specific probiotic or companion treatment to help the diet work better, or even the extreme version of this, if we can have this type of treatment replace the diet entirely so that people can cheat or be on normal diets but still get the same kind of effect.

Alie: And then what about microbes and gut flora in autism?

Elaine: That was actually my grad work, so now we're going to my first works in the microbiome field. The reason I got into the microbiome is, I became really intrigued by

this finding that some cases of autism are correlated with lots of GI abnormalities. So some kids with autism have severe GI abnormalities. Not all of them, but some of them. In the models that I was studying in the lab, I was seeing the same thing, that there are also GI abnormalities that are seen with the behavioral changes, too. I wondered whether we can use microbes to correct these GI problems, and if so, what happens to the behaviors.

Aside: Okay. This news is exciting as heck. Just buckle up your guts.

Elaine: We ultimately found that if we changed the microbiome we could correct some of the behavioral problems. [*DJ airhorns*]

Alie: Where do you go from there in, maybe, mouse studies to humans? I mean that's huge news!

Elaine: It's really exciting for the fundamental biology. I always like to temper my enthusiasm. A lot of things that are found in animals don't translate well to humans, so there's a big gap there. But I think it inspires more work to be done. If we do a good job on studying mechanisms in animals then we can justify studying similar pathways in humans and maybe doing some safety trials to see whether the microbiome-related treatments we tested in animals are also safe and effective in humans.

Alie: And what was the mechanism in terms of the autism or the epilepsy that told the brain to work a little bit differently?

Elaine: We don't have all the answers but what is really cool is that a lot of gut bacteria have this unique chemistry that they can make biochemicals that our body doesn't normally have, and so we became really interested in... for the diet story, what are the microbes doing with these components from the diet, and what do they make that's unique? Similarly in the autism story we also were looking at, in this context, what do the microbes make? What do their molecules do to neurons? Things like that.

Alie: So they may have been making certain chemicals that made neurons fire differently?

Elaine: Absolutely, yeah. So, in the epilepsy work we think that they were metabolizing molecules that ultimately restricted GABA which is an inhibitory neurotransmitter. So GABA is this molecule in the brain that neurons use usually to silence activity. So we were seeing that these microbes were controlling brain levels of this molecule that is telling neurons to quiet down and we think that's what's helping with seizures.

Aside: So the dietary change upped the GABA in the brain and reduced seizures.

Now what about autism? Elaine says that they've found at least one molecule produced by a certain bacteria that, at least in the mouse models in their experiments,

was abnormally high, and which they suspect can affect neurons in a way that influences behavior.

Details are still fuzzy but where the work is leading is really promising. So, potentially very life-changing. All because someone has the sense to think, “I wonder if these trillions of tiny animals living in my intestines are sending messages to my brain loaf.”

Alie: When you have people who are looking at your work and they’re like, “Boy howdy hot damn! That’s a big deal,” and then we go to the store, and we’re in Whole Foods in the probiotic aisle being like, “Which one of these will make me less depressed?” Is there any advice or any correlation, or is it kind of a bunch of flim-flam?

Elaine: Oh, man. Those are the hardest questions to answer, because on the one hand I believe in the promise of probiotics and what bacteria can do. But on the other hand the stuff that’s on the shelves and the supermarket, they weren’t rigorously tested to treat disease or to be anything more than nutritional supplements, I think.

And also some of those probiotics have bugs that are not native to the body. So there are things that came from dairy or fermented foods which are really different from bugs that are normally in the body. Those are so hard. I can’t even advise on which ones work or not.

I did take one before, just to see if I felt any differently, and I didn’t, but that doesn’t mean that it doesn’t work. There are some people that respond really well to them. Especially some people that experience GI problems or have intestinal disease. Probiotics could help.

Aside: So the bad news is that despite the \$32 billion we citizens of Earth spend yearly on probiotics. [*skeptical*] Uuuuhh, eeh... They may not be effective. I read in one report in the *annals* — the *annals*! *The Annals of Internal Medicine* — that certain shelved brands of probiotics can be harmful to folks who already have shaky flora to begin with. And there was a recent *New York Times* article that noted that the studies are almost all low-quality, small in size, and are usually funded by companies with significant conflicts of interest. [*‘The Price is Right’ loser horns*]

So in terms of shelved probiotics, see what works for you. Some do work for some people. And more importantly, maybe, eat a lot of fruits and veggies because that is feeding the good bugs. So, maybe your mouth is like, “Ugh. Cabbage. We are not friends.” But your gut flora is just losing its mind with excitement like you just walked in with a tray of fireball shots and fluffernutters. Cabbage salad, it’s party o’clock for those little motherfuckers.

Alie: I feel like this is just a new field that’s just cracked open and we’re all peering in, being like, “What’s gonna happen? This is amazing!” Because we just never even looked at any

kind of psychological or mental health issues. We never really looked at those like a holistic, full-body situation, it seems like.

Elaine: Exactly! It's so cool to think that we're all here when this field was born, y'know? It was only, maybe 10 years ago that people were even able to name the bacteria that were in the body and the majority of them no one knows anything about what they do. Now is the time. It's just born, people have to get in on this to study it. *[laughs]*

Alie: I feel like you're kind of like a cosmologist of butts. Like, there are so many stars in the universe and then there's so many things we don't know happening every day. I mean not of butts specifically, but in general. There's this unknown that's so important to us. When it comes to anxiety and depression—because we've talked about autism and epilepsy—when it comes to anxiety and depression, how does gut flora affect those?

Elaine: We're really interested in that. A lot of anxiety and depression is also comorbid with GI problems, and so some people are really curious about whether we could use microbes to correct GI problems and influence these disorders.

Right now in animals—again, I always like to distinguish “in animals”—we can clearly see that behaviors that are related to anxiety and depression seem to be changed when we change the microbiome.

Aside: Aaaaaah! Okay. I'm sorry. I'm trying to contain myself.

Elaine: But again, it's not always a one-to-one from... A mouse is not a human.

Alie: What kinds of things are these mice doing, are they just like, scrolling on social media too long, and like, talking about their ex-boyfriends too much?

Aside: *[as a mouse:]* “I mean, everyone is at this party and probably my ex is like with a new girlfriend who probably has a way longer tail than me. Mine is so short and stumpy. No one will ever mate with me. I'll never have a litter of 40 babies, some of which I might eat.”

[back to normal] Okay, for realz, though. What do anxious mice really do?

Elaine: There's a lot of really cool behavior tasks that you can put them through. They're pretty benign. It's just, y'know, for one common anxiety task is just to put them in a box. Usually they'll just be scared and be around the edges of the box, and after a while go and venture into the center. That's kind of what people measure as an anxiety-related behavior. And when you treat them with SSRIs or anxiety drugs, you can see that they change the duration of time that they spend along the edge versus the center.

Alie: Gosh. They're actual wallflowers. Who knew that was a thing?

Let's get down to the nitty-gritty of your work. So, you have a stuffed poop emoji sitting next to me. How much of what you do is cultured matter from our bodies or other people's bodies? Where are you getting them? How do you keep track of them?

Elaine: We do usually start with poop. *[laughs]* We'll often take either human poop or we usually start with animal models and we'll sequence. For example, in the diet study we take mice, we put them on the ketogenic diet, and then we sequence off of their poop to see how the microbiome changed. And once we get some interesting hits from that sequencing, then we might get very specific species and culture them in the lab. Those you can usually buy from a culture collection. There are companies nationwide, or country-specific culture collections for bacteria.

Alie: Really? Like a catalog of bugs you can just flip through?

Elaine: Yes.

Alie: Look at that! You're like, "I'll take a lactobacillicus, or whatever..."

Elaine: Exactly. You just buy them and we grow them in the lab.

Alie: And so when it comes to sequencing, what happens when you're sequencing things but they're unknown species?

Elaine: Sometimes that happens. What you can do is keep tabs on what those sequences are and then you just kind of consider them as unknown or new species when you analyze them. That's a big problem, too, is that not everything has been identified.

Alie: How many different species do we have in our guts?

Elaine: People say that across humans that over 1,000 different species have been identified from the microbiomes.

Alie: Do you get tripped out by microbiology at all? Like, when you touch a keypad at CVS or something, are you like, "What am I touching?" Or are you like, "Y'know what? The more the merrier."?

Elaine: When you study microbiology you realize that there are a lot of bugs that are just normal and that it won't kill you to be exposed, that maybe some of them are really important for educating your immune system, so exposing yourself is not that bad.

Of course, you don't want to take it to an extreme. *[laughs]* There are things that I would not do.

Alie: Like, don't lick the doorknobs.

Elaine: Yes.

Alie: What do you think of the hygiene hypothesis?

Aside: Just a side note: This is the theory proposed by British epidemiologist David Strachan in 1989. PS: He might pronounce that “Stracken,” and I’m sorry. But essentially this theory says that the rates of auto-immune conditions and allergies have gone up in Western cultures because of sanitation, and antibiotics, and smaller family size means exposure to less diverse microflora. Also western cultures have something called “low orofecal burden.” [*gasps from “audience”*]

[*high-pitched*] And I googled that. With one eye closed for safety.

And, yeah. It means what you think it means. Less poo in our mouth. So the hygiene hypothesis has also been called a few different things. It’s been called the ‘Biome Depletion Theory’, and the ‘Lost Friends Theory’, which just produced a mélange of feelings in me. Like, you’re sick with autoimmune disease possibly because you’ve lost a bunch of your friends, because you grew up with less poo in your mouth. Which is sad and disgusting, and also adorable all at once.

Elaine: I think it’s really interesting, this idea that you should encourage your kids to go play in the dirt so that exposure to microbes helps educate your immune system and protect from chronic diseases. I think that’s really interesting. I haven’t seen anything that has outright refuted that idea. Only things that have kind of supported it.

Alie: So we’re maybe a little too clean for our own good.

Elaine: When you look at big population-wide studies, definitely you could see that we’re really good at treating infectious diseases. Historically, rates of infectious disease have gone down, but rates of chronic diseases like metabolic diseases, like diabetes and obesity, and multiple sclerosis, things like that, have gone up.

There’s a different problem now that’s not infection so people wonder whether it’s just this... if we’re too clean for our own good.

Alie: Wow, like it feels like whack-a-mole with diseases. [*whack-a-mole music and mole whacking*] You get one and then another pops up.

What is the correlation between multiple sclerosis and gut biome? I did want to ask that because my mom has MS.

Aside: Super quick: If you’re not sure what MS is, I’m gonna do a PSA right now, because my mom has it and I want people to know more about it. It stands for ‘multiple sclerosis,’ and it’s a neurological condition in which your immune system wants to be so helpful by attacking things, but it goes for the myelin sheaths around your nerves. And myelin is kind of like the rubber around an electrical cord.

So, imagine if your roommate, in trying to clean house was like, “Great news. I stripped all of the electrical cords. So, we got a bunch of raw spots now. I cleaned ‘em.” And you’re like, “Well? No, actually. That was unnecessary. And now the lights keep flickering and there’s a fire in the kitchen. Please calm down.”

For my family, treatments and possible cures for MS would be aces. Thank you to anyone out there who’s working on that. Now, if you’re not affected by MS, this info is important too because chances are that you or someone you know is affected by an autoimmune disease and has an immune system that somehow got jolted up and is cleaning, attacking things that you don’t want it to. So, if you know someone with an autoimmune disease like rheumatoid arthritis, or hair loss, or psoriasis, or lupus, type-one diabetes, celiac—this inflammation and autoimmune disease is of interest.

Elaine: First, people were studying how the microbiome interacts with the immune system, because there’s this situation where if you’ve got 100 trillion bacteria in the gut, how do we keep them in check? The way that we do that is that about 80% of your body’s immune cells are right there and it’s this boundary where there’s microbes talking to the immune cells and immune cells always surveying what’s going on. Out of these really pioneering microbiome immune studies people found out that you could use certain microbes to control inflammatory responses.

So there are these cells called T-cells that, in MS, they infiltrate the brain and people think that it causes some of the damage. T-cells that are super-reactive or hyper-reactive enter the brain and start attacking myelin on neurons. These early microbiome studies people found that if you temper... if you use microbes to quiet down those T-cells, then you can ameliorate the MS symptoms.

Alie: Is that used in any kind of therapy at this point, or are we still so far off?

Elaine: I think people are developing that. I know people are taking that to human studies and I’m not sure how far along it is right now in what phase of trials, but it is being developed.

Aside: So if we very, very highly suspect that the microbiome is involved, what kinds of illnesses are being treated through restoring a healthier one? Like, through a doctor? Not as much as you’d hope. Yet.

Elaine: The only thing right now that can be treated with microbiome is *C. difficile* infection, an intestinal infection. That’s the only thing that currently is being treated with these fecal transplants. We wanted to get there!

Alie: YES! That was on my list! I mean I had so many Patrons that asked about it. And it was like, “Duh, it’s gonna be on my list.” ‘Cause I feel like, there’s just this like, [*sings a choir note:*] “Aaahh!” like a golden cure that’s a poop transplant but it’s not legal yet. And it

seems like it's a bit frowned upon. But yeah, can you run me through: What is a fecal transplant? [laughs]

Elaine: It is legal for *C. diff* infection. In this infection, basically there's some people, they'll get this, basically, opportunistic pathogen. So, this bug that's normally in a lot of us, but can turn bad in certain situations and then cause intestinal disease. Usually the first line of treatment is antibiotics, but what ends up happening is you clear out all these good bugs with antibiotics and then you just make space for *C. diff* to grow more if you didn't clear it out completely. Often people will get recurrences. In that case, what ends up being one of the most effective treatments is fecal transplants. Basically, we'll clear everything out [crowd booing], and then repopulate with a whole new community. [peaceful community, birds chirping, neighbors chatting]

Alie: How is that actually done?

Elaine: [laughs] So, it's much better now...

Alie: Oh my god. What was it like before?!

Elaine: Before, I think you would actually have to find a donor, usually someone in your household, and you'd go in, and the donor would poop, and then you would get an enema of what they gave. And that was the treatment. ["Nailed it!"]

Now there are more controlled materials to transplant with. You can buy from a company that really rigorously screens what was in there and what's being transplanted. They make sure that it's safe. And so the doctor can either buy the liquid material or they could have capsule versions.

Aside: So, I started looking into this, and I think, I *think*, that this is a prescription formula with the very romantic name called VSL#3, which has nothing to do with PSLs (pumpkin spice lattes). Or going #3, if you know what I mean. Though, it does help with it. In one newspaper of India, it was reported that this could help the condition of 'looseys', which is a word I will never forget no matter how hard I try. Anyway, VSL#3 has shown some potential as a clinical remedy for maladies such as ulcerative colitis, and irritable bowel. So it's legally called medical probiotic food, which is perhaps a more palatable administration than, say, some other methods.

Elaine: You could either take a series of several capsules in a row, or what works better is if you get that enema.

Alie: Do they have to make sure that you're pretty much clear of the bad ones. So you have to take a ton of antibiotics first?

Elaine: Yeah. I think so. You take antibiotics first to clear out, and then you immediately transfer it.

Alie: What do you think about people who are doing it just Pinterest, DIY-style?

Elaine: I've seen that. I mean, it's really dangerous. Who knows what— You wouldn't know what's in it until you sequence it and really test it. And now that people are studying the microbiome so deeply and finding neurological things that are related or metabolic or chronic diseases that are related, you don't want to be in a situation where you cured your *C. diff*, but then you predisposed yourself to other diseases in the long run. I would recommend not doing it at home. But I can see that people are eager to try, since currently you can only use that treatment for this one intestinal disease.

Alie: I wonder if that's gonna change in the future. It'll be like, "Okay. We let IBS in. Okay, we let arthritis in," you know, different ailments will get the pass for it.

Elaine: Yeah. I wonder, too. Alternatively people are trying to parse out the transplant material into just the select bugs that are important and maybe you'll just have cleaner capsule versions for each of these diseases.

Alie: Is that slurry of fecal transplant that doctors obtain, is that from a donor base?

Elaine: It's from donors, yeah. Heavily screened professional poopers.

Alie: Who are they?

Elaine: Good question! I'm not sure, but I think you can make a good living off of it.

Alie: I bet you can, because I mean, you'd have to be even better than a sperm donor, I feel like. Like, you'd have to make sure that you had the best BMs ever. I'm gonna look up their salary! I bet it's pretty good. Maybe more than the doctor's, who knows?

Aside: Okay. Citizens of planet Earth, you're welcome. I googled this for you. So, a Boston-area non-profit stool bank called OpenBiome does collect fecal donations to help treat patients of severe microbiome imbalance. Like a *C. diff* intestinal infection, and they pay 40 bucks a stool, which in terms of extra income is more than just *a drop in the bucket*.

And you can donate as many times a day as you are productive. So, each contribution can potentially help up to five patients, in case you were looking for not just some income from your outcome, but also some good-ass karma and some good ass karma.

But don't get your hopes too up there. One spokesperson quoted in *The New York Times* dropped the knowledge that only 3% of screened applicants are accepted as being perfect poopers. That means statistically it is twice as easy to get into Harvard than to get money for your waste. Now, I had to lob one question at her regarding a very serious situation that happened to me recently.

Alie: I have a personal question. Something happened to me last week, and I'm glad I'm sitting down with you, because there is probably no one who could better educate me.

I dropped my wallet in a Starbucks toilet. It was flushed, but there was a moment where I was like, I don't know what to do. Do I just cut and run? So, I grabbed it out of the toilet with a bunch of tissue, and then I washed my hands *forever*, and then I sprayed bleach on it. And then I bleached everything in there. But like, am I gonna die?

Elaine: No. That's exactly what I would have done. I probably would have fished it out and just, you know, washed it with soap. The bleach will do it for sure. It's what we use to decontaminate things in the lab, so...

Alie: Okay. I did. I sprayed everything with a bleach solution afterward and that wallet is now in the garbage, but I was like, what do you do? And then I thought, well, you know what? Maybe this will be good for me?

Elaine: [*apologetically*] Yeah...

Alie: No?

Elaine: No. No.

Alie: No. No. Not good for me. Oh my god, what a horror.

And so is there anything that's, kind of, on your list that you want to study next? Like, any particular angle that you really want to go for?

Elaine: We have a lot of things going on in the lab. At the end of it, what we really want to study is how is the microbiome doing so many things to behavior. What are the molecules... What is the pathway? What is the cascade of events that is happening to allow them to do things like that? We study these mechanisms in lots of contexts.

One context is, I mentioned, epilepsy. Another context that we're really interested in is neurodegenerative diseases like Parkinson's and Alzheimer's. We are interested in depression, too. And then otherwise, some other people in the lab study more the nitty-gritty of, like, we don't care what disease it is, but I'm just going to study how do microbes communicate or signal to neurons and how many different messages can be sent in this manner.

Aside: So, right now, you have tiny critters just gabbing over your influx of morning coffee, like doughy old men gossiping in a park over a chess set.

Now, who funds this microbiome research? Do pharmaceuticals fear the day when we can get good poo for free to fix all of our problems? So, funding, Elaine says, comes from some federal sources, and the National Institute of Health, even the Department of Defense want to study the mental and physical health of deployed personnel.

The EPA is even getting in on the action, figuring out how environmental toxins can make our microbiomes take a hit. So, there are of course more intentional bacterial wipeouts out there.

Alie: Now, what about all the antibiotics we take just for everyday things? You have a sinus infection, whatever. We take those and they save a lot of lives, but what are they doing to our microbiome?

Elaine: Antibiotics are not specific, they're broad-spectrum, so they'll kill the bad bugs, but they'll also kill off your microbiome too. [*"Nooooooooooooo!"*] And so after you're on antibiotics, then you basically need to repopulate. Your microbes will grow back and repopulate your body.

Aside: So this is like the cops coming in and shutting down your party because there are a few obnoxious guests. Like, even your trusted pals; tossed out the door. The cops are like, "I don't care if she was your maid of honor and is cleaning up empty cups. That guy over there? Is rapping along with Sublime and getting the dog high. Everyone is out!"

Elaine: And so people are really interested in how do you control... How do you get them to repopulate correctly back to healthy state rather than to some alternate poor microbiome state?

Alie: How *do* you do that?

Elaine: That's a good question. Nobody really considers that. One question is: Maybe after a course of antibiotics, should we be considering taking a probiotic to replenish or transplants to replenish the microbiome correctly? People are considering the same idea for C-sections, for example. If you have C-section babies, they end up not being exposed to the same kind of microbes, and does that mean we should inoculate them immediately so they do grow a normal microbiome?

Alie: Yeah, what happens? Because if you're squeezing out of the V, I imagine you probably get a little something from the back door on you, and you're like, "Thanks Mom!" And she's like, "I couldn't help it, but... enjoy." But with a C-section, you skip all that. Do they swab babies with a little bit of poo, or what happens?

Elaine: Right now I don't think it's normal practice in the US, but in some other countries, I think it is normal to kind of swab the baby in Mom's stuff.

Aside: Ummmm... "stuff"? [*'80s-era speech synth: Stuff; Miscellaneous items, things with possessive personal effects.*]

Elaine: Their secretions, yeah.

Alie: Just like, a little dab'll do ya, and...

Elaine: Yeah.

Alie: How do you interact with pop or spa science when you see articles on goop or Instagram, products that are like, [*snooty*] “This tea will restore your whole microflora.” Like, are you like, “That’s a little true,” or are you like, “Oh my god, how dare you.”?

Elaine: What grad school and science trains you to do is be skeptical of everything, so that’s my default.

Alie: If you could give one tip to people about how to build a good microbiome, would it be, like, ‘don’t wash your vegetables as much if they’re organic,’? How do we do it without running through Whole Foods and spending a bunch of money?

Elaine: I think what is safe to say, hopefully this is not just more of what we already knew, is that you could eat a diversity of different fibers to feed all of the different types of microbes in your gut.

Gut bacteria have food preferences, too. So if you keep eating that same thing then you might only be feeding some bugs and not others, and so many diverse things is...

Alie: I never thought about that! I read that Martha Stewart eats the same bagel sandwich every morning. She’s gotta diversify her gut bacteria!

Elaine: We gotta do a sequencing study!

Alie: I know! It’s the bacteria that like a bagel with a slice of onion or whatever it is.

Aside: I swear to gut that I read this somewhere, and I just want you to know that I spent over an hour while on semi-vacation in Hawaii, sitting on a porch with slow-as-fuck WiFi, trying to fact check this. And now I think I just hallucinated it, because I can’t find it anywhere.

But I did learn that every morning Ina Garten eats the same coffee and an oatmeal, and Mariah Carey’s diet consists of just two items: Norwegian salmon and capers. Now Martha Stewart apparently has the same cappuccino with whole milk and a green smoothie every morning and it involves; spinach, celery, parsley, mint and a piece of fruit; either a pear, a mango or a papaya.

She said, [*as Martha Stewart:*] “It’s very good juice. Everybody loves the juice.” Okay. We get it, Martha. You like juice. But honestly, the woman has been in prison. Let her eat as many bagels as she wants.

Alie: So really a diversity of foods and probably... Maybe that’s a little bit why we feel better if we’re eating a lot of fruits and vegetables?

Elaine: Yeah. A diversity of fibers, mainly is what... Carbs, basically is what they eat. Complex carbs.

Alie: Do you ever notice that if you eat terrible food you feel kind of grouchy for a couple days?

Elaine: I do. It's so good in the moment, and then afterward it's just [*slowed-down*] remorse.

Alie: Can we do a rapid-fire round? These are questions from listeners. They were so pumped. [*squishy splat*] They're so excited.

Okay. One of the most frequent questions I got... which really surprised me, how many times I got this question. I got it by like, 20 people, and I will read their names very quickly in an aside.

Aside: Lydia McGuinis, Tyler, Beth Frosto [phonic], Lisa Tang, Mark Larson [ph], Makenna Hopwood, Serena Keraga [ph], Jamie Cattanach, Kennedy [ph], and Tony Thompson.

Alie: Is kombucha really worth all the hype? What's the deal with kombucha? Can kombucha actually be helpful? So many kombucha questions!

Elaine: Oh, man! Okay. These are hard. In general I think that I've only seen positive things, if not neutral things, about fermented foods - kombucha included - fermented drink. So I think it definitely doesn't seem harmful and if anything it could only help.

Alie: Okay. It's yeast... it's a fungus and a bacteria, right?

Elaine: Yeah. That being said, and a lot of people make their own kombucha at home so you've got to be careful that you keep the culture clean, because sometimes there are these rare cases of growing the scoby... I don't know what it stands for...

Aside: SCOBY stands for 'symbiotic culture of bacteria and yeast,' and it looks like a beige, flabby, slimy disc that feels, in texture, what I imagine preserved dolphin skin might feel like. And after finding a feathery brown thing in my store-bought kombucha, I thought I'd do a science. And now I have grown it, and it is sloshing around in a large jar in one of my kitchen cabinets. It's just growing larger and larger and probably more sentient by the hour.

If you smell them? I would say a scoby has kind of an acrid musk, which I imagine is similar to the groin of an ox. But they brew some great fizzy, yummy stuff. It kinda tastes like a mix between a Snapple and a PBR. And I mean that in a good way.

Elaine: Looks kinda gross, the scoby.

Alie: Trust me. I have grown them, and they're like a big slimy pancake in a jar.

Elaine: It's more frightening than things we grow in the lab, a scoby. *[laughs]* But yeah, there are certain cases, weird cases, where they got contaminated with pathogen and it really made people sick. Be careful with your scoby.

Alie: Okay! Good to know! So, probably couldn't help unless you get a bad apple.

Elaine: Yeah.

Alie: And so many people asked, Al Martinez, Forrest, Craig Curry...

Aside: Also, Henry Strong, Christopher N. Brewer, Ryan Moore, Athena Ballistrari [ph], Katelyn Donald [ph] and Sarah Welch.

Alie: Everyone was like: Do store-bought probiotics do anything?

Elaine: I think that's it's another case, for certain people, they seem to really help, especially people that have GI problems, there are intestinal diseases that it seems like they can help. Actually, there is one case of a medical-grade probiotic for intestinal diseases that truly seems to help, and your doctor prescribes it.

Aside: The aforementioned spy-name sounding *[in an echo chamber:]* VSL#3.

Alie: Another Patreon question: PF Foxhall [ph] asks: What is the weirdest thing you've learned about how the gut microbiome influences us so far?

Elaine: Weirdest thing? Let me think... *[Jeopardy! theme song]* None of it seems weird now, because we study it so deeply. *[laughs]*

I think one thing, it's not super weird, but we're really interested in this idea that gut bacteria can control these neurons that connect... They touch your gut and they extend directly in the brain. And so this weird idea that there's this long telephone where gut bacteria can send these molecules and control messages that are being sent up to the brain. So that's one thing that I think is really cool. Maybe kind of weird, and cool.

Alie: Is that the vagus nerve?

Elaine: The vagus nerve. Yes.

Alie: So, from what I understand... This is how I envision it, which is probably wrong: There's like a nerve, like a cordy thread fiber that just hangs out from your brain to your stomach and it's just like a... you remember those pneumatic tubes where bank tellers would send checks through? *[pneumatic tubes with cannisters moving through]* And it's just like that, but with feelings. And I know that that's not right. But what exactly is that vagus nerve?

Elaine: No! I mean, that's pretty close! It's a bundle of neurons. On one end it touches your brain stem and the other end it touches a bunch of different organs, and so there are these fibers that extend to the intestine, too. And they are bi-directional, so you can send messages up, some of them relay messages up into the brain, and other neurons relay in the other direction from brain back to the gut. And so, yeah, that's how they work.

Alie: Oh my god, that so weird! What happens if they sever that?

Elaine: A lot of things. Animals will end up having behavioral problems. This has actually been done historically in people, too, is vagotomies. [*Alie gasps*] Yeah. I don't know what the original indication was, or their outcomes from it.

Aside: So. Vagotomies. Alright. I looked this up, and animals with damaged vagus nerves can gain weight, even with super restricted diets, because the signaling that turns off energy storage and turns on burned energy gets whack. So, yes.

And in humans this can lead to increased insulin and increased fat storage. So. Vagus nerve. Important. [*Vince Vaughn in Swingers: "Vegas, baby. Vegas."*]

Alie: I'm guessing they don't do those anymore?

Elaine: I don't think so. [*laughs*]

Alie: I mean, that's another thing. They used to be like, "Someone acting up? Give them a lobotomy!" And I think we'll look back on the way that we treat mental illness as, like, "Oh man. We really did that wrong."

So, Anonymous Bob wants to know... Which by the way, Anonymous, you said your name was Bob, so "Anonymous Bob." [*"Hi, Bob!"*] Okay.

The difference between pro- and prebiotics. What's the difference?

Elaine: So, probiotics is where you have the actual cultured bacteria. And then prebiotics is related to what I was mentioning before, where different bacteria have different food preferences.

So, prebiotics often have very specific types of fibers, basically, that will feed a certain type of bacteria. So prebiotics is giving food that will enrich a particular bacterium, and then probiotics is where you give the bacterium itself.

Alie: [*gasps*] It's so cute to think that our little bacteria is little fish that we have to feed. You know what I mean? Like, "I'm gonna sprinkle you some prebiotics! I hope you like it!" And we do that with our diet all the time. It's so interesting, too, that we're like, "Oh, it's good to eat a lot of fiber." And part of that might be just to feed all of our little dudes and ladies. And... I mean, they're asexual, but you know what I'm saying.

Let's see... Todd McLaren wants to know: Do various microbes have a form of brain?

Elaine: That's an interesting question. They don't have a brain, of course, they don't have any organs, they're the single cells. But they can still do really cool things. They have behaviors. They don't have an official brain, though.

Alie: But they can still do stuff.

Elaine: Yeah.

Alie: And have preferences, evidently. They're like, "I love rutabaga!"

Tom Myers says: To what extent is a septic system an extension of our digestive system?

A septic repair person told me some things that sort of blew my mind.

Elaine: [laughs] Really?!

Alie: I was like, "Oh my god!"

Elaine: Oh my gosh, I want to know, because I have no clue how to answer this! [laughs]

Aside: Looked this up and again, you're welcome. Yes. True stuff. So, in a 2015 paper entitled *Sewage Reflects the Microbiomes of Human Populations*, researchers reported that, "The distribution patterns reflected human population variation, and predicted whether samples represented lean or obese populations with—get this—an 81 to 89% accuracy." Scientists can analyze sewers and figure out whether or not the population is lean or obese. That is how involved with your body your microflora is.

So just think: Behind your walls, under your feet, every murky pipeline tells your story.

Alie: Julie Noble, Heather Wills, and ironically someone with the last name Brewer, wants to know how alcohol affects gut bacteria.

Elaine: Oh! Okay. That's also a really interesting one. I mean, in general, in the lab, we'll use certain alcohols to basically decontaminate things, so you'd think that particular alcohols will probably kill bacteria. But I'm not sure... I feel like these studies must be underway now, what people are looking at, like sequencing studies in response to drinking. I don't know the outcomes, though.

Alie: Right. I imagine if you're drinking a lot of Everclear on Friday night, that maybe your gut bacteria's like, "Oh, noooo! Why are you doing this to me?!" That's interesting.

Ariel asks: Have you investigated these gut-brain interactions in species with different types of digestive systems? I'm thinking specifically ruminants, who have such a rich gut microbiome and if that plays a role similar to what you've seen in humans and mice?

Elaine: As a field, my lab doesn't study ruminants. [cow mooing] We mainly study animals, or mice, and sometimes we'll get human microbiomes to study, but there are definitely labs that do study ruminant microbiomes and it's really cool.

As a grad student, I did one rotation through a termite lab, studying termite microbiomes, and basically what allows termites to digest wood is the microbes that they have. So yeah, I think studying microbiomes across species is really cool and will be important.

Alie: That is interesting, because ruminants, kind of, got a whole other... they got so much work to do. They're like, "We got so much cellulose, gotta break this stuff down."

Cathy Arnell [ph] says: Okay, gross one from me. What is the culprit of the intensely grotesque smell that emanates from my hubby's time in the bathroom? And she says: I'm not talking about the average smelly poo, but the kind that drives you from the room. No discernible pattern. Happens five, six times a month. I believe that his biome is whack.

Elaine: [laughs] I have no clue! I mean normally, this would be like, methane gas or something. There are microbiomes that are being studied that make this molecule that underlies the fishy, foul, fishy odor, so maybe those are microbes that could be related there. And in general, people are really interested in how microbes can make molecules with different odors, and where the microbes make chemicals that are olfactory cues.

Alie: So they might be telling other microbes... By stinking a certain way inside us they might be telling other microbes to do certain things?

Elaine: Yeah. They, kind of, are determinants of different scents. There are some labs that are also studying microbiomes on the skin and maybe that they can make olfactory chemicals that influence how likely you get bitten by a mosquito.

Alie: That's nuts!

Tyler Q. wants to know: Is it true that your gut influences what you want to eat more than what your brain does?

Elaine: I think that's a really cool question, but nobody has really shown it definitively. I'm really interested in that too, since if microbes have food preferences... I'm really interested in 'microbe food preferences influence my food preferences'. I haven't seen anyone show that yet.

Aside: Okay. So. Quick aside: I watched this documentary on Vimeo. It's a short documentary called *Gut Hack*, and it's about noted biohacker Josiah Zayner's "grueling and grotesque DIY fecal transplant." And apart from the fact that he appeared to do a lot of the dirty work in his kitchen, I was struck by how after he finds that the donation

from a healthy friend was successful, he's looking at the gene sequencing of his new microbiome and he starts breaking down:

[Zayner: *That is pretty insane. The experiment actually worked. I don't know why I might cry. This is crazy.*]

Which was very... moving.

[Zayner: *It's one of those things where you're just so moved and impressed by how science works, or just how... yeah.*]

Side note: He also developed the same sweet tooth as his buddy. So your sweet tooth is really, really deep in your bowels. Metaphorically.

Alie: I have heard that if you start eating a healthier diet you start to crave that more. So, I don't know.

Eliana Zack [ph] and Kayla Jane both had questions kind of about Crohn's disease, ulcerative colitis and IBS, like, if someone has debilitating symptoms like that, are there any suggestions you have for good gut health that might also help with that?

Elaine: I think with the ulcerative colitis, that might be a situation where you could talk to your gastroenterologist about this medical-grade probiotic. I'm not sure if it is actually indicated for UC or if it's some other variant of IBD. But all of those disorders that you just listed off I think maybe are next in line for microbiome-based treatments that get to humans. After *C. difficile* infection, I think, the most likely candidates would be these types of disorders.

Alie: So we're kind of gonna use them on the guts and then work our way up to using them for the brain, probably?

Elaine: Maybe. Maybe. I wonder if it'll ever get up to the brain. I think if we can really do a good job on the science side, maybe that would be a possibility in the future.

Alie: Well, you're like, doing that! It's amazing. That's why I'm like, [*gasps with excitement*].

Aside: I'm sorry. That was the sound of me fan-girling.

Also, if we live in close proximity of others...

Alie: Do you think that our gut biomes are, kind of, contagious?

Elaine: Oh! That's a good one. It is known that people that live together have more similar microbiomes to each other and that your pet has a more similar microbiome to you than to some stranger. So, I think there is some degree of sharing and transfer.

Alie: I wonder if your partner has a certain, like, let's say, depression or anxiety or serotonin deficit, if you can kind of influence each other's microbiome and then you're like, "Oh we both gotta get ours on track."

Elaine: That would be crazy. I'm not sure. But if we end up finding... If science tells us in the future that the microbiome is the root of certain diseases then I think this type of transfer or sharing would become a big issue.

Alie: And what's the, and pardon this, but the shittiest thing about your job? Like, what's the hardest, the most annoying, the most tedious, just... What is the one thing you *hate* about your job?

Elaine: I was not trained to be a good manager. But there's a lot to manage. There's a lot of little nitty-gritty things to manage all at once. Like safety-related things. Coordinating, purchasing. So I personally do not enjoy getting stuck in emails and administrative duties. But I can't complain. It's the price you pay for having an awesome job.

Alie: For having your own lab? [*Turn Down for What airhorns*] Being the captain of your ship? What do you love the most about your job?

Elaine: I love the discovery part. It's so fun. There's always new things going on. I love working with the students and seeing data that they're producing and all the cool discoveries going on. I also really love conceiving new projects, things that we should work on in the near future.

Alie: Do you have a list that you keep in a moleskin notepad of like, [*cartoonish self-importance*] "Things I'd Like to Discover"?

Elaine: Almost. I have a really plain Excel document that's called 'Projects,' or 'Experiments,' or something, and the list of everything that I would love to work on some time.

Alie: What's on there?

Elaine: All sorts of things. Like, what you mentioned, this food preference idea, whether microbes influence our food choices. There's just so many things. Usually when people come to the lab I like to let them study what they enjoy, but if they can't think of something, I'll pull up this document and say, "Hey! What about this one?" [*laughs*]

Alie: This, like, 10-foot scroll just produces out of a cloak. "I have some ideas."

It seems like you could do this for decades and decades and still have so many questions to answer.

Elaine: It never ends. It never ends. Actually the more that you discover, there's more questions. It's just exponential, like, curiosity basically.

Alie: You're doing such a great job. I'm a literal fan of your work. Thank you so much for doing this.

Elaine: Thanks!

So. Gather your guts and ask smart people stupid questions because chances are the questions are not crappy. So, to learn more about Dr. Hsiao's work, check out hsiao.science, or you can find her on Twitter [@pipethero](https://twitter.com/pipethero). I will link both of those things in the show notes. *Ologies* is on [Twitter](https://twitter.com) and [Instagram](https://www.instagram.com) @ologies. I'm on both [@alieward](https://twitter.com). I also host CW's *Did I Mention Invention?* every weekend on CW. I'm on CBS' *Innovation Nation* with Mo Rocca every Saturday morning and also on *Brainchild* on Netflix. You can watch all three of those with your children. No swear words.

You can support the making of this show via [Patreon.com/Ologies](https://www.patreon.com/Ologies). Even a dollar a month gets you in the club. You can ask Ologists questions before I record. [OlogiesMerch.com](https://www.ologiesmerch.com) is where to go for t-shirts and now there are wintery items like science socks, and long-sleeve shirts, and knit caps. Thank you Boni Dutch and Shannon Feltus for helping out with all of that. The [Ologies Podcast](https://www.ologiespodcast.com) [Facebook group](https://www.facebook.com) is so great. It's full of really smart, chill, funny people sharing links, and stories, and science facts. Thank you Erin Talbert and Hannah Lipow for being such great admins. The theme song was written by Nick Thorburn of the band Islands. And I appreciate the editing so much of Steven Ray Morris. He also hosts *The Purrrecast* and dino podcast *See Jurassic Right*.

And now if you listen to the very very end of the episode through the credits, I tell you a secret, and today's secret is: I'm in a hotel room in Hawaii. I'm on a business trip for *Innovation Nation* and I'm crouched behind a bed recording this to try to get the least echoey sound. And I started to see that the sun was going down, and so I paused record to go see it, but one of my legs was so asleep. It was just like lumber attached to my body. So, I just crawled across the carpet to stick my head out the window to see the sunset and then I just crawled back with one leg that was just like, "No. I'm not into this."

And now that I'm done recording the asides and the outro, I think I might have a drink with rum in it. I'm in Hawaii. Right? Okay. My microbes are gonna haaaate it! They're gonna hate it. I'm gonna have a side salad, too. Please calm down.

Okay. Berbye.

[*Outro Music*]

Transcribed by B. Stewart Caswell, who once had dinner with a member of the Dutch Royal Family in a high-school cafeteria.

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[The natural gut of the Amerindian Yanomami people](#)

[“Office Space” yeeeeeah drop](#)

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