## Erin Welsh

"July 3rd. I woke that morning lethargic. The coffee didn't help my energy materialize nor did it clear away the clouds that had formed in my brain. My function ability was so affected that at one point I was sitting at my desk holding my head in my hands. That was the moment home seemed like the best place for me to be. Something was wrong, something was churning. That was the night the sickness hit. It reared its ugly head first by the expulsion of the contents of my stomach. I couldn't stop it from happening, try as I may no deep breath would stay the sick. I was thwarted at every turn, worship at the throne of the toilet god was inevitable. Dehydration became the scariest factor in this situation. I was losing more water than I could drink partly because I had no desire to drink. I tried to work, I tried to eat, I slept on my sofa, I slept in my bed, I didn't get dressed, I barely ate. Sitting in my apartment alone, feeling the rumblings of my bowels, knowing that I was getting neither enough water nor nutrients was alarming.

July 8th, Tuesday, a week since the beginning. Niagara rushed again. All the happiness and confidence that had been present on Monday got flushed right down the toilet. I was scared but I thought I just had to keep waiting.

July 24th. I sent an email to my doctor's office pleading my case, begging for a spot in his busy schedule. Three weeks after life took a drastic turn towards Liquidville, I had an appointment.

July 26th, Thursday. How was I going to catch the evacuating contents of my colon? Bowl? Bag? Milk jug? Milk jug with the top cut off? Ew. A bag it was. Having finally figured out how to catch the liquid, I was ready. Now to the fun part. I was back on my knees at the throne, only this time I was armed with a spoon smaller than one used to feed a child its baby food. Thankfully I only had to scoop about a 1/4 inch worth of waste into each vial. With a spoon that small though it took scoop after scoop.

July 29th, Sunday. I got a call from another doctor who works with my doctor. I'd been compromised! Small amounts of the parasite Giardia had been found, a parasite. I had a parasite. After the initial shock, relief again washed over me. It was treatable with an antibiotic and I could actually start it that day.

August 5th, Sunday morning. I took the final dose of antibiotic. The party is over, Giardia has left the building. As the host of a few human parties in my time, this was one of my least favorite. A host should have fun at their won party but this party was full of selfish guests. They took and took and took from me, giving me nothing in return for my accommodations."

TPWKY	(This Podcast Will Kill You intro theme)
Erin Allmann Updyke	(laughs) You find the best firsthand accounts, Erin.
Erin Welsh	(laughs) That one is one of my favorites, I think. It's amazing. Hi, I'm Erin Welsh.
Erin Allmann Updyke	And I'm Erin Allmann Updyke.
Erin Welsh	And this is This Podcast Will Kill You.
Erin Allmann Updyke	And where did that firsthand account come from, Erin?
Erin Welsh	So that came from a blog I found, it's michaelrohrer.blogspot.com and it's from a August 2012 entry titled 'Giardia Ruined my Julydia' which is an amazing title.

Erin Allmann Updyke	It's a very good title.
Erin Welsh	So as you might have guessed, this week we are covering Giardia.
Erin Allmann Updyke	Yes we are!
Erin Welsh	The beautiful, beautiful protozoan parasite that will cause you to have horrible diarrhea.
Erin Allmann Updyke	Yes. How fun.
Erin Welsh	Wonderful.
Erin Allmann Updyke	What a joy. This is kind of back to our standards in terms of disease which I feel like we haven't done for a while, so I'm excited to. Like it's a pathogen and it makes you sick like our first season ones, you know? I feel like we've been doing some off the wall crazy episodes lately.
Erin Welsh	We did H. pylori which was along the same lines.
Erin Allmann Updyke	That's true, that's true.
Erin Welsh	No it's hard to keep track, we have done a lot of sort of nontraditional format type ones.
Erin Allmann Updyke	I'm very excited for this.
Erin Welsh	I'm excited to hear all about how it works, I don't really know how it works.
Erin Allmann Updyke	Oh good, I can't wait to tell you.
Erin Welsh	To honor Giardia, what are we drinking this week?
Erin Allmann Updyke	Our quarantini this week is Backpacker's Delight. (laughs) That's a good name.
Erin Welsh	(laughs) Thus named because it is a very frequent infection in backpackers and many other people as well.
Erin Allmann Updyke	Yes.
Erin Welsh	But backpackers tend to get it from drinking contaminated streams. So make sure to filter your water, people. What's in Backpacker's Delight?
Erin Allmann Updyke	In this beverage we have coconut water, you know to rehydrate you after all that diarrhea.
Erin Welsh	Perf.
Erin Allmann Updyke	Pineapple juice because it's tasty with coconut water.
Erin Welsh	Delish.
Erin Allmann Updyke	Ginger liqueur because that's good for your stomach, right.

Erin Welsh	Fanc.
Erin Allmann Updyke	And vodka.
Erin Welsh	(laughs) Not good for you stomach, not good to rehydrate you.
Erin Allmann Updyke	No.
Erin Welsh	But essential for our quarantini.
Erin Allmann Updyke	Yes.
Erin Welsh	But our placeborita does not contain alcohol and we will post the recipe to both the quarantini and the alcohol-free placeborita on our website and on our social media platforms.
Erin Allmann Updyke	Yes we will. So before we start on today's episode I actually have two corrections that I'd like to make that people emailed us about. So very quickly. One is from I believe our last episode or second to last episode on encephalitis. So in that - this is very embarrassing, Erin - you mentioned that Robert de Niro won the Academy Award and I was like oh I'll fact check you and I did that live during our recording of the episode and I failed at fact checking you. I did it incorrectly. Robert de Niro did not win Academy Award for Best Actor for Awakenings.
Erin Welsh	But he was nominated.
Erin Allmann Updyke	He was nominated.
Erin Welsh	Okay.
Erin Allmann Updyke	Thank you to true trivia nerd Amelia for writing to let us know.
Erin Welsh	Thanks Amelia. Keeping us on the path.
Erin Allmann Updyke	Oscar trivia nerd. Self-proclaimed. Okay. The other one is from our recent crossover with In Defense of Plants where we talked about aspirin. So as I was talking about all the various effects of aspirin, one of the effects of aspirin is that it's an antipyretic or an anti-fever, so it reduces fever.
Erin Welsh	Yep.
Erin Allmann Updyke	And in the episode I mentioned that this is due to its effects on vasodilation. I got overexcited. Vasodilation can produce local heat production, so like if you get a cut and then you have heat, the cut feels hot, that kind of heat production can be from the vasodilation. But systemically aspirin is even cooler in that prostaglandins in your brain which aspirin blocks the production of modulate the temperature center in your brain. So aspirin and other NSAIDs actually work by reducing the temperature set point in your brain or blocking the increase in it. And that's how they reduce fever.
Erin Welsh	Oh. Okay.

Erin Welsh Interesting.   Erin Allmann Updyke For anyone listening who has no idea what I'm talking about, that means you didn't listen to our aspirin episode so you should go check it out. Hey! (laughs) Okay, is that all the business that we have?   Erin Welsh Yeah, I think so.   Erin Allmann Updyke Well then let's take a quick break and then get started on the biology.   Erin Welsh Let's do it.   TPWKY (transition theme)   Erin Allmann Updyke Giardial   Erin Allmann Updyke Giardial   Erin Allmann Updyke Giardial   Erin Allmann Updyke I know, I always call it 'gerardia'.   Erin Allmann Updyke I know, I always call it 'gerardia'.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke Giardia.   Erin Welsh It's like you're saying Gerardia Butler.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke Is that better?   Erin Allmann Updyke Is that better?   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay but 1 am alwa	Erin Allmann Updyke	So that's actually a much cooler mechanism and I'm really bummed that I didn't mention it in that episode, so thank you very much to Kelly for emailing about this.
our aspirin episode so you should go check it out. Hey! (laughs) Okay, is that all the business that we have?   Erin Welsh Yeah, I think so.   Erin Allmann Updyke Well then let's take a quick break and then get started on the biology.   Erin Allmann Updyke Well then let's take a quick break and then get started on the biology.   Erin Welsh Let's do it.   TPWKY (transition theme)   Erin Allmann Updyke Giardia!   Erin Welsh Okay first of all there's only one 'R' in Giardia.   Erin Welsh I know, I always call it 'gerardia'.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke I know, I always call it 'gerardia'.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke Giardia.   Erin Allmann Updyke Is that better?   Erin Allmann Updyke Is that better?   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay.   Erin Allmann Updyke Okay but 1 am always afraid that 1 am gonna do that so 1 never say that word	Erin Welsh	Interesting.
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Erin Welsh Say it.	Erin Welsh	I think it's the biology equivalent of saying 'nucular'.
	Erin Allmann Updyke	Okay but I am always afraid that I am gonna do that so I never say that word in public.
Erin Allmann Updyke No. (laughs) Giardia, okay? Beaver fever. That's what we're talking about today. So giardiasis	Erin Welsh	Say it.
which is the disease caused by Giardia-	Erin Allmann Updyke	
Erin Welsh (laughs) Still doing it.	Erin Welsh	(laughs) Still doing it.
Erin Allmann Updyke Giardia. Giardia.	Erin Allmann Updyke	Giardia. Giardia.
Erin Welsh There we go.	Erin Welsh	There we go.

Erin Allmann Updyke	Listen, it's fine. Giardiasis is the most frequently diagnosed intestinal parasite in the United States. That's my first fact for you. It's a massive, massive disease worldwide. It's common among travelers, it's common across the globe, so let's talk about what it is.
Erin Welsh	Yeah.
Erin Allmann Updyke	First of all it's a parasite, it's a protozoan which means it's a single celled organism, protozoan's not a great word but I used it, so there. It has three different species names that people call it and it's all the same species which is just to me the most annoying thing.
Erin Welsh	Oh my gosh, it made it very difficult to research.
Erin Allmann Updyke	Yeah.
Erin Welsh	Cause it has also changed throughout history multiple times.
Erin Allmann Updyke	Oh I'm not surprised about that at all.
Erin Welsh	Yeah.
Erin Allmann Updyke	So in medicine they're more likely to call it Giardia lamblia.
Erin Welsh	Yeah.
Erin Allmann Updyke	But in the rest of everything other than human medicine it's Giardia duodenalis or Giardia intestinalis which is kinda funny cause duodenum is just the first part of your intestine so it's kind of like those are interchangeable. But anyways. Giardia. I'm only saying one 'R' Erin. It's never gonna stop. I can't at this point. It's too late. It's a flagellate so that means it has flagella which we've talked about before that they use to move and swim.
Erin Welsh	Like a little tail.
Erin Allmann Updyke	Little tail. In fact not just one little tail, Giardia - god, I did it again, didn't I?
Erin Welsh	Mm-hmm.
Erin Allmann Updyke	Giardia has four sets of flagella, so it actually has eight that it uses to swim around and it has two adorable little nuclei that look like eyeballs. Giardia is one of the cutest parasites of all time in my opinion.
Erin Welsh	I was just gonna say I think it is the cutest one we've done so far.
Erin Allmann Updyke	It is, yeah. I think it's one of the top cutest ones ever cause it really looks just like a little person's head.
Erin Welsh	Yeah.

Erin Allmann Updyke	They're so cute. Okay so because this is a parasite we get to talk about the life cycle. As far as parasites go Giardia has a very simple life cycle compared to a lot of parasites. It has two different life cycle forms. Inside of your intestine it's called a trophozoite and this is the form that looks like what I described, so it has two big old nuclei that look like eyes and eight floppy flagella that look like hair running off of it. So the trophozoite form can swim through your intestine, stick onto your gut walls, and then they also divide by fission. So one trophozoite can actually replicate and replicate and replicate all on its own.
	They also then form a cyst phase and the cyst phase is what you're most likely to poop out and what ends up in the environment. You poop out trophozoites too but the cysts are really important in their life cycle because the cysts are very resistant to environmental stressors. So they can survive in water like ponds and rivers and storm drains and mountain streams for weeks to months. And then when an unsuspecting animal comes by to take a drink from that beautiful mountain spring, they're gonna get a big old mouthful of Giardia cysts. And then inside of your body or the animal's body that cyst will then split and produce two trophozoites and begin the cycle all over again. How cool, right?
Erin Welsh	It's beautiful and simple, I like it.
Erin Allmann Updyke	It's simple, yeah. It's simple, it's straightforward. Another thing that's very cool about the cysts is that they're resistant to a lot of the common ways that we disinfect water including chlorination and ozonation or whatever you call it. Ozonification.
Erin Welsh	But the chlorination, is the chlorination that we use to treat the drinking water high enough to kill Giardia?
Erin Allmann Updyke	Nah, dude. You have to filter or you have to boil it.
Erin Welsh	Oh.
Erin Allmann Updyke	Giardia can live in your pool for up to like 45 minutes, not for a long time.
Erin Welsh	Huh, interesting.
Erin Allmann Updyke	Yes! And when you're infected with it you can poop out between 1 and 10 billion with a 'b' cysts every time you poop.
Erin Welsh	10 billion is a lot of cysts.
Erin Allmann Updyke	It's a lot of cysts. And guess how many cysts it takes to get you sick?
Erin Welsh	Probably one?
Erin Allmann Updyke	Well usually about at least 10. (laughs) Anyways so that's why it's really, really common to get Giardia from contaminated water sources, that's one of the most common ways that we think about the transmission of Giardia is from contaminated water. However you can also get infected directly with trophozoites which you're also pooping out at the same time your pooping out cysts. So other places that you can get infected are places that have a little bit less hygiene like maybe daycare centers.
Erin Welsh	Aha.

Erin Allmann Updyke	Which are one of the most common places that we see outbreaks in for example the United States.
Erin Welsh	Yeah.
Erin Allmann Updyke	Tiny humans poop their diapers, rub their hands in it, touch their friends faces, everyone gets Giardia.
Erin Welsh	I mean we see a lot of GI things, parasites, pathogens. Yeah. Filthy, filthy tiny humans.
Erin Allmann Updyke	Yes. Okay so let's talk about the symptoms. Symptoms can range from absolutely nothing, entirely asymptomatic, just feeling normal, pooping out parasites without ever knowing that you're sick to an acute illness that pretty much is self-limited, so you have diarrhea for a short time and then you get better to some pretty severe chronic infections that can result in things like weight loss and malnutrition.
Erin Welsh	Question.
Folia Alles and the data	
Erin Allmann Updyke	Yes.
Erin Welsh	What proportion are asymptomatic vs symptomatic?
Erin Allmann Updyke	That's a good question, I haven't found an exact number on that and in the epidemiology section we'll talk a little bit about why that's hard but it does seem to be a pretty high proportion and it depends on what strains of the parasite are circulating in the area cause different strains are more likely to produce asymptomatic infections than asymptomatic infections. It's a good question. So the variability and presentation like I said is partially due to the virulence of the pathogen, like which one you end up getting infected with. But it also has a lot to do with your own host immune factor, so just something about you that makes you more likely to get a symptomatic infection. And then also the infectious dose, so how many of those cysts did you actually swallow? So let's talk about how it causes these symptoms cause I'm really excited about it.
Erin Welsh	Good. Yes, me too.
Erin Allmann Updyke	So the biggest symptom that you get with giardiasis is diarrhea. You also get generalized abdominal pain, maybe distention, maybe it feels big. Maybe you get nausea and vomiting, you can definitely get that from infection with Giardia.
Erin Welsh	Getting better.
Erin Allmann Updyke	But diarrhea is the number one. So it turns out that we don't know everything about how it causes these symptoms but we do know a few things. So first of all Giardia does not invade your intestine wall. So unlike something like hookworm that when it gets in is gonna make a hole in your intestine and like actually punch through, Giardia doesn't do that. What it does is it has on its ventral surface, so on the opposite side of where the flagella are, it has this adhesive disk. So it uses its flagella to swim through your intestine up to the wall of your intestine and then it uses this adhesive disk to just suction cup onto the wall of your intestine. Isn't that cute?
Erin Welsh	And then do what?

Erin Allmann Updyke	And then absorb your food essentially and just live and replicate. And they replicate by fission so you don't need to have multiple parasites to replicate, they just replicate the way that bacteria do, they just divide. They don't sexually reproduce.
Erin Welsh	There is some question as to whether they do sexually reproduce.
Erin Allmann Updyke	They definitely do recombination which is cool.
Erin Welsh	Yeah, there's some really interesting articles that are like 'Sex in the Dark: does Giardia have sex in the dark?' Or something like that.
Erin Allmann Updyke	(laughs) It would be pretty dark in your intestine.
Erin Welsh	Yep. But so how long does an average Giardia infection last if untreated?
Erin Allmann Updyke	It's hard to say because in some cases it can cause a really prolonged chronic infection. If you just have an acute infection it'll probably resolve in a number of weeks but some people can be infection for months and months.
Erin Welsh	Okay.
Erin Allmann Updyke	So it's a very difficult thing to put like a straight number on. The incubation period, so the time from when you're first infected to when you start showing symptoms is usually between 1 and 3 weeks.
Erin Welsh	Okay.
Erin Allmann Updyke	Okay so once this parasite is attached onto your intestine wall, they have a number of different mechanisms that again none of them are completely well understood but these are the things that end up resulting in you having potentially massive diarrhea. So first is that they basically induce the cells, the epithelial cells lining your intestine to start undergoing apoptosis which is cell suicide.
Erin Welsh	That's bad news.
Erin Allmann Updyke	I know. So they don't directly kill any of your cells but somehow something that they're releasing causes those cells to start undergoing apoptosis and essentially dying.
Erin Welsh	Whoa.
Erin Allmann Updyke	So what that is gonna do is increase the permeability of that epithelial cell layer. So normally the cells of your intestine you can imagine are every tightly packed because you only want certain things to pass through, right? You wanna absorb nutrients but leave a lot of stuff in your intestine, you wanna absorb water but not too much water, etc. right, it's a very fine balance, the whole process of digestion. So you're basically poking a bunch of holes by destroying these cells lining your intestine. On top of that they flatten the microvilli. So microvilli are the protrusions on your intestinal wall that increase surface area to be able to absorb water and nutrients. If you flatten those, then you decrease the surface area, then you can't absorb that water and nutrient as well.

So what that means is that in combination when you have increased permeability and then you also have a decrease in the microvilli, you're completely messing up digestion essentially and absorption. What that means is that you're gonna end up with more stuff left in your intestine and that's gonna pull even more water out from your cells into your intestine instead of the other way, so that means that you're left with a watery stool and that's what diarrhea essentially is, right. It's like your food is passing through without actually getting absorbed.

Erin Welsh	Does diarrhea have to be 3 times in 24 hour period?
Erin Allmann Updyke	That's a very good question. No. There's no official definition on how your classify diarrhea, usually we say 3 loose stools in 24 hours in when you can start being like, 'Oh I have diarrhea and not just like one bad poop' or something like that. But it's not an official official definition.
Erin Welsh	Okay.
Erin Allmann Updyke	Yeah. (laughs) On top of that there have been studies that show Giardia increases the rate of transit through your intestine. So your food is moving faster and if it's moving faster then your body can't absorb everything that's in it. So that's another way that it can cause diarrhea and malnutrition because if it's moving so fast that you can't absorb what's in there, boom dude. No good. Right?
Erin Welsh	I wonder if what you eat affects any of these things.
Erin Allmann Updyke	Ooh, what a good question. That's a very fun question. There's more.
Erin Welsh	Okay. (laughs)
Erin Allmann Updyke	On top of all of that there's some evidence that Giardia causes hypersecretion of electrolytes. So on top of not allowing your intestine to properly absorb electrolytes and other things in your intestine, it causes the secretion of electrolytes from your cells into your intestine and wherever electrolytes go, water goes. So now you have even more water going from your body into your intestine instead of the other way around.
Erin Welsh	It's definitely kicking you when you're down, it's not content to just like wring out your intestines a little bit, it's like no, completely dry.
Erin Allmann Updyke	100%. No, no. Completely dry.
Erin Welsh	Burning some bridges there.
Frin Allmann Linduko	Right? And so that's all of sort of the diarches based things that Ciardia does. Okey?
Erin Allmann Updyke	Right? And so that's all of sort of the diarrhea-based things that Giardia does. Okay?
Erin Welsh	Okay.
Erin Allmann Updyke	Pretty cool. It's a lot.
Erin Welsh	Yeah.

Erin Allmann Updyke	And we don't fully understand exactly how it happens but it's easy to see how the few things that we do know can end up leading to maldigestion, so losing nutrients, malabsorption, not being able to absorb these nutrients. So if you are not able to fight this parasite off and you have it chronically it's easy to see how this can become a pretty serious infection that leads to poor nutrition.
Erin Welsh	Yeah.
Erin Allmann Updyke	Now here's some things that I didn't really realize when I started researching this. In many cases Giardia is linked to later development of a whole host of diseases that we usually consider to be more autoimmune like irritable bowel syndrome.
Erin Welsh	Oh.
Erin Allmann Updyke	There's a pretty strong association between infection with Giardia and irritable bowel syndrome.
Erin Welsh	Okay.
	Unay.
Erin Allmann Updyke	You also can get extra intestinal manifestations, so that means manifestations of this infection outside of your intestine but not from the parasite because again this parasite doesn't penetrate your intestine wall. So the parasite itself isn't traveling through your bloodstream and going anywhere else. But you can still get ocular symptoms, you can get eye infection type symptoms, you can get joint pains, you can get skin rashes from Giardia infection.
Erin Welsh	Does it have some sort of surface protein that mimics human surface protein?
Erin Allmann Updyke	You're so I love this, Erin. I don't know if it mimics human proteins but there is thought that because the intestinal wall permeability is increased, antigens from Giardia are being sucked into your bloodstream and those are what's causing the extra intestinal manifestations. So it's not the parasite itself but it's some of their surface protein that make it into your bloodstream. How cool is that?
Erin Welsh	Oh that's cool, that's cool.
Erin Allmann Updyke	I know, oh my gosh.
Erin Welsh	That's horrible, that's horrible.
Erin Allmann Updyke	It's horrible.
Erin Welsh	I have a question about a symptom.
Erin Allmann Updyke	Yes?
Erin Welsh	Rotten egg burps.
Erin Allmann Updyke	Yeah, I heard you mention that earlier, sulfur burps. I didn't come across that as a thing in researching this but I mean it's totally screwing up your gut, so

Erin Welsh	Yeah I just wondered what specifically would be causing this sulfur smell from that.
Erin Allmann Updyke	Yeah, that's a good question. I don't know. The good news about this parasite is that it's pretty easy to treat.
Erin Welsh	Yeah.
Erin Allmann Updyke	You basically just go on a course of antimicrobials, usually metronidazole or nitazoxanide, there's a couple different classes of antimicrobials that we can use that are very effective so far at treating it. The problem is reinfection is really, really common especially if the reason that you got infected in the first place was that sanitation isn't great where you live or something like that. If you got infected while you were out backpacking you're probably less likely to get reinfected once you clear that infection. But anyways I'll talk a little bit more about that all in the epidemiology section. But anyways that's the biology of Giardia.
Erin Welsh	I like it. On the surface straightforward but I think there's a little bit more interesting things going on.
Erin Allmann Updyke	Yeah and it seems like there's very, very cool research being done on figuring out exactly how this pathogen ends up causing all these different manifestations and exactly how it's affecting all the different cell layers in your intestine, it's very cool. We at this point don't even know exactly how it adheres, we know there's a bunch of different proteins that are interacting on that ventral disc to suction it on but still.
Erin Welsh	Well it's surprising that it's sort of an up and coming field of research considering that it's so widespread.
Erin Allmann Updyke	Yeah, yeah. Shall we take a quick break and then I want you to tell me all about how we got here and where the heck this parasite came from.
Erin Welsh	Okay I'll try my best.
ТРШКҮ	(transition theme)
Erin Welsh	Before I get started I just want to admit that when I was researching this history I had a bit of a tough time and you know this because I complained to you in excess.
Erin Allmann Updyke	I wouldn't say excess.
Erin Welsh	Well I did complain about it, yeah. Which is nice to have this be something to complain about instead of many other things. It shows that my life is pretty good. But the thing is that there isn't a super cut and dry history of Giardia in humans which is strange to me because it is one of the most prevalent water-borne infections and causes of diarrhea around the world today and has probably held that title for centuries. Giardia doesn't have the glitz and glam of a pathogen like cholera, it's more of a background parasite, always kind of causing a bit of trouble here and there but rarely headline worthy.
Erin Allmann Updyke	I just love 'glitz and glam of cholera'. It's fantastic.
Erin Welsh	(laughs) Has anyone said that about cholera before?

Erin Allmann Updyke	(laughs) Not until this podcast.
Erin Welsh	That's why we're here.
Erin Allmann Updyke	Yeah.
Erin Welsh	But the history of Giardia can be condensed pretty much into a few sentences.
Erin Allmann Updyke	Oh, okay.
Erin Welsh	And in most of the papers that I skimmed, that's all that it was. But that wouldn't really make for a very good podcast episode in my opinion so I kept digging deeper. And as I dug more and more into the history of Giardia I found that it was part of a larger story that I could tell, one about a new way to see the world.
Erin Allmann Updyke	Yes! Ooh.
Erin Welsh	Okay. Just bear with me, I hope this is okay.
Erin Allmann Updyke	I love it already.
Erin Welsh	Giardia was first described in 1681 by the famous Antonie van Leeuwenhoek when he was examining his diarrheal poop under a microscope of his own making. Yeah, that's the kinda guy he was.
Erin Allmann Updyke	(laughs) Yep.
Erin Welsh	I think he would've been a fan of TPWKY maybe
Erin Allmann Updyke	We would've been friends for sure, yeah.
Erin Welsh	Possibly. And so this isn't the first time that we've come across Leeuwenhoek during the podcast and I remember this because every time I talk about him I have to try to figure out how to say his name and I end up just crossing my fingers and hoping for the best. But mostly when I've mentioned Leeuwenhoek it's just been in passing. 'So this guy named Leeuwenhoek saw this thing', and then I would move on to another part of the history. But for this episode I really wanted to go more into this period of science and what a critical role the microscope played in the development of many different scientific fields and even more importantly maybe or more interestingly our perception of the world.
	On the surface Antonie van Leeuwenhoek may not have been the person you would have predicted would discover and develop a new way to see the world. He was born in 1632 in Delft in what was the the Dutch Republic. He was a cloth merchant a bureaucrat for most of his life and throughout a lot of his life he didn't really seem preoccupied or even that much interested in the natural world. It was only later that he started to dabble in lens making and maps and collecting of odd specimens and having a curiosities cabinet which was by the way all the rage in the Dutch Republic in the mid 1600s.
Erin Allmann Updyke	(laughs) Of course. A curiosities cabinet? Of course.

## Erin Welsh

Yes. Yes! I want a curiosities cabinet! I'm getting there. Okay. One warm August day in 1674, Leeuwenhoek was relaxed and maybe a tad restless though. Now that he was retired and no longer had his thread counts to keep him occupied he had turned his sights toward natural science pursuits which often pulled him outside into the sun. On this particular August day he does something extraordinary, something that would go on to revolutionize our understanding of the world around us. He had taken some water from a lake that was a couple hours walk away and he put it in the lens and tube mechanism that he had made himself, an early microscope. Even though the lake was cleaned or at least believed to be clean by the people who lived near the lake, the drop of lake water that he examined is teeming with life not visible to the human eye on its own.

accurately measure whatever it was they were interested in and produce consistent results across other observers. And as we know, necessity is the mother of invention. And during the 17th century a lot of invention happened. So all kinds of empirical tools were developed that expanded the realm of human observation. The thermometer, the barometer, the pendulum clock, the telescope, the microscope, these things were all either invented or developed to the point where they were in almost wide use.

Erin Allmann Updyke	That's so cool.
Erin Welsh	It's so cool! Because these tools also, they turned these personal experiences into impersonal numbers. The subjectivity in describing natural events decreased but the words that were used to describe these observations became more specific and more relatable across cultures and languages.
Erin Allmann Updyke	Oh wow, I never even thought about that aspect of it.
Erin Welsh	Yeah! It really did sort of flatten the globe I guess in terms of advancing knowledge. To be able to say, 'How hot is it? It's pretty hot,' or 'It's this many degrees.' Although here I am, Celsius and imperial.
Erin Allmann Updyke	Oh that's okay.
Erin Welsh	We won't get into it.

Erin Allmann Updyke	We have calculators now. (laughs)
Erin Welsh	Yeah exactly, we have Google for that.
Erin Allmann Updyke	Google, yeah.
Erin Welsh	This fascination with empiricism extended beyond those that we studying mathematics or geography or the natural world. This time, so like the mid 1600s, the 1600s, 1700s was a time of observation, of recording. Surveyors would map the land while astronomers mapped the sky and painters used camera obscuras to record scenes from life while natural historians recorded the plants and animals around them. In this time also the boundary between artist and scientist was thin. Some of those that considered themselves catalogers of the natural world had been trained in painting or drawing cause how else could you relay what you were seeing or observing?
Erin Allmann Updyke	Right.
Erin Welsh	And Dutch artists in particular were becoming more detail-oriented with the tendency for art during this time to be more about what is directly observed rather than telling a story or idealizing a person or place by ignoring or glossing over the flaws. This general focus on recording and realism during this time is I think a really important part of the story of microscopy because for the first few decades of its existence the microscope was primarily used to demonstrate the wonders of the natural world. 'Look at this super cool grasshopper. Look at this tiny mite living in your cheese.'
Erin Allmann Updyke	This animalcule. What does he call them?
Erin Welsh	Animalcule. (laughs)
Erin Allmann Updyke	Animalcule. (laughs)
Erin Welsh	And while telescopes shortened distance, bringing far away things closer to the eye, those things were already generally known to humans, just far away. You could see that that star or that planet or that tree was there but if you looked at it through the telescope, it's closer. But microscopes on the other hand revealed this whole new world. And this is feel like would've completely shifted the perception of the natural world and what role humans play in that.
Erin Allmann Updyke	Oh yeah.
Erin Welsh	It's really hard to imagine.
Erin Allmann Updyke	It blows by mind quite honestly.
Erin Welsh	Yeah. It's impossible, it really is unimaginable to wonder at what that would be like today. It would be like discovering that we live in the teardrop of a giant, I don't know.
Erin Allmann Updyke	I feel like, I mean this is not as extreme but I feel like it was how I felt the first time I ever went scuba diving. Like sitting at the bottom of a kelp forest and looking up you realize it's an entirely different world and I feel like it's a similar If you have no concept that things this small exist and then you look at a drop of water and you see this, it's like what? Yeah.

Erin Welsh	Yeah!
Erin Allmann Updyke	That's the closest I can come.
Erin Welsh	I read before that people who go to space, astronauts, and then they look down at the earth that their perception of world, of life, of humanity is forever changed by that in a way that you can't imitate or mimic.
Erin Allmann Updyke	Yeah. Right.
Erin Welsh	And I kind of wonder whether it was similar to that, being some of the first people to say there's a whole new world here and not just being told or seeing pictures of it.
Erin Allmann Updyke	I can't stop singing A Whole New World every time you say it by the way. (laughs)
Erin Welsh	I know. (laughs)
Erin Allmann Updyke	Every single time.
Erin Welsh	It's amazing.
Erin Allmann Updyke	Yeah.
Erin Welsh	But yeah, these microscopes could reveal the tiny, tiny little intricacy of a flea's leg and how beautiful it could be to look at a spider's eye. It's amazing.
Erin Allmann Updyke	It's incredible.
Erin Welsh	And Robert Hooke was one of the first people to develop or to use the microscope in observation and he had this groundbreaking book called 'Micrographia' that displayed the exteriors of these tiny creatures or of everyday objects magnified to sizes never before seen. And he had a fold out of a flea, for instance.
Erin Allmann Updyke	Yeah I've seen that, I've seen that. It's incredible.
Erin Welsh	Yeah I wanna get that. Coffee table book? Wonder if they make it.
Erin Allmann Updyke	Yes!
Erin Welsh	But the simple description of these things soon wasn't seen as enough. Some people were like okay, these microscopes are incredibly powerful tools that should be used to explore the inner workings of both living and nonliving things. How do things work?
Erin Allmann Updyke	Yeah.

Erin Welsh	Just to use them only on making pretty drawings seemed like a waste to a lot of people. Okay so Leeuwenhoek would not have been unfamiliar with microscopes or at least magnification using lenses because as a cloth merchant he had to inspect his fabric for thread count. So it makes sense that he would have maybe tried experimenting with lenses especially considering the trend that had swept society because people were obsessed, fascinated by lenses.
Erin Allmann Updyke	Oh that is so funny.
Erin Welsh	They wanted to look at the mites crawling in their bread, the fleas on their dogs, anything and everything. By the mid 1600s you could find lens stores in every marketplace and wearing glasses even if you didn't need them could be considered fashionable.
Erin Allmann Updyke	Okay that's still fashionable today, isn't it? So nothing has changed.
Erin Welsh	Yeah. (laughs) Lens crafting varied in technique and quality and imperfections in the glass led many people including Leeuwenhoek to experiment with making lenses of their own. After retiring from the cloth trade, Leeuwenhoek started to venture into lens crafting first with bead lenses which is where you melt the end of a glass rod over a flame and then you draw out a thread of glass, cutting off the end when it becomes a bubble.
Erin Allmann Updyke	What?
Erin Welsh	Yep. And so from these bead glasses you could make powerful lenses but with very short focal lengths. And because you were using flame to create them, you were gonna make a lot of duds before getting a new one.
Erin Allmann Updyke	Okay.
Erin Welsh	So after bead lenses Leeuwenhoek moved onto grinding and blowing glass. His obsession or patience maybe or maybe it was both rewarded him and his microscopes ended up being some of the best known during this time. In his life he made loads of microscopes of varying magnification and construction and quality, an estimated 566 total.
Erin Allmann Updyke	Wow.
Erin Welsh	Of which sadly only 9 survive, 8 with lenses.
Erin Allmann Updyke	I thought I remembered you saying that like he's got a whole cabinet somewhere that just disappeared.
Erin Welsh	Yep, it disappeared. He left it to the Royal Society after his death and somebody went to look at it in the mid 1800s and then the Royal Society was like, 'We don't know where it is.'
Erin Allmann Updyke	That's the most depressing.
Erin Welsh	Anyone who's thrifting or antique hunting in England I think is where the cabinet was last seen, keep an eye.
Erin Allmann Updyke	Yeah man.

Erin Welsh	I think a lot of the other ones too, the glass tubes were melted down, not the glass tubes, the
	gold tubes were melted down for gold. Yeah. But of those surviving lenses, of the 8 ones that have lenses, the magnification ranged from 69x to 266x.
Erin Allmann Updyke	What?
Erin Welsh	But he may have achieved even higher magnification, up to 500x.
Erin Allmann Updyke	That's bananas!
Erin Welsh	He was probably the first person to see bacteria. He saw some on peppercorns.
Erin Allmann Updyke	Wow, I had no idea that he Wow!
Erin Welsh	Yeah.
Erin Allmann Updyke	225 is a lot already.
Erin Welsh	I know. It's amazing.
Erin Allmann Updyke	That is very cool.
Erin Welsh	So Hooke had shown the world this beauty and intricacy of things that humans already knew to exist like the foldout flea but Leeuwenhoek would reveal a whole new world, a brand new world - I'm just gonna keep saying whole new world.
Erin Allmann Updyke	(singing) A whole new world!
Erin Welsh	There we go. That previously had been completely unknown. And he started out like Hooke observing invisible things in miniature but when he stuck lake water under his scope is when he discovered this microscopic, teeming life that was present in not just lake water but rainwater and everything else.
Erin Allmann Updyke	Yeah.
Erin Welsh	It's hard to say whether even Leeuwenhoek realized at first the magnitude of his discovery. He published his observations but they were buried 20 pages in his manuscript around other microscopic observations of things like the working of the eye. And so his description of this new unseen world wasn't met with much acclaim. And he kept sort of writing in with new observations saying, 'Oh remember when I found tons of microscopic life in rainwater? They were very small, they were very small.' And finally he was like, 'Wait, did no one read this? Probably not.'
Erin Allmann Updyke	(laughs) No one makes it 20 pages in, Antonie.
Erin Welsh	Uh uh, come one man. After his repeated writings, people finally did start to take notice of what he had said and they were like, 'Eh, really? Come on.' There was a little bit of disbelief happening. Because Leeuwenhoek was describing a world that was unimaginably small. He was describing living creatures 10,000x smaller than the smallest thing perceivable by the naked eye.

Erin Allmann Updyke	Jeez.
Erin Welsh	It sounded like a fanciful story made up by a very creative and bored person.
Erin Allmann Updyke	(laughs) An old retired dude.
Erin Welsh	Yeah. The credibility of his findings also wasn't helped by his extreme possessiveness of his instruments. He was famous for jealously guarding the secrets of how he made his powerful microscopes. And this was super frustrating to the Royal Society who had no patience for people obscuring the methods behind their discoveries, acting like magicians. And that's I think reasonable.
Erin Allmann Updyke	Yeah.
Erin Welsh	Cause how can you take someone at their word who claims that the water you drink, the rain that falls contains billions, trillions of small animals invisible to the naked eye?
Erin Allmann Updyke	Right.
Erin Welsh	It sounds absurd.
Erin Allmann Updyke	And they won't tell you how they made the thing in order to look at it.
Erin Welsh	Right.
Erin Allmann Updyke	Yeah.
Erin Welsh	Yeah. And he recognized that this was standing in the way of the world accepting his immense discovery but he was too stubborn to do anything about it. So what he did was he was like, 'Alright, now you all can come here to look through the lens for yourselves.' And they were like, 'I'm not gonna do that, man. We're in England, we're not gonna go all the way to Delft.' It's not that far. But then so he was like, 'Okay fine, stay there, don't come here.' He got people to sign affidavits saying that they had seen this in his scopes. (laughs)
Erin Allmann Updyke	This guy.
Erin Welsh	And they were like, 'Okay it's a little bit better but we're still not content.' So then the Royal Society was like, 'Alright, we just need somebody else to do this.' So then they pulled Robert Hooke away from his workings of circulatory systems and respiratory systems. Cause Hooke had by now moved on from microscopy.
Erin Allmann Updyke	Okay.
Erin Welsh	And they were like, 'Okay Bob, will you try to replicate these findings?'
Erin Allmann Updyke	Bob, can you help us out here?
Erin Welsh	Bob! And bob did. So he did eventually after a little bit of trying find these animalcules that Leeuwenhoek had supposedly seen. So that was a pretty big step, his world was confirmed.

Erin Allmann Updyke	Yeah.
Erin Welsh	And this discovery caused this major shift. Once it was confirmed by Hooke it was reported widely and it caused this major shift in human perception because suddenly the world both grew and shrank.
Erin Allmann Updyke	Yeah.
Erin Welsh	Some people were comforted by it, taking it as evidence of a divinely created world while others took a more nihilistic view.
Erin Allmann Updyke	Ooh.
Erin Welsh	Yeah. For his part, Leeuwenhoek didn't stop at examining lake water or rainwater. Once he'd gotten a glimpse of those microscopic worlds teeming with life there was no substance off limits. He looked at his own blood, urine-
Erin Allmann Updyke	Of course.
Erin Welsh	Tooth plaque, pus, gunk from between his toes after not taking off his stockings for two weeks.
Erin Allmann Updyke	(laughs) That's pretty gross, man.
Erin Welsh	(laughs) Isn't that gross? He also looked at earwax, semen, and of course his own feces.
Erin Allmann Updyke	Poop!
Erin Welsh	Which is of course where he first spotted his sweet little Giardia. One of the things that I think is really fascinating about the development of microscopy is how long it seemed to take for people to make the connection between the little microscopic animalcules seen in sources of drinking water and diarrheal disease.
Erin Allmann Updyke	Yeah.
Erin Welsh	Even Leeuwenhoek was so fond of his little animalcules that he would never have accused them of causing the diarrhea in which he found Giardia.
Erin Allmann Updyke	That's very adorable.
Erin Welsh	He loved them, they were like pets.
Erin Allmann Updyke	Even though he found them in his poop.
Erin Welsh	Yes. I mean he loved the ones in rainwater, he missed them when he went away.
Erin Allmann Updyke	That's very adorable.
Erin Welsh	Yeah. Okay so going into Giardia little bit now. It took almost 200 years after Leeuwenhoek first observed Giardia in 1681 for it to get an official name and even then it would be another 100 years or so before it was officially recognized as actually causing disease in humans.

Erin Allmann Updyke	Does that mean we're talking about the 1900s?
Erin Welsh	Yes.
Erin Allmann Updyke	What?
Erin Welsh	Yeah. So in 1859 Vilém DuŠan Lambl, I probably said that wrong, was a Czech scientist and he was examining the stool of a child, found it teeming with Giardia protozoa. He called them Cercomonas intestinalis but the name eventually was changed to Giardia lamblia to honor Lambl and Alfred Giard who also described the parasite. So to put the official discovery of Giardia in 1859 into our history of disease timeline, that happened just a few years after the infamous Broad Street cholera epidemic in London and as we remember from that cholera episode, the theory of miasma was in full swing at that time.
Erin Allmann Updyke	Mm-hmm.
Erin Welsh	Of course over the next few decades people would use microscopes to develop the field of germ theory, linking a parasite or pathogen to the site of infection. And microscopes were also used to develop so many other fields both in biology, in chemistry, in physics, and everything. It's amazing.
Erin Allmann Updyke	I don't know why I was expecting that since it's a parasite it somehow would've been earlier.
Erin Welsh	Yeah.
Erin Allmann Updyke	But I mean it's still microscopic, it's still like malaria. Yeah.
Erin Welsh	Well it's still microscopic but even when it was recorded and given a name in 1859 it was still just seen as an organism, not necessarily a parasite.
Erin Allmann Updyke	Right. Yeah, god. That is so interesting.
Erin Welsh	Yeah I was thinking about this and I'm like well okay, that seems like one of the easiest links to uncover between microbe and disease.
Erin Allmann Updyke	Yeah.
Erin Welsh	But it didn't seem like it got a lot of focus and maybe that's because it was almost ever-present and didn't necessarily cause a lot of obvious mortality or epidemics.
Erin Allmann Updyke	Right.
Erin Welsh	Even though it did cause occasional epidemics.
Erin Allmann Updyke	Yeah and if you can have just Probably everyone was infected with it so you're testing everyone's poop and not everyone is having diarrhea, you're still gonna see Giardia in everyone's poop so you wouldn't think
Erin Welsh	Yeah.

Erin Allmann Updyke	Yeah, yeah that makes sense.
Erin Welsh	So it's a little bit of a harder Yeah. And there were some researchers in the early 1900s that claimed that Giardia was a common cause of diarrhea and they had conducted experiments on both humans and animals to observe the effects of the infection and they also had recorded their observations of giardiasis in English soldiers in WWI, I think. But interest in the parasite seemed to wane throughout the 20th century. So the WHO officially declared it a human pathogen or parasite in 1981 but it wasn't officially recognize as fulfilling all the postulates until 1987 and even after that it was still debated whether some cases of disease could be contributed to the parasite. Yeah.
Erin Allmann Updyke	That's like in our lifetime.
Erin Welsh	I'm surprised, I know.
Erin Allmann Updyke	I can't evenwow.
Erin Welsh	And this decline in interest I think was possibly maybe due to the massive reduction in water- borne infections throughout the developed world as water filtration increased. So I couldn't really find any good numbers for global prevalence of Giardia throughout history and that's maybe because it was only recently recognized as a human parasite and possibly because it dropped off in places that had the highest amounts of research funding. But even though I can't give you hard numbers, I can make some guesses which is a statement that the 17th century Dutch Society would've hated. It was very non-empirical.
Erin Allmann Updyke	(laughs)
Erin Welsh	Giardia has probably infected humans for millennia as is evidenced by its global distribution and prevalence likely increased as humans settled and population density increased. As water treatment and filtration became more widespread in the first half of the 20th century, cases of intestinal diseases declined in many places as did mortality from water-borne diseases. So for instance in 1900 if you lived in the U.S. you had a 1 in 20 chance of dying of a gastrointestinal infection before you were 70 years old.
Erin Allmann Updyke	Whoa. That's a lot.
Erin Welsh	Yeah. By 1940 that was a 1 in 3333 chance and in 1990 a 1 in 2 million chance.
Erin Allmann Updyke	Wow.
Erin Welsh	But for much of the world the risk of dying of a water-borne disease remains staggeringly high and Giardia remains one of the most common infections and causes of morbidity out there. So Erin, tell me exactly what we're dealing with in Giardia today.
Erin Allmann Updyke	I'd love to. We'll take one more quick break.
ТРШКҮ	(transition theme)
Erin Allmann Updyke	It's funny that you said you couldn't find good numbers on Giardia throughout history because I couldn't find good numbers on Giardia today.

Erin Welsh	What's the deal?
Erin Allmann Updyke	End of our episode. Just kidding.
Erin Welsh	This is the most slept on parasite out there.
Erin Allmann Updyke	So this is a disease that is so widespread that on the World Health Organization website page about giardiasis it just says "distribution: worldwide". (laughs)
Erin Welsh	Wow.
Erin Allmann Updyke	Like legit, that's what it says. So according to the CDC nearly 2% of adults and 6-8% of children in developed countries will be infected at some point in their lives with Giardia and nearly 33% of people living in developing countries will have been infected at some point in their lives.
Erin Welsh	And we still don't exactly know how it causes disease.
Erin Allmann Updyke	Well apparently it was alike 30 years ago that we decided we'll call it a human pathogen.
Erin Welsh	Yeah!
Erin Allmann Updyke	So when you hear that it's not that surprising.
Erin Welsh	Yeah, that's true.
Erin Allmann Updyke	Yeah.
Erin Welsh	Wow.
Erin Allmann Updyke	So it's by a long shot the most common human intestinal parasite diagnosed in the U.S. I did find a few numbers, one of the papers that I read reported at least a few numbers so I'll give those to you. Between 2006-2008 in the U.S. there were at least 20,000 cases reported annually and the estimated actual number was closer to 2 million. And that's in the U.S.
Erin Welsh	Okay.
Erin Allmann Updyke	And for you in Finland In Finland, Norway, and Sweden, again in like the mid 2000s, they estimated that for every single case that was reported there were likely between 250 and 850 actual cases that went unreported.
Erin Welsh	Wow!
Erin Allmann Updyke	Yeah. And then throughout Europe the numbers really vary, like hundreds to thousands to tens of thousands reported every year. So we just absolutely do not have a good handle on how many people are actually infected at all.
Erin Welsh	It's a real tip of the iceberg situation.
Erin Allmann Updyke	And here's where it gets even more fun and even more tip of such a large iceberg, Erin.

Erin Welsh Erin Allmann Updyke	Okay. This was thrilling to get to read. One of the biggest things that we absolutely do not have a
Erin Allmann Updyke	
	handle on that we're still trying to figure out is in regards to how much overlap there is between cycles of this disease.
Erin Welsh	Between cycles.
Erin Allmann Updyke	Let's talk about it.
Erin Welsh	Yes.
Erin Allmann Updyke	So as it turns out there are several distinct cycles in which we can identify that Giardia circulates. There's wildlife cycles, so wildlife poop in the wild and infect other wildlife. Okay, that's a wildlife cycle of disease. There's livestock cycles where livestock on a farm poop on that farm and infect all the livestock on that farm. That's a livestock cycle. There's domestic animal cycles like dogs and cats infecting each other. And then there's human cycles where humans poop and infect each other. The question that we don't know is how much overlap is there between these cycles and what kind of overlap is it. Are things being directly transmitted between wildlife and humans? Is it all water-borne transmission between wildlife and humans? Is it more cycling between livestock and humans or between humans and livestock? Which direction do these spillovers occur? And are there distinct species or subspecies of Giardia being transmitted between these different groups or is it all the same parasite? We have no idea, Erin.
Erin Welsh	But I imagine that there's work being done on geographical variance or subspecies or whatever.
Erin Allmann Updyke	Yeah, there's very, very cool work being done on the molecular epidemiology of Giardia. It's very cool.
Erin Welsh	a couple questions real quick.
Erin Allmann Updyke	Yes.
Erin Welsh	Because you mentioned wildlife and livestock. What do we know about the prevalence in - I know that this is a huge question but like in general is there much known about the prevalence of Giardia in wildlife or different wildlife species? Everyone calls it beaver fever and we can't get through the episode without saying beaver fever.
Erin Allmann Updyke	Yeah.
Erin Welsh	And so what is the actual prevalence in beavers? And then second question or fifteenth question, what about livestock? Are pigs more likely than cows? Are chickens more likely than goats? Where?
Erin Allmann Updyke	Erin, you're asking all the right questions. You're 100% asking all the right questions. I don't have the answers to all of them.
Erin Welsh	Erin!

Erin Allmann Updyke	(laughs) Livestock are affected at very high rates in general and a lot of times if you end up with one for example infected cow on a farm, then you're likely to have every single cow infected on that farm. So that's livestock, it's very, very common among livestock. How common it is among wildlife totally varies and depends on what type of wildlife you're talking about and where they are because again this is a parasite that's found across the entire globe.
Erin Welsh	Are there any species that don't get infected when exposed?
Erin Allmann Updyke	Ooh, good question. Don't know.
Erin Welsh	Okay.
Erin Allmann Updyke	Yeah. Have no idea. The other thing is we don't have a good grasp on whether it's distinct species or subspecies of Giardia parasite being transmitted among wildlife and livestock and humans. I know I keep saying it with two 'R's, just leave it.
Erin Welsh	(laughs) I just keep thinking Gerardia Butler.
Erin Allmann Updyke	(laughs) Every time I see your face I know I've said it wrong.
Erin Welsh	I'm trying to poker face this but I can't.
Erin Allmann Updyke	You're failing at a poker face. But there is a lot of molecular epidemiology work being done to try and figure this out because WHO has classified this as a zoonotic pathogen which means that you would expect that most of the transmission happens in a zoonotic pathogen between wildlife or other animals and humans. But in many cases that doesn't seem to be the case and it might even be more likely that humans are actually infecting wildlife at just as high if not higher rates than wildlife end up infecting humans.
Erin Welsh	Mm-hmm.
Erin Allmann Updyke	Mm-hmm. It's so cool. So while there's no doubt that Giardia can be a zoonotic disease, we don't know how frequently it's actually zoonotic vs just a human disease that circulates among human populations.
Erin Welsh	Also quick question, what's the opposite of zoonotic? Is it anthro-
Erin Allmann Updyke	Anthroponotic? Anthroponotic. Fact checked me.
Erin Welsh	I'm doing it.
Erin Allmann Updyke	Thank you.
Erin Welsh	Anthroponosis, yeah.
Erin Allmann Updyke	Anthroponosis. Yep, there we go. Perfect.
Erin Welsh	Cool.

Erin Allmann Updyke	So we don't know fully. I will post a link on our website to two very great reviews, one from 2004, another from 2011 that dive really deeply into this. We don't have time in this episode to dive into all the different subgroups and subspecies and whether there should be multiple species of Giardia duodenalis or not, etc etc. But what I do wanna say is it seems as though at this point a lot of the transmission and a lot of the outbreaks that we see in humans happen between humans, human to human transmission. So while things like drinking surface groundwater from a mountain stream is absolutely a risk factor for getting giardiasis it's not like we can just blame it on the beavers. Don't blame it on the beavers! It's equally possible that that water has been contaminated by humans or domestic or livestock animals. Isn't that just so cool?
Erin Welsh	That's very interesting.
Erin Allmann Updyke	It makes so much more sense to me knowing that it's been so recent that people have even been recognizing this as a disease because I was like how do we know so little about the molecular epidemiology and the distribution of this disease among wildlife and livestock and what species of subspecies are affecting humans vs wildlife? Like it's bananas to me that we know so little. But there's very, very cool research being done on it.
Erin Welsh	Yeah, good.
Erin Allmann Updyke	The other big field of research right now is in vaccines. So there does exist already a licensed vaccine for dogs and cats but it's not great, it doesn't work very well as it turns out. It decreases the shedding of cysts in the stool of dogs but it doesn't actually prevent infection or reduce symptoms of the disease so it's kind of If you're talking about giving it to your pet dog it doesn't seem to actually be that helpful.
Erin Welsh	Okay.
	Okdy.
Erin Allmann Updyke	But that just means that there's room for new research. I found a very cool study that was published in 2016. It was a massive, massive study. Sometimes I look at these and I'm like good lord, you put like 6 years of work into one paper.
Erin Welsh	Yeah.
Erin Allmann Updyke	But it was Nature so, you know.
	·····,,
Erin Welsh	Yeah. (laughs)
Erin Allmann Updyke	(laughs) So this group developed a vaccine, a component vaccine that was actually a vaccine against the human genotypes that are more common among humans than dogs and cats.
Erin Welsh	Okay.

Erin Allmann Updyke	And it was a component vaccine so just the surface proteins, not an entire killed parasite which is what the vaccine that's for dogs is today. So in this paper they showed that this vaccine could both stimulate an immune response in puppies and kittens, so actually stimulated their immune system to develop antibodies, that this immune response was actually protective against infection with Giardia. So they exposed the puppies and kittens to Giardia and then they vaccinated dogs and cats in a community and they found that it protected the puppies and kittens of the dogs and cats in that community from infection. So over time infection was less in the dogs and cats that were vaccinated, in fact none of the dogs and cats that were vaccinated ended up getting infected after two years.
Erin Welsh	Whoa. That's great.
Erin Allmann Updyke	Yeah. On top of that, they tested children in that community and infection in children in that area decreased over that time period as well. So in this paper they were suggesting that vaccinating dogs and cats against this specific species or subspecies, this specific genotype of Giardia could actually help potentially prevent the spread of disease in humans even.
Erin Welsh	Huh.
Erin Allmann Updyke	Based on a lot of the other molecular epidemiology studies, it seems like that's very context- dependent because in a lot of communities there's actually very little overlap between the genotypes of Giardia that circulate among dogs and those that circulate among humans so it would really depend on So where they did this study in Argentina that happened to be true but in another community it very well may not be.
Erin Welsh	Right.
Erin Allmann Updyke	But it's still very cool. So and again I'll post the link to that study as well of course.
Erin Welsh	So about the widespread prevalence of Giardia and how problematic it is for nutrition and just overall health, what are the kind of secondary outcomes associated? Like in terms of dallies or anything else like that?
Erin Allmann Updyke	So I couldn't find numbers on that, a lot of the studies on Giardia that look more at that Giardia becomes more important in cases of coinfection. So when you have areas where you have really high rates of coinfection with Giardia and things like hookworm or other intestinal worms, that's when you see worse outcomes for people in terms of nutrition and malnutrition and things like that. But just looking at Giardia alone, there's not a ton of great epi data that I was able to find.
Erin Welsh	Okay. Interesting.
Erin Allmann Updyke	Yeah.
Erin Welsh	Yeah.
Erin Allmann Updyke	So yeah that's pretty much giardiasis in a nutshell.
Erin Welsh	Wow. How bout it.
Erin Allmann Updyke	How bout it. Don't swim in a pool if you have diarrhea. Please.
Linn ann opuyke	non souch. Son commini a poorn you nave diarried. riedse.

Erin Welsh	Yeah.
Erin Allmann Updyke	That's what I gleaned from all of this. (laughs)
Erin Welsh	I have one more question for you.
Erin Allmann Updyke	Okay.
Erin Welsh	How scared should we be of Giardia?
Erin Allmann Updyke	I think we should be scared that we know so little about it. Gosh.
Erin Welsh	Oh I like that, okay. Maybe it's another H. pylori.
Erin Allmann Updyke	Yeah, could be. It really could be. Like who knows what this thing has been doing in our guts for so long? Clearly we have no idea.
Erin Welsh	Causing lactose intolerance in all kinds of people and IBS.
Erin Allmann Updyke	And all kinds of things. IBS, etc.
Erin Welsh	Yeah.
Erin Allmann Updyke	Cool. That's was fun. Sources?
Erin Welsh	That was fun. Okay, sources. I'm gonna mention a couple of books that I read. One is called 'Drinking Water: A History' by James Salzman and the other one is called 'Eye of the Beholder: Johannes Vermeer, Antonie van Leeuwenhoek, and the reinvention of seeing'. That's by Laura Snyder.
Erin Allmann Updyke	Ooh.
Erin Welsh	So if you just google 'eye of the beholder' you're gonna get a lot of like bodice-ripping romance novels.
Erin Allmann Updyke	(purrs)
Erin Welsh	You have to put in Leeuwenhoek or Vermeer. But this book was really interesting because it dove into both art history and the history of microscopes and it was just a really sort of big picture history book. I really enjoyed it.
Erin Allmann Updyke	So Melissa Allmann if you're listening, you should read it.
Erin Welsh	Yes.
Erin Allmann Updyke	You'll love it.
Erin Welsh	Yes, Melissa. Please. And I read some articles that I'll post the links to on our website.

Erin Allmann Updyke	Yep. As always we'll post the links to all of our sources on our website thispodcastwillkillyou. com. You find our sources from this and all of our episodes.
Erin Welsh	Thank you all for listening, we really appreciate it.
Erin Allmann Updyke	Yeah. Thank you also to Bloodmobile for the music in this episode and all of our episodes and-
Erin Welsh	Stay tuned because you are going to get a wonderful song that if you listened to the hookworm episode you've heard before. Parasite Love Song is gonna play us out. It's the best. Thank you so much to Meramec Valley Girl for letting us play it again. And you can find her website at meramecvalleygirl.com and she also has an Instagram.
Erin Allmann Updyke	All right.
Erin Welsh	Until next time, wash your hands.
Erin Allmann Updyke	You filthy animals!
ТРЖКҮ	('Parasite Love Song' by Meramec Valley Girl plays)