Erin Welsh	"Experiment one. A large vessel containing 170 gallons of saltwater was placed in the open air. The atmosphere was damp and raw. The thermometer both in the air and in the water stood at 44 °F. The subject of the experiment was Richard Edwards, a healthy man, 28 years of age with black hair and a ruddy complexion. The hour chosen for his immersion was four in the afternoon, about two hours after his dinner; a time Dr. Curry tells us appointed rather for his own convenience than as being most proper for the purpose. The heat of the person who was the subject of the experiment was 98 degrees before undressing, his pulse 100 in the minute.
	He was undressed in a room where the mercury was at 56 degrees and afterwards stood naked before the fire til his heat and pulse were examined again and found as before. He then walked pretty briskly into an open court where the northeast wind blew sharply upon him. He was exposed to it for a minute and then plunged suddenly into the water up to the shoulders. The thermometer, which had been kept in a jug of warm water at the heat of 100 degrees, was introduced into his mouth with the bulb under his tongue. As soon as the convulsive sobbings occasioned by the shock were over, the mercury fell rapidly and a minute and a half after immersion it stood at 87 degrees.
	He remained motionless in the water and the mercury rose gradually. At the end of 12 minutes, it stood at 93.5 degrees. Dr. Curry expected to see the mercury rise on changing the medium of water for air and therefore he kept him exposed, naked to the wind, two minutes after taking him out of the bath. To his surprise, although the attendants were rubbing him dry with towels during this time, the mercury fell rapidly. He was put into a warm bed and his heat when examined under the tongue was 87 degrees. Frictions were used and brandy mixed with water administered. Three hours afterwards however he had not entirely recovered his former heat but by eight at night he was in all respects as usual."
TPWKY	(This Podcast Will Kill You intro theme)
Erin Allmann Updyke	Whoa.
Erin Welsh	Convulsive sobbings. As soon as I read that I was like that's the one, that's the one. Yeah.
Erin Allmann Updyke	They kept him cold for so long.
Erin Welsh	So keep in mind that was experiment one.
Erin Allmann Updyke	Experiment one.
Erin Welsh	In subsequent experiments, Dr. Curry seemed only encouraged to try harder.
Erin Allmann Updyke	Okay.
Erin Welsh	So like the experiment seven which I almost included and I was like no, no, that's enough. I'll just read you a little bit.
Erin Allmann Updyke	Oh no.
Erin Welsh	It was supposed to be tried on Richard Sutton, age 19, of a pale complexion and feebler frame.
Erin Allmann Updyke	Okay.

Erin Welsh	And then it said so he was in the water, intended to be in the water for 45 minutes but only made it to like 35. And then when they put the thermometer in the doctor was like well it's reading 83 degrees but it must be that his teeth are chattering so much and so it's just the cold air causing the temperature drop.
Erin Allmann Updyke	Oh god.
Erin Welsh	So that was from an experiment, I don't know, a paper by James Curry titled 'An account of the remarkable effects of a shipwreck on the mariners with experiments and observations on the influence of immersion in fresh and saltwater, hot and cold, on the powers of the living body from the same work' from 1794. Which explains like the most long detailed title.
Erin Allmann Updyke	The title that tells you everything they did in the paper.
Erin Welsh	And also like unethical experiments. Yeah. Yeah.
Erin Allmann Updyke	Oh wow. Well that's a lot.
Erin Welsh	Yeah. Hi, I'm Erin Welsh.
Erin Allmann Updyke	And I'm Erin Allmann Updyke.
Erin Welsh	And this is This Podcast Will Kill You. I like forgot that I had to do that part.
Erin Allmann Updyke	Well I mean we did half the episode it seems.
Erin Welsh	It really does seem like that, yeah. It was a long one.
Erin Allmann Updyke	But really good, really, really sets us up well I think for today's topic which I am thrilled about. We are veering just slightly off course of typical, really not that far off course, let's be honest.
Erin Welsh	Yeah.
Erin Allmann Updyke	We are talking today about a medical invention called the thermometer.
Erin Welsh	The thermometer.
Erin Allmann Updyke	The thermometer.
Erin Welsh	So I will say, this is my little kind of caveat-
Erin Allmann Updyke	Okay.
Erin Welsh	Is that the focus, I would say about half of my part is on the thermometer.
Erin Allmann Updyke	Okay.
Erin Welsh	Yeah. I'll explain later.

Erin Allmann Updyke	Okay, I can't wait.
Erin Welsh	Yeah.
Erin Allmann Updyke	I'm going to talk about fevers.
Erin Welsh	Yeah.
Erin Allmann Updyke	Because like what do we use a thermometer for? Checking if you have a fever.
Erin Welsh	That's mostly what I'm going to be talking about too.
Erin Allmann Updyke	Great.
Erin Welsh	It'll be good.
Erin Allmann Updyke	I can't wait. It's going to be really fun.
Erin Welsh	Yeah. But we have a few things to get out of the way before we get into the content.
Erin Allmann Updyke	Of course we do. Yeah.
Erin Welsh	Yeah.
Erin Allmann Updyke	It's quarantini time.
Erin Welsh	It is. And we're drinking this week Give Me Fever.
Erin Allmann Updyke	Give Me Fever.
Erin Welsh	Like the song.
Erin Allmann Updyke	(singing) You give me fever. That's the song, right?
Erin Welsh	That's the song, yeah. In Give Me Fever, we figured we would have to do some sort of hot cocktail.
Erin Allmann Updyke	Something spicy.
Erin Welsh	Yeah, hot as in spicy. And so we're doing, and I don't know if we've done this before but we're doing a pineapple margarita with jalapeno.
Erin Allmann Updyke	With Mezcal.
Erin Welsh	And Mezcal. Don't know if we've done this exact variation. Hope not. But it's delicious and we will post the full recipe for the quarantini and the non alcoholic placeborita on our website thispodcastwillkillyou.com as well as on all of our social media channels.
Erin Allmann Updyke	We sure will.

Erin Welsh	Yes.
Erin Allmann Updyke	On our website thispodcastwillkillyou.com, there's just so many things that you can find there. You can find transcripts from all of our episodes, you can find sources that we use for every episode, you can find our bookshop.org affiliate account and our Goodreads list and our merch and our Patreon and Bloodmobile who does our music and a contact us form and a firsthand accounts form. It just keeps going on and on.
Erin Welsh	It's the website that keeps on giving.
Erin Allmann Updyke	So check it out. And what else? Business? If you haven't already, please rate, review, and subscribe. It helps us so that other people can listen to this podcast as well.
Erin Welsh	Yeah. Send us episode suggestions.
Erin Allmann Updyke	Yeah.
Erin Welsh	Weekly episodes. We need some ideas.
Erin Allmann Updyke	Yeah.
Erin Welsh	We have lots of them.
Erin Allmann Updyke	We have so many.
Erin Welsh	And they have everyone who has sent incredible suggestions, we are taking you up on some of those this season.
Erin Allmann Updyke	Yeah. It's going to be a great season.
Erin Welsh	It is.
Erin Allmann Updyke	Well should we get into fever?
Erin Welsh	Yeah, I think we should. Let's take a quick break and then jump in.
TPWKY	(transition theme)

Erin Allmann Updyke	I'm gonna try and start at the beginning here. Ready? Pretty much all animals seek to exist at a particular temperature set point, we have to do that. And this particular temperature that our body likes to exist at varies animal to animal. I'm not going to get into the details of it. Endotherms like mammals like us maintain our temperature by physiologic mechanisms like energy production and then vasodilation or sweating to cool ourselves off if we get too hot and produce too much heat or vasoconstriction or shivering or non shivering thermogenesis if we get too cold. As endotherms, we generate our own heat via our metabolism in our body. And our brain, specifically our hypothalamus, has an internal thermometer that keeps really tight control over our temperature. Humans have to stay at around 37 °C or 98.6 °F plus or minus like one degree. And our body and our brain does a really, really good job of keeping us there despite the fact that as humans we live at all of these extremes of temperature and despite the fact that we have massive fluctuations in our energy expenditure and our energy intake and all of these things.
Erin Welsh	Why? I know, I'm interrupting you.
Erin Allmann Updyke	Are you gonna hit me with questions already?
Erin Welsh	Why 98.6 or thereabouts?
Erin Allmann Updyke	Oh I have no idea. That's a really fun and interesting question.
Erin Welsh	Yeah.
Erin Allmann Updyke	Because it totally varies mammal to mammal. I mean dogs and cats run a lot warmer.
Erin Welsh	Birds are super warm.
Erin Allmann Updyke	Yeah.
Erin Welsh	And then you have things like opossums which are like 94 degrees.
Erin Allmann Updyke	Right. And bears. I did a little bit of a deep dive on bears and animals who hibernate in the winter.
Erin Welsh	Yes. God, we love some hibernation.
Erin Allmann Updyke	I know. But I don't know why, like why each animal has evolved to their particular temperature.
Erin Welsh	It might just be-
Erin Allmann Updyke	I assume it has something to do with the rate of metabolism.
Erin Welsh	Right. So there's like body size in terms of metabolism and stuff like that-
Erin Allmann Updyke	Right.
Erin Welsh	And like heart rate.
Erin Allmann Updyke	Right.

Erin Welsh	But it could also just be like drift to a certain extent. There might not be a driver of it.
Erin Allmann Updyke	Exactly. I have a lot of feelings about drivers in general and we'll keep talking about evolution certain things.
Erin Welsh	Oh okay, okay. I'll let you keep going.
Erin Allmann Updyke	Okay. It's a great question though. So extremes of temperature can and do, as we heard in our firsthand account, result in things like hypothermia, 86 degrees is not okay for a human body to exist at, or heatstroke on the other end which kills lots of people every year. But here's where things get really interesting. In hypothermia or in hyperthermia, so when we are exposed to extremes of environmental temperatures, our brain would still be doing its darndest to keep our bodies at a balmy 37 °C. Our temperature set point would remain the same. A fever is what happens when our temperature set point gets moved. When our body, our brain, our hypothalamus that's controlling our temperature set point decides, and we'll talk about why and how, decides we gotta heat things up a little bit. And so it moves that temperature set point and then our body actively seeks to raise its temperature. And that's a fever.
Erin Welsh	Okay. When can I start asking more questions? Should I just let you keep going and assume that you'll explain it all?
Erin Allmann Updyke	I mean I'll probably answer them but like I guess what order you want things in. You can hit me with questions now.
Erin Welsh	No, just go, just go, just go.
Erin Allmann Updyke	Okay. Because if I don't answer them, then it'll be really fun to try and figure out how to answer them. The first question that I assumed that you would ask is how high is a fever.
Erin Welsh	Sure.
Erin Allmann Updyke	But maybe that's too easy of a question. But it turns out actually when I was reading this that different places actually do define it differently. So it made me feel like I need to get off of my high horse a little bit because I do exist on a high horse when it comes to fever.
Erin Welsh	Wait, wait, what do you mean by you exist on a high horse when it comes to fever?
Erin Allmann Updyke	Well okay, I have always 100% of the time learned that a fever is anything above 38 °C which is 100.4 °F.
Erin Welsh	Okay.
Erin Allmann Updyke	So there are a lot of times when people will say oh I have a small fever like 99.9. That is not a fever. That is my high horse. That's me on my high horse.
Erin Welsh	You correcting someone? Thank god they didn't also say a spider is a bug. They would be dead to you.
Erin Allmann Updyke	It would be the end of a friendship for sure. Okay.

Erin Welsh	Yeah. So is there a difference between low grade fever...?
Erin Allmann Updyke	I'm so glad that you asked that question. I hate the term low grade fever.
Erin Welsh	I guess we're not friends.
Erin Allmann Updyke	There's another high horse. But that's just me. Like lots of people use that term. So when I then was digging into this, some organizations like the Infectious Disease Society of America and the American College of, oh I forget the actual acronym but it's the intensive care like academy in the US, they actually said that they kind of consider it more like 38.3 °C or 101 °F, which is even higher.
Erin Welsh	Oh wow. And so you could have been even higher on your horse.
Erin Allmann Updyke	Exactly. I could have. 99.9 is definitely not a fever. But it's really, if you think about it, if you think of 37 as the kind of human typical temperature set point, plus or minus one degree is normal and our temperature is going to vary throughout the day. So one degree off is really not that abnormal. And so I think that that's kind of the main point is that and we'll really get into what happens when we have a fever and like is it bad? Is it good? What, what, what?
Erin Welsh	Yeah.
Erin Allmann Updyke	And so I think that's why in a kind of critical care scenario, you might end up tolerating a little bit higher before you need to say this is a fever that we need to do something about if that makes sense.
Erin Welsh	Okay.
Erin Allmann Updyke	And when it comes to a fever, our body also generally has a lot of mechanisms in place that keep this from getting too high. Usually it stops around 41 °C or 105.8 °F, although some papers that I read said that pre antibiotics we saw more like 42 °C or 107.6. So it's not that it's impossible to go higher. But usually if it's a fever and not heatstroke or heat exhaustion that's happening from external factors entirely but a fever caused by this shift in your internal set point, then there's also these mechanisms in place that will stop it from getting too high.
	So then what is causing this? Why does our brain decide all of a sudden to change our temperature set point and thereby cause a fever? Most of the time it takes two different things to start a fever. It takes some exogenous substance, something from outside of us that we do not produce like for example a bacterial endotoxin or viral proteins, something that our body recognizes as foreign, as not self, that interacts with our immune system. And then it takes substances that we do produce, and these are called pyrogens. Really they're both called pyrogens.
Erin Welsh	Okay.

Erin Allmann Updyke	Exogenous and endogenous pyrogens. Our endogenous ones are things like interleukins and TNF alpha and I'm not going to get into the nitty gritty because it's not that important. The point is that these things together act on our hypothalamus where that temperature set point is. And our hypothalamus then produces something that we've talked about on this podcast before, which is prostaglandin E2 which acts on yet another part of our hypothalamus to kind of slow down how much our warm sensitive neurons fire. And that's what then results in the increase in our body temperature. Now the deep, deep details of what's hitting what and why is it doing XYZ we don't fully understand. But that is the basic picture of it. It's stuff in our body that our immune system recognizes, usually bacteria or viral infections that then trigger our brain to say hey, we need to raise the temperature. So that really raises this question of is a fever this adaptive mechanism to fight off infections? Because the vast majority of the time or maybe not the vast majority but a lot of the time a fever is associated with an infection. So there is a lot of literature about this hypothesis that because fever is this response to infection that it has adaptive significance specific to reducing pathogen survival. And we talked about this kind of in our Blastomycosis episode.
Erin Welsh	Yes.
Erin Allmann Updyke	Just in like yeah, how the evolution of endothermy and having a higher body temperature at baseline might have been adaptive against fungal pathogens like Blastomycosis. So then if you take that one step further, then perhaps having a fever intermittently raising our temperature even higher protects us against other pathogens as well. And we do have some support for this idea, both directly and indirectly. So indirectly there's a lot of evidence that ectotherms like lizards will lay out in the sun to induce a fever. They will raise their own body temperature in order to fight off pathogens when they're infected. Or fish, some fish will swim to warmer water if they're infected which I find so cool.
Erin Welsh	Really cool.
Erin Allmann Updyke	Now in humans the studies are a little bit maybe more indirect I guess, I don't know. But in some studies, for example in the ICU, people who have sepsis and have a fever that's not too high, so usually not above 41 or 40 even celsius, people who have a fever have lower mortality rates than people who do not have a fever. But if that fever gets too high, then it's no longer true. And then there's also like in vitro studies that show that various organisms that tend to cause infections in humans do poorly at higher temperatures. And that fever, one hypothesis as to the mechanism of why is that increased temperatures increase the iron requirements of bacteria and then reduces their survival. I also found this really fun paper that tried to dig deep onto different hypotheses of how you can inhibit pathogen growth. It's too much detail but I'll post it because it's really fun.
Erin Welsh	Yeah.
Erin Allmann Updyke	But the idea is just that we have pathogens that are less well adapted to survive at higher temperatures so raising our body temperature helps us to fight off those infections. That's the idea.
Erin Welsh	I mean and also the fact that fever is highly conserved across mammals. Like mammals in general have fevers.
Erin Allmann Updyke	Fever. yes.

Erin Welsh	So whether it's adaptive across the board, I don't think, I actually don't think anyone has really like tried to argue that point specifically, like I think it's always been there's nuance to it because back even in the 1920s or even before then, people were seeing fever as being adaptive but also realizing that some pathogens cause fever on their own and actually replicate better, ie malaria parasites replicate better at higher temperatures.
Erin Allmann Updyke	Yeah.
Erin Welsh	So it depends I guess.
Erin Allmann Updyke	It depends, Erin. And fever is not a response that's specific to pathogens either.
Erin Welsh	Right, right.
Erin Allmann Updyke	So we also can see fever in malignancies. We see fever in autoimmune conditions. Now in those cases it's very likely that the fever mechanism, like the generation of that fever is due to the same underlying inflammatory mechanisms, right, it's still like our immune system activating the same pathways just without the presence of a bacterial endotoxin to start it off, if that makes sense. But then we also see fever in people with traumatic brain injury, we see fever from endocrine disruptions like hyperthyroidism, and then there's also drug induced hyperthermia where you can get incredibly high body temperatures as a result of drug interactions which is kind of separate, like a separate mechanism entirely. So then the question is like can fever be bad? And like the short answer is yes, definitely. Right?
Erin Welsh	Yeah.
Erin Allmann Updyke	And part of it is that fever is not an isolated phenomenon.
Erin Welsh	Yeah.
Erin Allmann Updyke	So your face just like-
Erin Welsh	I have a question! I have a question. Okay. Are there people who do not get fevers or cannot change that set point?
Erin Allmann Updyke	That's an excellent question. Definitely. And I think that's part of why... So in some of those studies where they have looked at patients in ICUs who have sepsis, people who don't have a fever at all, who are either normothermic or even hypothermic have less good outcomes, like higher mortality and things like that.
Erin Welsh	Yeah.
Erin Allmann Updyke	So not being able to mount a fever response is usually a sign that your immune system is not activating enough. So in terms of what the specific cause of that could be, I don't have a list of things for you but definitely there are instances where you could have an immune system that's not able to mount a febrile response.
Erin Welsh	But I mean like just people, like you can never, not just situationally but like have never been able to have a fever.
Erin Allmann Updyke	I don't know if there's like a documented human who's never fevered.

Erin Welsh	Well it makes me think a lot about like why is it in this part of the brain, the hypothalamus? When did we talk about prostaglandins on this podcast?
Erin Allmann Updyke	Oh when we talked about Tylenol and when we talked about-
Erin Welsh	Oh that makes sense.
Erin Allmann Updyke	Yeah.
Erin Welsh	Aspirin.
Erin Allmann Updyke	Yeah.
Erin Welsh	Okay.
Erin Allmann Updyke	Yeah.
Erin Welsh	Anyway, interesting. Now I'm sort of even struggling to think about like body heat, period.
Erin Allmann Updyke	Oh my gosh.
Erin Welsh	What is it?
Erin Allmann Updyke	I have deep, I've got like four more pages from a paper that goes deep into like the generation of heat in mammals and different mammals and like heat generation and heat loss and all of these like thermodynamics stuff because there's a lot there.
Erin Welsh	I can't wrap my head around it. So sorry to have interrupted. Let's just keep going.
Erin Allmann Updyke	That's okay, that's okay. It is really fascinating.
TPWKY	(transition theme)
Erin Allmann Updyke	But when we look at fever specifically, it's not an isolated phenomenon. Your brain is not causing a fever and that's the only thing that's happening in your body whether it's during an infection or during malignancy or whatever the cause is. The mechanisms of that inflammatory response that are triggering fever also trigger things like an increase in your heart rate, an increase in your metabolism and oxygen requirements. And these things are not physiologically benign, right? They are costly for us. So that is one way that fever can actually cause more damage, right. It's metabolically very costly to have a fever because of all of the other things that come along with it. But on top of that, at a certain point the heat alone damages our cells.

	So we see both cellular and tissue level and then even like organ level damage as a result of that increase in body temperature as a result of fever. And so it makes sense then that there are usually these mechanisms in place, these kind of negative feedback loops that kick in over certain temperatures in order to keep our fevers from getting too high. But you're right, there are situations in which those fail. And there's a few ways to think about that depending on what the cause of fever was. If it is something like sepsis or an overwhelming infection, then a fever that is getting so incredibly high that it's causing things like brain damage or other organ damage is a sign that the damage has already begun. And so your body can no longer regulate that fever cycle, if that makes sense. And the same thing is true if it's a cause like a TBI, like a traumatic brain injury where you've disrupted the ability to do that temperature regulation, period.
Erin Welsh	Why when you have a fever do you feel cold?
Erin Allmann Updyke	Oh that's a really good question. From what I read, it's because your body is trying to raise its temperature. And so it's doing that by things like vasoconstriction in your extremities in order to funnel the heat into your core. So you're going to feel cold. It's also then behaviorally going to cause you to put on layers which is going to help you raise your body temperature. How cool is that? Huh?
Erin Welsh	Yeah. Yeah.
Erin Allmann Updyke	So it's not... I think what's interesting too is a lot of times people are like oh if you have a fever you should try and cool your body down. You should put a cold cloth on, etc. But that is going to fight against what your body is trying to do so then it will actually probably cause you to shiver more, which is the way that you're trying to generate heat, shivering is trying to generate heat.
Erin Welsh	Yeah.
Erin Allmann Updyke	So it kind of works against yourself to do those mechanisms. It doesn't mean they're harmful necessarily.
Erin Welsh	Right.
Erin Allmann Updyke	But it's interesting.
Erin Welsh	But then also like okay, maybe this is just I'm thinking of, I don't know, 'The Secret Garden' or something.
Erin Allmann Updyke	Okay, yeah.
Erin Welsh	But is it like ice bath when the fever is out of control really high where you can sort of like overwhelm externally your body to the point where it brings the temperature down? It sounds and it looked, from the movie Secret Garden, really painful.
Erin Allmann Updyke	Yeah, I don't know that in a fever situation an ice bath would be the way to lower your temperature. In a hyperthermia situation something like that, yes potentially.
Erin Welsh	Okay.
Erin Allmann Updyke	Right. Because your body got overheated externally.

Erin Welsh	Like heatstroke type of thing?
Erin Allmann Updyke	Exactly.
Erin Welsh	Okay.
Erin Allmann Updyke	Heatstroke type of thing.
Erin Welsh	But this was not that. But yeah.
Erin Allmann Updyke	No. I think we have better ways than an ice bath to lower body temperature.
Erin Welsh	It was like the early 1900s.
Erin Allmann Updyke	Right. They didn't in 'The Secret Garden' but we do today.
Erin Welsh	Okay, good to know.
Erin Allmann Updyke	Yeah. Yeah, don't do an ice bath. Not that I'm telling you what to do. This is not medical advice. But yeah, that is kind of the fever. That's the fevers. That's it. That's what I have. Did you have more questions? I have a lot more things I could talk about but that was what I really wanted to get across.
Erin Welsh	Yeah. Okay. So talk to me about when fevers get out of control, why does it cause certain types of responses? Like convulsions, seizures.
Erin Allmann Updyke	Like seizures? Okay. Seizures, febrile seizures we don't fully understand like straight up.
Erin Welsh	Okay.
Erin Allmann Updyke	Febrile seizures are most common in young kids. They're not impossible to happen in older individuals as well and in adults but they're most common in young kids and you don't have to have a high fever to have a febrile seizure. It's not necessarily a function of how high the temperature is.
Erin Welsh	Okay.
Erin Allmann Updyke	And it's not indicative of damage really. What we think is going on is that the same cytokines that are inducing fever also can result in increases in excitatory neurotransmitters and decreases in the inhibitory neurotransmitters. So increases in glutamine, decreases in GABA. And so those things together can result in seizures, right.
Erin Welsh	Okay.
Erin Allmann Updyke	So it's not necessarily a result of the temperature, it's a result of the other parts of the inflammatory response that are doing the same thing. Why is it more common in kids? I don't fully know. But is it because their brains and neurotransmitters are just not all online the way that adults are?

Erin Welsh	Okay.
Erin Allmann Updyke	Probably that.
Erin Welsh	Question about treatments. So obviously we've covered a couple on the podcast before.
Erin Allmann Updyke	Yeah.
Erin Welsh	Aspirin, acetaminophen/paracetamol.
Erin Allmann Updyke	Yeah.
Erin Welsh	We have to do ibuprofen.
Erin Allmann Updyke	We do.
Erin Welsh	Someday.
Erin Allmann Updyke	Someday.
Erin Welsh	And probably something else. Am I forgetting something?
Erin Allmann Updyke	Those are really all that I know about.
Erin Welsh	Which is kind of interesting, I guess quinine which we've already talked about. But this kind of goes along with the whole like evolutionary medicine type of thing which I like very briefly touch on in my section in terms of just like mentioning that there is this conversation sometimes that that springs up about when to treat a fever.
Erin Allmann Updyke	Yeah.
Erin Welsh	And are we fighting against our millions of years of evolution leading to this response that is in many ways good for us or protective?
Erin Allmann Updyke	Potentially, yeah.
Erin Welsh	Potentially.
Erin Allmann Updyke	Right.
Erin Welsh	So like yeah, is there sort of, are there guidelines for this or is this not really... I don't know. Yeah.

Erin Allmann Updyke	It's such a good question. There's not guidelines for it. At least not for like normal people living their normal lives. There are guidelines for like ICUs where there's consensus of this is when you should investigate vs treat a new fever in the ICU type setting because that's where we have like the most data. But really there's not a ton of clinical evidence one way or the other to say like oh we should be treating fevers because the fevers are detrimental on their own or there's not data saying we should let fevers run their because treating a fever causes more problems than letting it run its course. We don't have the data to say that one way or the other.
Erin Welsh	Right. And I feel like I mean I guess you could probably design studies that would not be entirely unethical to do this. You know what I mean?
Erin Allmann Updyke	Yeah. You could. I think that part of the problem is just that it's so... The medicines that we use like acetaminophen and ibuprofen are just so common and so generally safe and well tolerated.
Erin Welsh	Right.
Erin Allmann Updyke	And fevers suck, man.
Erin Welsh	They do, they do.
Erin Allmann Updyke	They feel crappy. And so I think that that is why they're just so common to be used. But I do think that to know that a fever has even the potential to help is a sign that our body's immune system is doing what it is supposed to do and is trying to fight off this infection if it is a result from an infection, right, like assuming that you have a fever because you have an infection. What I think that can provide is just like a peace of mind that like there is no data saying we have to treat a fever. If you're not uncomfortable from it or if you're sleeping through it or like whatever the situation is, you don't have to treat it, right. And I think that that, like we don't have data that says you have to treat a fever in order to prevent harm. Even if it gets pretty high quite honestly.
Erin Welsh	Is this my moment to tell you about my high fever that went untreated?
Erin Allmann Updyke	Yes!
Erin Welsh	Okay. So I was a freshman at the University of Kentucky in 2005. It was my first semester. I was living in Donovan Hall with my roommate Megan.
Erin Allmann Updyke	Shout out.
Erin Welsh	And it was like really just pretty early on. And I got sick, like achey, I don't even know, sore throat probably. And I don't remember much of the week and I missed class a few days in a row and it was the first time "living on my own" quote unquote. And I just laid on my top bunk for days covered in blankets, freezing, couldn't even watch Gilmore Girls which I watched religiously at the time. I do, I remember like vaguely seeing the intro and then just passing back out. And then on I feel like it was Thursday or Friday, in the afternoon my roommate came back from class and she was like I am really worried about you. This is bad. Like you have not moved. Have you eaten anything? Have you had anything to drink?
Erin Allmann Updyke	No.

Erin Welsh	And I just like could not take care of myself because I was used to my mom taking care of me. And we didn't have a thermometer, we didn't have any sort of Tylenol, ibuprofen, anything to like relieve fevers.
Erin Allmann Updyke	Of course you didn't, yeah.
Erin Welsh	Of course not. So then I walked like the half a block with my roommate, my roommate was like we're going to campus health right now. And I remember almost passing out on the walk.
Erin Allmann Updyke	Oh my god.
Erin Welsh	This is such a longer story than I intended it to be. Get into the doctor's office, they see me right away and the doctor, she takes my temperature with an electronic thermometer and looks at it and then leaves the room. And then she comes back again and takes my temperature again, looks at it, leaves the room and comes back with a mercury thermometer and takes my temperature. And I'm just like laying, like I can't even form sentences. And she is like okay, you probably have strep throat, we'll test you to make sure. But I'm going to give you antibiotics anyway and you need to take a Tylenol or something. She's like your fever is 105.5. I didn't believe it. This is why she took my temperature with the mercury thermometer because she's like it must be malfunctioning.
Erin Allmann Updyke	Yeah. Something's wrong with the electronics.
Erin Welsh	Yeah. And so then she sent me back to my dorm with instructions to do all that and she called the ERs during the night to see if I had checked in because she was like-
Erin Allmann Updyke	She was so worried.
Erin Welsh	She's like I felt bad about sending you back. And then by the next day I was fine, it was like 97.6.
Erin Allmann Updyke	Gotta love antibiotics, huh?
Erin Welsh	Antibiotics, I know. That's my fever story.
Erin Allmann Updyke	It's a good fever story.
Erin Welsh	Thanks. 105.5. Never want to experience that again.
Erin Allmann Updyke	105 is just below what I said the physiologic set point was, right?
Erin Welsh	Listen, I push it to the max.
Erin Allmann Updyke	Listen to your body.
Erin Welsh	Take it to the limit one more time. Never again, no.
Erin Allmann Updyke	Oh yeah. Yeah. I feel like that also brings up the interesting point of like treating a fever alone vs like if you're giving antibiotics, you're treating the fever because you're treating the infection which is causing the fever, right.

Erin Welsh	Right.
Erin Allmann Updyke	So yeah. But just like straight antipyretics are like not doing that, right, they're just bringing down the fever. So it's interesting.
Erin Welsh	It is, it's interesting. I feel like I'm going to have more questions for you as we go on.
Erin Allmann Updyke	Okay. Oh that sounds great. So Erin, tell me how did we learn, I'm not going to say like what is temperature but like...
Erin Welsh	Oh god. Yeah.
Erin Allmann Updyke	How did we start to measure it? Tell me about the thermometer. I'm thrilled.
Erin Welsh	Thermommy. Okay, let's take a break and then I'll get started.
Erin Allmann Updyke	Okay.
TPWKY	(transition theme)
Erin Welsh	Well Erin.
Erin Allmann Updyke	Erin.
Erin Welsh	The history of fever. This is not what I told you that I was going to research initially, not what we were like oh we'll do this episode on thermometers and it'll be medical invention, really cool. And like that is really cool and really interesting.
Erin Allmann Updyke	Yeah.
Erin Welsh	And I thought okay, I started out reading and being like how did we even begin to conceptualize temperature and then to create this tool to measure it where we needed fix points? Because you can't just, like how do you know what 98 degrees is?
Erin Allmann Updyke	Yeah.
Erin Welsh	Right? Like compared to what?
Erin Allmann Updyke	You don't have something to compare it to. Right. Yeah.
Erin Welsh	Exactly. So like what is these different fixed points? And then there's like the whole standardization thing, all of that. So like how do you do that across the world?
Erin Allmann Updyke	I mean we still don't, right. Celsius, Fahrenheit, Kelvin.
Erin Welsh	Right. But we can like communicate among those, we can like... What do you call it? Calculate.
Erin Allmann Updyke	Translate?

Erin Welsh	Translate, yeah.
Erin Allmann Updyke	That's not the right word.
Erin Welsh	Yeah, what is it? It doesn't matter.
Erin Allmann Updyke	Convert!
Erin Welsh	Convert! Thank you. I was like calculate, translate, somewhere in there. But yeah, I mean like how do you standardize those temperatures? So even if you're talking about the freezing point of water or the boiling point of water, there is down the rabbit hole. Turns out boiling is not as simple as you would think it would be because it's like there were entire decades of arguments about like no, water is boiling when it looks like this; no, water is boiling when it looks like this. And then you can superheat water so that it actually is higher than 100 °C which is the boiling point of water. But then like at what point does it turn into steam? Is it still...
Erin Allmann Updyke	And like what atmosphere are you at? What elevation?
Erin Welsh	Right. In Denver it boils lower, like at a lower temperature.
Erin Allmann Updyke	Yeah. Yeah.
Erin Welsh	So I quickly was like this is not for me. I am not equipped to do this. But I wrote this whole intro thing where I was like it's so amazing that we have these thermometers because like, and it is really cool. Like what was life like before we had standardized measurements? Like nowadays I can be like Erin, what's the temperature in San Diego?
Erin Allmann Updyke	And I'll tell you.
Erin Welsh	How much does your dog weigh? Can you send me that recipe for espresso fudge cheesecake so I can see if I have enough cream cheese to make it?
Erin Allmann Updyke	Sure can, three bricks.
Erin Welsh	But we can understand and relate to one another and the world around us because we have those standardized units. You can say to me oh it takes two cups of cream cheese, which that sounds like an awful lot but maybe more.
Erin Allmann Updyke	It's more than that.
Erin Welsh	Okay. Well instead of like, I don't know, two scoopfuls of this bowl that I have in my house.
Erin Allmann Updyke	Right. Right.
Erin Welsh	How much does your dog weigh? I don't know, kind of heavy but I can lift him. It's like that kind of thing, right.
Erin Allmann Updyke	Yeah.
Erin Welsh	And so before it would be like oh the castle is three days by horseback.

Erin Allmann Updyke	Right.
Erin Welsh	And what kind of horse do you have? Is it fast?
Erin Allmann Updyke	Does it have a broken foot?
Erin Welsh	Yeah. Is it carrying something? Like are you dragging something?
Erin Allmann Updyke	Are you camping? Yeah.
Erin Welsh	Exactly. Exactly. And so these standardized units are really cool because they help us navigate the world and also really important in science of course, it's so crucial for us to be able to replicate scientific studies being like 0.5 ml, whatever.
Erin Allmann Updyke	Yeah.
Erin Welsh	But then the boiling and superheating, I was like I can't do this, I'm out of my depth. So then I went back to the drawing board and I was like okay, what about the medical use of thermometers? When did we decide that we needed to use those? And then that kind of led me down into what are fevers and the history of fever from capital F Fever to fever the symptom. And I wanted to kind of like take this approach by looking at like what did fever mean to someone in... To Hippocrates et al? What did fever mean to someone in the 1700s? What did fever mean to someone in the early 1900s? Like those things are very different. And then I want to kind of incorporate the use of the thermometer in clinical medicine.
Erin Allmann Updyke	Love it.
Erin Welsh	That's what I did.
Erin Allmann Updyke	I love it.
Erin Welsh	So long intro. But a fever started out, at least as far as we can tell, as a cluster of symptoms, kind of as a disease in its own right or as a frequently encountered state of being. Like it wasn't something that was like super rare. And I will say that if you want like a very full comprehensive history of fever and all of its metaphors, the book that I used for this is called 'More Than Hot: A Short History of Fever'. It's by Christopher Hamlin. And yeah, there's a lot more information than I ever anticipated in there. But in Ancient Greece and Rome fevers were, like I said, kind of the state of being brought on often by external factors not necessarily tied to specific disease. Like working out too hard when it's hot outside could lead to a fever. You're overheating, your body might feel like warm to the touch and your sweat is cooling you down. And so then if you stop working out, that could lead to chills.
Erin Allmann Updyke	Sure.
Erin Welsh	Sure. And then there were fevers associated with epidemics of what we now know to be infectious diseases. Those were kind of more on the periphery of things, like they happened but they weren't as much of an everyday part of life as something like this exerting yourself fever, I guess.
Erin Allmann Updyke	Interesting.

Erin Welsh	Sushruta, so the Ancient Indian medical scholar from around the 700s BCE described fever as the quote unquote "lord of ailment, king of all bodily distempers in as much as it can affect the whole organism at one time". Quote, I have a lot of quotes: "An indispensable condition under which a creature can come into being or depart from this life." I think that's kind of interesting.
Erin Allmann Updyke	Yeah.
Erin Welsh	I don't want to give the impression that fevers were not indistinguishable in ancient times because they were, people did recognize that certain fevers followed certain patterns, like malaria for instance. So there were many ancient medical texts from China and India and Greece that like characterize malaria or other fevers that seem to follow this like every three days or every, however it is, this pattern. Or those fevers that tend to appear during certain times of year or those that appear after wounds like putrid fevers. And the prognosis was different for each of these different kinds of fevers. But the fever was the disease. Do you know what I mean?
Erin Allmann Updyke	Yeah.
Erin Welsh	Like it was a putrid fever. It wasn't like oh that fever is really high because he has a wound and that wound is clearly infected.
Erin Allmann Updyke	No, it was he has Fever.
Erin Welsh	The whole state of being. Capital F, yeah. And those make sense. Like I feel like those, that characterization makes sense to us today. But what I think is a little bit more challenging to grapple with at least in terms of what we know now is something like this passage from the Hippocratic text which kind of brings into question like wait, what is fever? Quote: "Fevers. Some are pungent to the touch, some gentle. Some are not pungent but increasing. Some are sharp but decreasing to the touch. Some are straight away burning hot and some are faint throughout. Some dry, some salty, some with blisters dreadful to see. Some damp to the touch. Some are red, some livid, some yellow. And so on." End quote.
Erin Allmann Updyke	It's almost like they're just using the word fever to mean infection, right? Or am I missing it?
Erin Welsh	Yes. No, I don't think you're missing it but I also don't know. I feel like what we're having a hard time doing is like putting that in our current framework of understanding of disease.
Erin Allmann Updyke	Yeah, yeah.
Erin Welsh	And it's hard to make parallels with that.
Erin Allmann Updyke	Yeah.
Erin Welsh	And so it is sort of like infection but also fevers, like when we think of fevers today, they're an indicator. It's like in your car, like a check engine light going on.
Erin Allmann Updyke	Right, right.

Erin Welsh	Like there's something that might be amiss here and we're not super concerned about the fevers themselves. It's more about like the overall infection. But for the most part we have a strategy with how to handle it and this was less so, like fevers were much more amorphous. I don't know. It's really hard to wrap my head around.
Erin Allmann Updyke	Yeah.
Erin Welsh	And I think that at least the impression that I get was that distinguishing which type of fever that someone had, it was important in understanding like the natural history or possible treatments for a disease. But it was less important, at least in Ancient Greece and China, than understanding the process of fevers. Because then you have to add on this layer of like the humors and humoral theory of disease and balancing out the humors and how much moisture is in your body or whatever. Because okay, you can have putrid fever or you could have like bilious fever or something like that and those could be caused by totally different infections and they could look totally different on the surface. But you would still treat them to balance out the humors.
	And then the fever schedule also mattered a great deal and was kept track of. Like if someone felt bad on the 4th and 7th day with good days inbetween, they would probably die. It was almost like here's your prognosis based on when your fever peaks. And this also lasted like well into the 1800s. It's interesting. And this was in theory supposed to help with intervention as in like the physician would time their visits to be with the patient during those more critical periods and providing treatment or maybe a spell, throwback to abracadabra and malaria.
Erin Allmann Updyke	Yes!
Erin Welsh	But in terms of treatment, if we're going with the humoral theory of disease, different fevers caused by different imbalances of the humors which are blood phlegm, black bile, yellow bile; most of the time it was excess of one humor. And so how do you get rid of a humor? Well if you have too much blood, you bleed them.
Erin Allmann Updyke	Let it out.
Erin Welsh	And bleeding really was like a primary treatment for fevers for hundreds of years. And this also sometimes applied to the prevention of fever which was dependent upon the cause, which was dependent largely upon the patients themselves. So if the cause was something like oh you have too much phlegm, then maybe you should hold off on eating this thing or overindulging in this way, that kind of thing. And that also in turn had very personalized to the person's like social status and class, all of that kind of thing. Just the normal thing that we expect to see. But I also think it's really interesting because this framework of disease that was highly individualized in this way, oh it's your overwork that caused this humor to increase and this is what you need to do; all of that was challenged when epidemic fevers appeared. But then those, there's always an explanation-
Erin Allmann Updyke	Of course.

Erin Welsh	Those could be explained away by society at large is bad and you're all being punished for what you've done. Now go into your room and think about your decisions. Or like the bad winds blew into town, whatever. So the concept of fever or the umbrella term of fever I think is kind of hard to get a handle on even if you're just looking at one time period like antiquity. It was recognized to be elevated body temperature but it was also Fever with a capital F, like a collection of symptoms. It could be brought on by everyday events or seasonal contagions, it could be cyclical or follow a totally different schedule. It could represent a horrible, deadly disease or just be a symptom of a more mild one. It was caused by an imbalance in the humors or too little moisture in the body or overexertion or overindulgence. It was anything, everything.
Erin Allmann Updyke	All of it.
Erin Welsh	All of it. And over the centuries these different definitions of fever kind of ebbed and flowed. Some became more popular, fell out of favor, that sort of thing. And as society and science changed, so did the meaning of fever. So we've already seen this a bit with the onset of fever thought to be caused by like various personality types or lifestyle habits or larger societal issues. But beginning in the 18th century, fever in the quote unquote "western world" became less about disease and even more a state of mind. It's hard from our 21st century vantage point, at least for me, to understand like again what this fever then shifted into. So let me give you a couple of examples and quotes of like some of the range of things that a fever could be.
Erin Allmann Updyke	Okay.
Erin Welsh	This is from the 18th century. The first one is about someone who isolated herself. Quote: "Resolved never to think, speak, answer, or hear. She is quite wearied with saying good night and good morning and has almost every day a touch of fever which a little rest always carries off." End quote. So is that malaise? Fatigue? Elevated temperature?
Erin Allmann Updyke	Right.
Erin Welsh	Something else entirely? All three?
Erin Allmann Updyke	Touch of fever.
Erin Welsh	And then there's this about somebody else's fever. Quote: "At the point of death of a violent fever he got with swallowing two glasses of brandy upon a debauch of wine." End quote. So like was he really hungover? So he had a violent fever from drinking a lot of brandy and wine.
Erin Allmann Updyke	Right. I mean that would make me feel crappy.
Erin Welsh	Right.
Erin Allmann Updyke	Does that mean like body aches and vomiting?
Erin Welsh	It's hard.
Erin Allmann Updyke	That is so interesting. I never thought about it because I just always assume when I've read old timey things if they say the word fever they mean what we mean fever.
Erin Welsh	Yeah. Nope.

Erin Allmann Updyke	Nope.
Erin Welsh	Nope. And during this period, like the 1700s, the early 1800s, fever seemed strongly tied to the brain, either brought on by too much mental work or intense emotions or directly affecting the mind. Like someone's fever causing quote "a lowness of spirits and falling away that alarm everyone." End quote. And I think that this is also really interesting because there is a term, I didn't really get into this too much but like brain fever is a thing that pops up a lot in Victorian literature, I guess like the Bronte Sisters, Charles Dickens, like Pip in 'Great Expectations' gets brain fever at one point, Catherine from 'Wuthering Heights' gets brain fever, dies of brain fever, spoilers.
Erin Allmann Updyke	You're allowed to spoiler 'Wuthering Heights'.
Erin Welsh	Yeah. Statute of limitations. But Elizabeth Gaskell, there was someone who had a brain fever in one of her books. Brain fever was like a trope almost in literature from this time where it was like this emotional shock brought on this fever that could then be a very like physical manifestation of an emotional shock.
Erin Allmann Updyke	It wasn't meningitis.
Erin Welsh	I mean or maybe it was. Like it very well could be. Who knows?
Erin Allmann Updyke	Who knows? Wow, okay.
Erin Welsh	I do think it's really interesting to use popular literature as a lens through which everyday people saw medical understanding from that, like contemporary medical understanding.
Erin Allmann Updyke	Yeah. Yeah.
Erin Welsh	Anyway, sorry.
Erin Allmann Updyke	That's our next Book Club.
Erin Welsh	Yes. There probably is a book like that.
Erin Allmann Updyke	Eventually. Yeah.
Erin Welsh	Okay. But also the meaning of fever had to do with your social standing, right. So those who are living in poverty fell victim to contagious fevers transmitted through unsanitary living conditions or like working too hard, the strenuous physical work. And it was seen as like a societal problem or personal shortcomings. And especially it was like clean it up so that the contagion doesn't affect the rich. And whereas the the origin of the upper class's fevers seem to be much more refined, like too much thinking, overindulgence in rich food or wine or whatever.
Erin Allmann Updyke	Yeah.

Erin Welsh	But this brain fever which like I already mentioned was very different than like bilious or putrid fever or remitting fever or tertian fever. And so it was understood that fevers could be caused by many different things and that there were many different types of fevers. And there began to be I think a dawning recognition that maybe fever as a symptom was at the core one mechanism, one thing with degrees of severity and a basis in the nervous system and vascular system malfunctioning. And so fever as a symptom, what I mean by that is well it's a little unclear but like mostly temperature.
Erin Allmann Updyke	Right.
Erin Welsh	Yeah. But the question then became like how do you measure how severe a fever is? Like how dangerous it is.
Erin Allmann Updyke	Yeah.
Erin Welsh	And so since ancient times, physicians had recognized that fever was associated with the body being warmer to the touch than normal. And sometimes they also observed that the pulse was elevated. One of the earliest pulse measurements was made in the 3rd century BCE.
Erin Allmann Updyke	Okay.
Erin Welsh	Erin, how do you measure a pulse?
Erin Allmann Updyke	You just count it.
Erin Welsh	Against what though? Like what is the unit of pulse rate?
Erin Allmann Updyke	Beats per minute.
Erin Welsh	But how do you measure a minute if you don't have a watch?
Erin Allmann Updyke	They didn't have clocks?
Erin Welsh	So the whole clocks-
Erin Allmann Updyke	A sundial thing?
Erin Welsh	In this 3rd century BCE, Herophilus used a water clock. I'm not sure how it worked but it was like presumably you could measure against this. Like how many drops or how long it took.
Erin Allmann Updyke	Okay. Like a sand timer thingy.
Erin Welsh	Yeah, yeah.
Erin Allmann Updyke	I didn't think about that.
Erin Welsh	Oh clocks are... And then you could use like pendulum clocks type of thing. But you couldn't use those on ships for navigation because...
Erin Allmann Updyke	Right, right.

Erin Welsh	It's so interesting. Anyway I'm not going to do that.
Erin Allmann Updyke	It's so deep just to be able to measure a fever.
Erin Welsh	And so in general, although these two characteristics of fever, body temperature and pulse rate, had been recognized since ancient times, there wasn't a whole lot of effort made to quantify them at least until around the 1700s. So okay, we talked about pulse rate. It was in the 1690s that watches with second hands were introduced.
Erin Allmann Updyke	1690s. Wow.
Erin Welsh	Yeah.
Erin Allmann Updyke	I don't know how to feel about that. It feels very early somehow but I guess I've never thought about when watches were invented.
Erin Welsh	I know, the stuff we take for granted. I'm telling you.
Erin Allmann Updyke	Seriously.
Erin Welsh	I'm telling you.
Erin Allmann Updyke	We're just talking to each other on the freaking airwaves internet.
Erin Welsh	The World Wide Web.
Erin Allmann Updyke	The World Wide Web. And when was a watch invented? Wow. 1690 with second hands. Okay.
Erin Welsh	I mean so before then there were other clocks or ways of measuring time.
Erin Allmann Updyke	Right.
Erin Welsh	But they weren't widely available or widely recognized to be useful in medicine.
Erin Allmann Updyke	Okay.
Erin Welsh	And so in 1707, Sir John Floyer, who wrote about his observations of pulse rate measured against a watch. Quote: "Our life consists in the circulation of blood and that running too fast or slow produces most of our diseases. The physician's business is to regulate the circulation and to keep it in a moderate degree." I don't know how he expected to do that.
Erin Allmann Updyke	Did that? Yeah. That was his job.
Erin Welsh	But that was his job. And so with the introduction of the 60 second watch, pulse rate kind of took center stage in terms of diagnosing a fever by the 17th century. So it was like a fever was not temperature, it was pulse rate.
Erin Allmann Updyke	Right, okay. That's interesting.

Erin Welsh	Yeah. But pulse rate is not ideal for this.
Erin Allmann Updyke	Yeah, yeah.
Erin Welsh	Like your pulse can rapidly change if you're active, if you get stressed it can go up or down without a corresponding change in body temperature. So it became apparent that like pulses could not be relied upon for like every sort of diagnosis. If only there was something that could quantify something like body heat, right? And the thing is by the 1700s thermometers had already been developed. So I love this, this is a quote by Thomas Willis from 1692 about using pulse to diagnose fever. This is about pulse. Quote: "First we consult the pulse as a thermometer constituted by nature for measuring the heat kindled in a fever." End quote.
Erin Allmann Updyke	So they had the word thermometer and they have thermometers but they're like the pulse.
Erin Welsh	The pulse is the thermometer. It is nature's thermometer. Isn't that amazing?
Erin Allmann Updyke	That is fascinating.
Erin Welsh	Yeah. So clearly people knew what thermometers were by this point. What kept them from being used in a medical setting? So the broader history of thermometers, like I said, is too much for me to get into. But I do want to focus on like when they were first used medically. So people had been toying around with measuring temperature for centuries.
Erin Allmann Updyke	Centuries.
Erin Welsh	But most histories put Galileo's invention of the thermoscope around 1595 as the first major advance in measuring temperatures since ancient times.
Erin Allmann Updyke	Wow.
Erin Welsh	Yeah. Yeah.
Erin Allmann Updyke	1590. That is a lot earlier than I thought, Erin. I don't know anything about history. We've done this for so long and this blows my mind. Like oh it's embarrassing.
Erin Welsh	It's not. I mean it's really hard to put this in context.
Erin Allmann Updyke	Yeah.
Erin Welsh	I don't know. Yeah. I also don't know how the thermoscope worked and how different it was to thermometers. But in the decades that followed, people did try to use various thermometers or thermometer-like instruments to measure human body temperature. So like somebody would be holding the bulb end of a thermometer in their hands or popping it in their mouth. But these methods and the measurements produced were pretty crude and certainly not fine enough to make any meaningful connection between fever severity or even establishing a baseline.
Erin Allmann Updyke	Okay.
Erin Welsh	Like I feel like especially when we're talking about a fever being 100 point... No, 101, excuse me.

Erin Allmann Updyke	100.4. 100.4. 101 if you're in ICU.
Erin Welsh	Okay. But that's not very far off from some of the extreme temperatures that you could measure from just like air to ground, whatever, water.
Erin Allmann Updyke	Yeah. Totally. Just go to Arizona.
Erin Welsh	Yeah, exactly. And so there really needed to be a lot more work done to establish a baseline and create instruments that had more fine, where you could actually like measure more finely. So in 1714, Gabriel Fahrenheit, like guess what he did.
Erin Allmann Updyke	The one.
Erin Welsh	He was the one, the chosen one. He invented the mercury thermometer. I don't know anything else about him so I don't know if he was indeed the chosen one. But 1714, right, mercury thermometer.
Erin Allmann Updyke	Okay.
Erin Welsh	And despite how revolutionary this tool could have been, has been for medicine, some people did point that out, it didn't really take off very quickly. So some people like the Austrian physician Anton De Haen took extensive measurements of both temperature and pulse of people of varying ages with varying health throughout the day, changes in temperature or pulse after activity or certain drugs. He was a firm believer that the physician's hand for assessing fever would no longer suffice. Thermometer only from here on out. But he scattered his observations that he had made, these tons of observations throughout a massive treatise that he published in the second half of the 1700s. And so it was just like way too long for anyone to actually make any sense of.
Erin Allmann Updyke	Oh no.
Erin Welsh	So it kind of just skipped. Yeah. And I think that it is still, from this vantage point it is a little bit baffling to be like here's this obvious tool that could be so helpful. How do you not see it? It is literally a part of every physician interaction pretty much or like go to a doctor's office, you're going to get your temperature taken.
Erin Allmann Updyke	Yeah.
Erin Welsh	But I think that we have to keep in mind a few things. So it wasn't that people didn't care about quantifying previously subjective things, like that was very much in style in this time. In the mid 1600s the Royal Society stated that they want to bring quote "all things as near the mathematical plainness as they can." End quote. But medicine kind of was considered to be separate from science at this point in history.
Erin Allmann Updyke	Yeah, yeah.

Erin Welsh	From the 1700s into the 1800s. I've seen it described as science wanting to use these new measuring devices to better understand the world around them whereas medicine was more concerned with a cure, with testing therapies on fever rather than understanding and characterizing fever. So you have people like Benjamin Franklin, very much like scientists observing that human body temperature stayed the same despite the weather outside but not necessarily measuring the body temperature in someone who had a smallpox or plague or something like that, yellow fever.
Erin Allmann Updyke	Right.
Erin Welsh	Plus it was harder to conduct experiments on the mechanism of fever than on possible treatments. The other major factor in this delay was in the thermometers themselves, which still had a long way to go in terms of standardization or quality control. So people would get recordings of 118 °F, like body temperature recordings of 118, 122.
Erin Allmann Updyke	Totally.
Erin Welsh	And the person would be like I'm okay, like I'm just chilling. I don't know what I did. So you can imagine being a physician looking at this reading and going this person shouldn't be alive if this thermometer is right so like this thing is useless, I'm not going to use it anymore.
Erin Allmann Updyke	Right.
Erin Welsh	And so thermometer accuracy did get better. And in 1835 the mean body temp of a healthy adult was established to be 98.6. The last bit of the recipe is just preconceived notions. If you think you knew how fevers worked or even what a fever was, then you're going to be less likely to investigate whether you were right. Like we just take this knowledge for granted and we're like yeah, of course it's that, of course this fever is caused by X, Y, and Z.
Erin Allmann Updyke	Yeah.
Erin Welsh	We don't need to measure the body temperature because it's the pulse rate or we don't need to measure the body temperature because I took a full patient history and they seem to have brain fever.
Erin Allmann Updyke	Yeah.
Erin Welsh	And so it took until around the mid 1800s for enough curiosity or doubt or need or knowledge to emerge to get people to reconsider how fevers worked and conclude that body temperature is actually a much better clinical guide for fevers than pulse. And it was then quickly integrated across medical practice. So for instance, before the mid 19th century patient records at mass general included pulse and respiratory rates but only some of them had those, like not all patients had these things. No other quantitative metric at all. By the 1880s though you've got daily pulse, temperature, and respiratory rate being charted. The thermometer was here to stay. And the knowledge that it generated was exponentially increased by all of the other scientific achievements or advancements happening during the 1800s. The laws of thermodynamics, discoveries of antipyretics, germ theory, showing that different fevers could be caused by different pathogens. Comparing temperature and pulse between typhus and typhoid for instance, even before germ theory was able to distinguish between the two, just looking at temperature and pulse could say that's typhoid, that's typhus.
Erin Allmann Updyke	Because of the pulse temperature dysregulation that happens in typhoid. Check our episode. It's really thrilling.

Erin Welsh	And so all of this helped to transform Fever, capital F, the disease into fever the symptom. From the whole diagnosis to just a data point. It was a huge shift in how diseases were perceived and managed. The individual personality or lifestyle habits like overwork or a troubled mind particularly among the wealthy were no longer seen to be the leading cause of fever. I was trying to think of like what the opposite of a silver lining is. Is it just like the gray cloud across the sun?
Erin Allmann Updyke	I think so.
Erin Welsh	Okay.
Erin Allmann Updyke	Yeah.
Erin Welsh	That's what this is. Thermometers began to show that what a patient felt might not be fact. So like what we talked about when you're shivering and you're like no, I'm really cold, I'm piling the blankets on, doctors could take your temperature and be like you're not cold, you're hot. You don't understand what you're feeling.
Erin Allmann Updyke	Oh dear.
Erin Welsh	Yeah. I mean and so this is one of the less extreme examples but the author of this book, Christopher Hamlin, wrote this little quote that I really enjoyed where he said for a patient quote "a century earlier, fever or feverishness would have referred to a state of feeling akin to a modern mood disorder. One expected a physician to assess its type and probably course and then suggest the best response, not sanction its existence." End quote. So all in all, obviously temperatures or thermometers were an incredibly valuable thing. And if we only had ways to objectively measure many other things, I feel like we could really advance treatment and care for people.
	But what we see happening with temperature and thermometer in the 20th century, the late 1800s and into the 20th century is the trivialization and domestication of fever. Medications became available to bring a fever down and most households began to have a mercury thermometer at home and these medications. So if someone had a fever, you just took care of it at home or you monitored it at home until it got worse. Whereas in the past you would probably have a doctor make a house visit or you would take someone to a doctor. But the story of the fever isn't over, it's almost over, don't worry about it. Because once capital F fever became lowercase fever, people began to wonder why this response existed.
Erin Allmann Updyke	Yeah.
Erin Welsh	Kind of like what we talked about and whether it could be beneficial. And so fever as a response to infection was found to be super widespread across the animal kingdom. And so some researchers took this friend not foe idea and ran with it maybe a little too far, developing something called fever therapy cabinets in the early 20th century where they would treat infections like syphilis that did not include fevers by locking someone's body in a cabinet with just their head poking out and they would crank up the heat until their body temperature got to like 106-107.
Erin Allmann Updyke	Which is not a fever. That's just hyperthermia.
Erin Welsh	Yeah.

Erin Allmann Updyke	Yeah. Great idea.
Erin Welsh	It's called fever therapy, Erin, get with the program.
Erin Allmann Updyke	No. I object.
Erin Welsh	Would you like this next program?
Erin Allmann Updyke	Oh dear.
Erin Welsh	Because I think I've mentioned this before. In 1927 the Nobel Prize for Physiology or Medicine was awarded to Julius Wagner-Jauregg who treated cases of neurosyphilis by infecting his patients with the malaria parasite, a malaria parasite.
Erin Allmann Updyke	Yeah. He got a Nobel Prize for that?
Erin Welsh	Uh-huh. I should have checked to see whether it worked, I assume it did.
Erin Allmann Updyke	Yeah, I would assume if you get the Nobel Prize for it.
Erin Welsh	Yeah. It's kind of interesting. Anyway. And so this this debate, is fever friend, is it foe, is it like the casual acquaintance that you met that one time and you don't really ever think about and it's just kind of like there in the background? I feel like that debate is still going on, like we talked about. But yeah, I mean I think like I said, I think that the thermometer, it was really one of those things where I was like if only we could measure pain in this way. Because once we developed the thermometer and we're able to use it in clinical medicine, then we could much better test things like does quinine actually bring down your fever? Does aspirin bring down your fever? How does it bring it down? When should we administer it? What are the different courses of these things? Because I think we're always down on quantifying symptoms and being like oh objective symptoms or objective signs of a disease are leaned on very heavily by modern medicine at the cost of the whole person. And like the other things that they're experiencing that are harder to describe.
Erin Allmann Updyke	Right.
Erin Welsh	And I think that's valid but I also think that like would be beneficial to have all of the things.
Erin Allmann Updyke	100%.
Erin Welsh	Yeah.
Erin Allmann Updyke	Yeah, I agree.
Erin Welsh	So there's a lot more to learn about fevers and especially about the evolutionary side of fevers. If you want to go into that and evolutionary medicine, it is an interesting field.
Erin Allmann Updyke	Ooh.
Erin Welsh	When you mentioned something about iron consumption.

Erin Allmann Updyke	Yeah, iron-
Erin Welsh	I was like we're going to have to do hemochromatosis.
Erin Allmann Updyke	Oh it's on our list. I think it's early in the season.
Erin Welsh	Season. Oh sweet.
Erin Allmann Updyke	Yeah. It's already like on our schedule.
Erin Welsh	Perfect. I should check our schedule. And if you would like to check our sources-
Erin Allmann Updyke	You can.
Erin Welsh	Let's do it. Okay. I already mentioned mine. What is it? 'More Than Hot: A Short History of Fever' by Christopher Hamlin. I have a bunch of other papers too that I'll post up there.
Erin Allmann Updyke	I had just a few papers that I used for this episode actually. One if you want really fun deep dives, I have some really, really fun ones. This one was called 'The physiology of mammalian temperature homeostasis.' And I already have like three other pages of notes that we didn't even get into about like bears and hibernation and blubber. And it does make you want to do a whole episode on temperature homeostasis. But tell us if that sounds too boring, listeners, because like I could go off. And then I also have a couple on, there was one by Walter et al from 2016, that was 'A pathophysiological basis and consequences of fever.' That was a really good primer on fevers. And a few more. We'll post the links for all of our sources from this episode and all of our episodes on our website thispodcastwillkillyou.com under the EPISODES tab.
Erin Welsh	We will. Thank you to Bloodmobile for providing the music for this episode and all of our episodes.
Erin Allmann Updyke	Thank you to Tom and Lianna for the wonderful audio mixing.
Erin Welsh	Thank you to Exactly Right.
Erin Allmann Updyke	And thank you to you, listeners. We had a lot of fun with this episode.
Erin Welsh	Yes. I actually really loved this.
Erin Allmann Updyke	Me too. It was super fun.
Erin Welsh	And a big thank you as always to our wondrous, wondrously generous patrons, we appreciate your support so very much.
Erin Allmann Updyke	Thank you. Thank you. Thank you.
Erin Welsh	I've been recording so many of these Book Club outros that I forget. Oh yeah, wash your hands.
Erin Allmann Updyke	You filthy animals.