

TPWKY	(This Podcast Will Kill You intro theme)
Erin Welsh	Hi, I'm Erin Welsh.
Erin Allmann Updyke	And I'm Erin Allmann Updyke.
Matt Candeias	And I'm Matt Candeias.
Erin Welsh	Yay!
Matt Candeias	I'm back.
Erin Allmann Updyke	Our favorite.
Matt Candeias	Oh hey, thanks for having me.
Erin Welsh	And this is a crossover edition of This Podcast Will Kill You and-
Matt Candeias	In Defense of Plants.
Erin Allmann Updyke	Woot woot!
Erin Welsh	Yeah. Cool! Well we're very excited to have you, Matt and we've been looking forward to recording another poisoncast for a long time.
Matt Candeias	I know, these are so much fun and it's just fantastic to be back. Thank you so much.
Erin Welsh	Yeah. So what are we doing this week, guys?
Erin Allmann Updyke	This week we're doing ricin.
Matt Candeias	Yes.
Erin Welsh	Yeah.
Matt Candeias	One of my all time favorite exotic plants, we'll call it that.
Erin Allmann Updyke	Oh, I didn't know it was an exotic plant.
Erin Welsh	Really?
Matt Candeias	Where do you draw the line for exotic?
Erin Allmann Updyke	I don't know.
Matt Candeias	It's a distance metric I think from like where your front doorstep is.
Erin Allmann Updyke	Okay, that's fair.

Matt Candeias: And to me this qualifies.

Erin Allmann Updyke: Okay. That's fun.

Erin Welsh: Well by the end of this episode I'm pretty sure that everyone out there, it's going to be their favorite poison, exotic plant episode etc etc. Right?

Erin Allmann Updyke: I agree. I think so.

Erin Welsh: Can we promise that this early on?

Matt Candeias: I mean I feel like this is one of the weird areas where I can actually feel confident so sure.

Erin Allmann Updyke: Okay, yeah. Let's make that claim.

Matt Candeias: Let me have this.

Erin Allmann Updyke: Do we have any business before we jump right in? I have one piece of business, that's why I'm asking.

Erin Welsh: Okay, go ahead. Share with the class, Erin.

Erin Allmann Updyke: I wanted to make one correction from one of our more recent episodes, the toxoplasmosis episode. We got an email and this is an important point of clarification that I wanted to make. Cats are not contagious for their entire life with toxoplasmosis. So when cats get infected they only shed Toxoplasma for like a few weeks of their life and then they're immune for life.

Erin Welsh: Right.

Erin Allmann Updyke: And I think that maybe didn't come across in our episode so I wanted to make that clear. And thank you to the people who emailed us to clarify that.

Erin Welsh: Right. Okay.

Erin Allmann Updyke: Well then.

Matt Candeias: Unexpected tidbit for me, thanks.

Erin Allmann Updyke: (laughs) Moving back to poisons.

Erin Welsh: Yes. What time is it?

Erin Allmann Updyke: It's quarantini time.

Matt Candeias: I got nervous.

Erin Allmann Updyke: You almost got me there.

Matt Candeias I was like it's 7:30.

Erin Welsh (laughs) Well 7:30 also means it's quarantini time at least.

Erin Allmann Updyke Definitely.

Erin Welsh It's 7:30 somewhere, it's quarantini time somewhere.

Matt Candeias Cool.

Erin Allmann Updyke So what are we drinking this week, Erin?

Erin Welsh We are drinking The Ticking Time Bomb.

Erin Allmann Updyke Ooh.

Erin Welsh And it's named this for reasons that will become clear later in the episode. But for now let's talk about what's in The Ticking Time Bomb.

Matt Candeias Yeah.

Erin Allmann Updyke Let's talk about it.

Matt Candeias What is this?

Erin Welsh Basically it's hot buttered rum.

Erin Allmann Updyke Yes.

Erin Welsh So you have some rum, you make a little mix of butter and spices and then you drop that into the rum, add some hot water. Boom. It's really delicious.

Erin Allmann Updyke It sounds weird to put butter in your rum but it is very tasty.

Matt Candeias Yeah.

Erin Welsh It works really well.

Matt Candeias Y'all are blowing my mind, I did not know that that was a possibility.

Erin Allmann Updyke A thing that you could do?

Matt Candeias Yeah. But this is a great winter drink.

Erin Allmann Updyke It is.

Matt Candeias Yeah.

Erin Welsh: It's perfect. Okay so I mean everyone's got their quarantini in hand and now we just have one last piece of business which is the episode itself.

Matt Candeias: Uh oh.

Erin Allmann Updyke: Oh, well let's do it.

Matt Candeias: I'm not ready. I'm just kidding, we're good.

Erin Allmann Updyke: All right.

Erin Welsh: We'll take one quick break before we get started.

TPWKY: (transition theme)

Erin Welsh: There are so many reasons that I'm excited for this episode and the very top reason is one that we kind of talked about as we were coming up with quarantini names and that's the etymology of ricin. Because I didn't realize it, like it took me researching this episode to understand the links between ricin and Ricinus the genus name and another creature that is very near and dear to my heart. So anyway we'll get into that in a second. The second reason that I'm super excited about this episode is because the history of ricin is pretty long, like much longer than I thought and super interesting and has a couple of murders along the way.

Erin Allmann Updyke: Yes!

Erin Welsh: At least a couple.

Matt Candeias: Yeah.

Erin Welsh: And the best final reason is because I feel like it's been so long since we have done this.

Erin Allmann Updyke: Yeah.

Matt Candeias: Yeah, it has. Too long.

Erin Welsh: Especially like we did aspirin earlier this year but we haven't done a poison in a really long time.

Erin Allmann Updyke: Yeah.

Matt Candeias: It's true.

Erin Welsh: So I feel like my plant blindness has really gotten out of control.

Matt Candeias: I mean I can sense it from here so let's get on this.

Erin Welsh: (laughs) Well I remember after our episode on chytrid we talked about how basically the world in crashing around us and everything's going extinct and you were like, 'Plants are at the biggest risk of all.' And I was like, 'No! My plant blindness!'

Matt Candeias

And I tried to preface that with all of the hand-wavy hand motions and goofiness and even picturing the accent.

Erin Allmann Updyke

But Sarah didn't, she was like, 'You guys, come on.'

Matt Candeias

Yeah that was just pure anger on her part, let's be fair.

Erin Allmann Updyke

It's understandable.

Matt Candeias

It is true, plants are leading the extinction charge and it's frightening.

Erin Welsh

Yeah. Well so there's our second correction of the episode already.

Matt Candeias

Oh no and I was the cause.

Erin Welsh

No! (laughs) No, no. Okay, all right. So basically what I wanna do for this section of ricin is to break it down into two parts and that hopefully should then lead into your discussion about biology, Erin.

Erin Allmann Updyke

Cool.

Erin Welsh

And the reason that we're doing this episode. Okay so we've established that the poison ricin, or so we haven't established this.

Matt Candeias

(laughs) Get to the establishing part.

Erin Welsh

The poison ricin comes from the castor bean plant, *Ricinus communis* which is also what is used to produce castor oil which as far as before this episode I was like oh it's that old-timey oil. That's it.

Matt Candeias

Yeah.

Erin Allmann Updyke

Old-timey oil.

Matt Candeias

And up until this episode I just thought it was an unfortunate overlap in naming and then I was like oh, it's the same.

Erin Welsh

Yeah, yeah. Okay so this section I'm gonna talk about the history of the plant starting with its uses as a medicine in the form of castor oil and then wrap up with how it was used as a poison in the form of ricin. Okay so I think I'll start off where I usually do which is in Ancient Egypt.

Erin Allmann Updyke

Yes!

Erin Welsh

And basically archeologists have found that people have been using this plant for thousands of years. So they castor bean seeds in Ancient Egyptian tombs dating back to 4000 BCE. And then in ancient times like in Ancient Egypt and the Middle East it was known by various names including palma christi because of the red leaves of the plant which are supposed to look like the hands of Christ. So it was known also as the African wonder tree because of how fast it grew or grows.

Matt Candeias Oh yeah, that makes sense.

Erin Welsh Yeah. And so it's this fast-growing quality that actually landed it a mention in the bible as probably the tree that sprung up overnight to shade Jonah from the sun, it's a story I'm not familiar with.

Matt Candeias Oh jeez, all right.

Erin Welsh Yeah. It's also called the mole plant because it has compounds that deter moles. Matt, maybe you'll tell us more about that?

Matt Candeias Sure. (laughs) Maybe.

Erin Welsh Okay. (laughs) You're like google this right now. And the common name for the plant, the castor bean plant, actually came about accidentally. So people confused it with another shrubby plant, Vitex agnus-castus but the name stuck.

Matt Candeias Okay.

Erin Welsh So all that's interesting enough, little bits of trivia that hopefully you'll take home with you. But I was so excited for the etymology of ricin and the castor bean plant because the scientific name for the plant, Ricinus communis, is where we get the word 'ricin' and Carl Linnaeus happened to choose this name, 'communis' the second part because it was found worldwide and he chose 'Ricin' because ricinus is the Latin word for tick. And Linnaeus thought that the seeds were shaped and looked like a tick, specifically the European sheep tick or the castor bean tick I've also seen it called. And I was just like oh my god, Ixodes ricinus is the tick that I literally studied in Europe.

Erin Allmann Updyke What?

Matt Candeias That's awesome.

Erin Welsh Ixodes ricinus, yeah.

Erin Allmann Updyke Oh how fun!

Matt Candeias I made a little noise when I read that, I was like, 'Uh Erin!'

Erin Welsh (laughs) And I was looking at pictures of the castor bean seeds and I was like oh man, it's not far off, it does kind of look like a slightly engorged Ixodes ricinus tick.

Matt Candeias No, it's eerie. It's great if you have someone with them in their garden pick one up, put it in your pocket and the just go like, 'Uh, I think I just found a tick on your floor' and pick it up and show it to them and just have them lose it for a little bit. I've never done that before.

Erin Allmann Updyke (laughs) Sinister.

Erin Welsh That's a very specific thing to imagine. That's something that you've never done before, Matt.

Matt Candeias Imagine what etymology could do for you.

Erin Welsh: Okay. So now that my favorite revelation is over, should we just stop and go right on to biology or do you wanna hear more about...

Matt Candeias: (laughs) Are we just done here?

Erin Allmann Updyke: The end of history.

Erin Welsh: Ticks and plants and poison and that's it.

Erin Allmann Updyke: Never have we had an under 10 minute history section, Erin. Let's get real.

Erin Welsh: Listen, our episodes just get longer and longer.

Matt Candeias: So do mine.

Erin Welsh: Okay. Would it even be an episode of This Podcast Will Kill You if I didn't mention the Ebers Papyrus?

Erin Allmann Updyke: No it would not.

Erin Welsh: Yep. I think every time we've recorded we've talked about it.

Erin Allmann Updyke: Yeah.

Erin Welsh: So just as a refresher, the Ebers Papyrus is the Ancient Egyptian medical treatise from about 4000 years ago. And in this Ebers Papyrus castor oil makes several appearances, it was prescribed for various illnesses, mostly skin related, also it was mentioned as a use for oil lamps, as a lotion, to prevent head lice, as a laxative and purgative. So in Ancient Egypt people would actually mix the oil with beer to get rid of everything, just evacuate everything.

Matt Candeias: Both ends.

Erin Allmann Updyke: Like what they use before you get a colonoscopy now?

Erin Welsh: Yeah.

Matt Candeias: Eject!

Erin Welsh: Yeah. (laughs) And so that's why we did hot buttered rum to be honest because oil in the drink.

Matt Candeias: Oh my god. (laughs) A few more of these and it might not be too far off the symptoms.

Erin Welsh: I mean yeah.

Erin Allmann Updyke: It is a Ticking Time Bomb.

Erin Welsh: There you go. Oh so thank you for reminding me, the ticking part is because Ricinus and the link between ticks and castor bean plant.

Matt Candeias

Boom.

Erin Welsh

So that's the first part. The Ticking Time Bomb part of it, I'll get into that also. Okay so even though people were ingesting the oil the dangers of the oil were known about somewhat and so it wasn't used that frequently and some cultures didn't use it at all to ingest. And so during this time the plant didn't spend too much time out of these roles, out of these medicinal or useful roles in terms of either topical treatment for skin conditions or oil for lamps. So it became super widespread but then cultivation in much of Europe apparently kind of died out except in places like Greece and then the plant started to be harvested from Jamaica or parts of Asia. And so that was sort of from the 1500s down to the late 1800s.

And then what happened was the 20th century comes around and then we have this huge boom in technology and particularly in the development of cars and other heavy machinery or improvements in trains that needed big engines. And these engines needed to be more efficient. So in order to be more efficient these super powerful engines needed a lubricant that could be liquid at cold temperatures but then remain thick at hot temperatures. And it turns out that if you add castor oil to the existing lubricants it would increase the temperature range over which these engines could operate and so it made them much more efficient and you could build much more powerful engines which is really cool. Without castor oil, who knows?

Matt Candeias

What a weird resurgence in the popularity of something.

Erin Welsh

Yeah! And so this is really what some papers suggest kind of paved the way for airplanes or at least allowed them to develop. And in WWI for instance... Okay actually do me this. Picture a pilot from WWI.

Matt Candeias

I got a Red Baron thing going on right now.

Erin Welsh

Yeah. He's got like a scarf around his neck kind of flapping in the wind, he's got that little leather cap and goggles and stuff.

Matt Candeias

Totally.

Erin Welsh

That wasn't just fashion, that was function because apparently the castor oil lubricant would just spray all over the cockpit. And so the silk scarf was to wipe his eyes, his goggles, his face, and also the windshield or whatever you call it in a plane.

Erin Allmann Updyke

I would say they probably still call it a windshield.

Matt Candeias

Yeah, the ultimate windshield.

Erin Welsh

The ultimate, yeah.

Erin Allmann Updyke

What?

Matt Candeias

Dude.

Erin Welsh

Isn't that interesting?

Erin Allmann Updyke You know we have a painting of my grandpa in his flight outfit and it looks just like that with the hat and the goggles and the scarf and everything.

Matt Candeias If only I could ask and be like what's it like to be sprayed with castor oil at 7000 feet?

Erin Allmann Updyke Castor oil! He was not in WWI.

Matt Candeias That's true, you would be quite the anomaly.

Erin Welsh Well they still used it in WWII. I think that they had better control over it.

Matt Candeias I think they had cockpits by that point.

Erin Allmann Updyke Yeah, yes.

Erin Welsh So then this was used heavily during WWI and then of course using planes to drop bombs and shoot things and whatever else increased a ton and so the US was like, 'Hey, we're gonna run out of castor oil.' So they were encouraging farmers in the Midwest to grow castor bean plants.

Matt Candeias (laughs) Yo.

Erin Welsh But then they realized that this pollen caused a huge increase in hay fever and asthma and so people were getting sick everywhere and they were like yeah, we gotta dial this down. Also castor oil was used medicinally all through WWII and also in ways that are a little bit less than medicinal. So even though this isn't the poison section, this kind of feels a bit more like poison section. Well let me just explain this.

Matt Candeias Whoa.

Erin Welsh So parents would give their kids a small spoonful of castor oil sometimes for purging or as a punishment apparently.

Matt Candeias Oh god.

Erin Welsh And then in Italy during WWII Mussolini and his fascist militia would force feed up to a liter of castor oil sometimes mixed with gasoline to people who dissented.

Matt Candeias What?

Erin Allmann Updyke What?

Erin Welsh So that would result in internal burns, extremely painful diarrhea, dehydration, and death for most people.

Matt Candeias Wow.

Erin Welsh So even though castor oil was like a medicine, it wasn't here's that whole thing about too much of a good thing.

Erin Allmann Updyke Yeah.

Matt Candeias: Yeah. A liter too much of a good thing?

Erin Allmann Updyke: A magician, a physician, etc.

Matt Candeias: Yeah.

Erin Welsh: Exactly.

Matt Candeias: That's disturbing.

Erin Welsh: Yeah.

Erin Allmann Updyke: Whoa.

Erin Welsh: But the good news in terms of that I guess if there is good news is that as medicine advanced throughout the 20th century, less harsh purgatives and laxatives were developed and castor oil kind of just fell by the wayside. But that's only one half of this story.

Erin Allmann Updyke: Ooh.

Erin Welsh: Okay, are you ready for the reason for this episode? The poisoncast part of it?

Matt Candeias: Yeah, bring it.

Erin Allmann Updyke: Yeah, okay.

Erin Welsh: Ricin. It's very human that archeologists believe that they have detected the use of ricin as a poison thousands and thousands of years before they could detect medicinal use of the plant. So in a cave in South Africa, researchers found a ball of beeswax that also had ricin in it and the archeologists think that this beeswax which is approximately 35,000 years old-

Matt Candeias: What?

Erin Welsh: 35,000 years old was used to attach stone points to arrows and spears. And they also found in this cave, the same cave, a stick that was around 20,000 years old that was thought to be used to apply ricin to spearheads.

Matt Candeias: Yo.

Erin Allmann Updyke: Whoa.

Erin Welsh: Right?

Matt Candeias: Human nature.

Erin Welsh: If that really was used for that purpose that would be the earliest known use of poison, period.

Erin Allmann Updyke: Wow.

Matt Candeias Dang.

Erin Welsh People probably used poison forever, but yeah.

Erin Allmann Updyke Wow, dude.

Matt Candeias That's super interesting.

Erin Allmann Updyke Where did you say they found this, in what part of the world?

Erin Welsh South Africa.

Erin Allmann Updyke Wow that is so interesting.

Erin Welsh Yeah. Yep. Okay so Ehrlich stumbled upon the possibility that you could build up and immunity to ricin and other toxins by feeding animals tiny doses over time and gradually ramping up. He tested it where you could get them to be resistant to a dose of ricin that was 800 times more than the deadly dose if that makes sense. I'm not saying that the right way.

Erin Allmann Updyke Yeah, yeah. The lethal dose.

Erin Welsh Yes exactly, the lethal dose. But this was not a new idea. So in parts of India farmers had been doing that to their cattle for hundreds of years.

Matt Candeias Nice.

Erin Welsh But yeah, Ehrlich was like, 'Oh I have this new idea.' And other medical uses of ricin, not just castor oil, were developed as researchers learned more about the mechanism of action. So it's been used as a tumor suppressant and in other ways that I'm sure you're gonna talk about, Erin, in more detail.

Erin Allmann Updyke Oh yeah.

Erin Welsh Okay cool. All right so just as WWI and WWII afforded castor oil the opportunity to shine as a lubricant for plane engines, these wars let ricin share a bit in the glory as well.

Matt Candeias Dun-dun.

Erin Welsh During WWI it's not good. During WWI the US looked into using ricin as a weapon, a bioweapon.

Matt Candeias Of course.

Erin Welsh Mostly by coating bullets or shrapnel or whatever with the toxin, resulting shrapnel with the toxin.

Matt Candeias Oh whoa. That's dark.

Erin Welsh It's very dark.

Erin Allmann Updyke

That's really dark.

Erin Welsh

So here's a quote from one of the researchers on this particular research project: "It is not unreasonable to suppose that every wound inflicted by a shrapnel bullet coated with ricin would produce a serious casualty, i.e. a casualty much more severe than from the bullet without the ricin. Many wound which would otherwise be trivial would be fatal."

Matt Candeias

Dang.

Erin Welsh

Isn't that ugh?

Matt Candeias

I mean from knowing the plant, not surprising but that is dark.

Erin Welsh

Right?

Matt Candeias

Yeah.

Erin Welsh

Yeah, yeah. It's very dark.

Erin Allmann Updyke

It's so ugh.

Erin Welsh

Okay. So believe it or not this weaponization of ricin was actually frowned upon and was found to be against international laws and could only be used, it was ruled that it could only be used if the Germans used similar weapons first, so it could only be used in retaliation which is kind of messed up.

Matt Candeias

Okay, sure.

Erin Welsh

So of course they could keep developing it and so on.

Erin Allmann Updyke

Right. That's what it means is that they can keep doing research on it just in case.

Erin Welsh

Just in case.

Matt Candeias

I'm pretty sure they used it. Just saying.

Erin Welsh

And this also didn't stop the US from investigating how ricin could be aerosolized because aerosolization apparently wasn't viewed as a poison, like that wasn't viewed as a poisoning event. I don't understand.

Matt Candeias

It was like miasma or whatever they're called.

Erin Allmann Updyke

I'm sorry, we can aerosolize this and spray it all over a whole city of people but don't worry, that's not poisoning them.

Matt Candeias

That's magic death.

Erin Welsh

Yeah. I'm not sure what was happening.

Erin Allmann Updyke

Wow.

Erin Welsh

Yeah. In any case fortunately ricin dust wasn't found to be an effective or efficient aerosolized weapon because breathing it in wasn't as toxic as ingesting it or having it injected. And so efforts to develop it were abandoned. Also it would be really difficult to get the amount that you needed and disperse it over an area. Yeah. So anyway fortunately. But then in WWII the word had gotten out about ricin because countries everywhere were trying to develop it as a weapon and people got pretty far with this, especially in the US where they were able to make this super concentrated deadly powder that they called Agent W.

Erin Allmann Updyke

Ooh. Why W?

Erin Welsh

I can't remember. I think I saw it somewhere and I forgot. I'm sorry.

Matt Candeias

I saw it.

Erin Welsh

I saw it I think.

Matt Candeias

Interesting.

Erin Welsh

But now it's gone, now it's way out of my head. But yeah so the Agent W was way too much work so they were like, 'Now we're not doing this. There are way easier toxic things that we can make.'

Matt Candeias

Oh totally, yeah. Low hanging fruit.

Erin Welsh

Yeah. And then also the other thing is that at the time, and I don't know about now, but at the time at least there was no remedy for-

Erin Allmann Updyke

Still true.

Erin Welsh

Oh okay. For ricin. There you go. So biological warfare was banned in 1970 in the US and in 1975 that also included toxins. And so since then ricin as a substance alone has been highly regulated in the US So that's in the US but what about abroad? Well okay, the USSR was reported to have continued developing ricin as a bioweapon throughout the 70s and 80s and it would end up making some headlines during this time.

Erin Allmann Updyke

Oh! I know what you're gonna talk about.

Matt Candeias

I think I might but surprise me.

Erin Welsh

This was the only thing I knew about ricin before going into this episode.

Erin Allmann Updyke

Yeah. Pretty much same.

Erin Welsh

Yeah. And I wasn't even sure entirely so the more I read about it, the more I was like what is happening? Okay. The only thing I knew was that ricin was used in some kind of spy murder and there was an umbrella.

Matt Candeias

Yeah, all right. Yep.

Erin Allmann Updyke

So I think that you should serve this drink with an umbrella in it, I'm just saying.

Matt Candeias

(laughs) I didn't even think about that when you said that earlier.

Erin Allmann Updyke

I suggested that and I think it's a pretty good idea.

Matt Candeias

Yeah, I like that.

Erin Welsh

(laughs) Okay. So in the 1970s Bulgaria was part of the Eastern Bloc, the USSR, and as you might expect opposition or dissent to the communist state was pretty risky business. It was gonna get you disappeared.

Erin Allmann Updyke

Was it ricinisky? I tried too hard.

Matt Candeias

Say that three more times really fast though.

Erin Welsh

So there was this Bulgarian writer named - and I have listened to YouTube videos about the news and I've heard it pronounced two ways so I'm going to say it both ways at the beginning - Georgi Markov.

Erin Allmann Updyke

Okay.

Erin Welsh

So Georgi Markov was initially friends actually with the president of Bulgaria but then he eventually got disillusioned with communism and he moved to England where he continued to be a prominent novelist and he wrote about and spoke about these criticisms that he had of the Bulgarian government. And he would go on TV and stuff like that as a BBC correspondent.

Matt Candeias

No, no, no.

Erin Welsh

Yeah. So his former friend, the president of Bulgaria Todor Zhivkov, decided that Markov should be silenced because he was insulting the citizens of Bulgaria and they might take offense to what he was saying.

Matt Candeias

Yup.

Erin Welsh

But really he was like, 'He's saying mean things about me and I want him to be killed.'

Matt Candeias

He's my ex-best friend.

Erin Welsh

Yeah. And so he wanted to kill Markov in a way that wouldn't be easily traced to the Bulgarian government and so he worked with KGB to develop a method. And they ended up deciding that what they would do is take some ricin and put it in a tiny, tiny pellet that could be surreptitiously somehow injected into Markov and then the coating surrounding this pellet would wear off or burn off and then the ricin would then start to disintegrate and go through the body and poison him. So they tested this out with a horse and a prisoner with mixed results.

Erin Allmann Updyke

Whoa.

Erin Welsh: Yeah. The horse died and the prisoner did not.

Matt Candeias: What?

Erin Allmann Updyke: Oh okay.

Erin Welsh: Yeah.

Erin Allmann Updyke: Not what I was expecting.

Erin Welsh: Yeah. And then they were like, 'Okay, 50% chance of working, good enough, let's try it out.'

Matt Candeias: Let's go for gold.

Erin Welsh: Yeah. So on September 7th, 1978 Georgi Markov was waiting for a bus at the Waterloo Bridge. And as he was sitting there he felt a sting on the back of his thigh and he turned to see a man apologize to him, walk away, pick up his umbrella, and leave in a taxi. And reportedly he had a foreign accent, this person who was saying goodbye and left in his taxi. And Markov went on to work and was complaining to a coworker like, 'Hey man, the back of my leg really hurts, there's a little bit of blood there, it was this weird incident that happened and I don't know, it was kind of weird.' And then by that night things were getting much weirder because he was experiencing symptoms like muscle cramps, dehydration, fever, and he eventually went into the hospital but the doctors were like, 'We don't know what's going on, maybe it's some sort of weird infection. Your white blood cell count is going up and up and up and you're not getting any better.' And then four days after this incident, so on September 11th, he died of cardiac arrest.

Erin Allmann Updyke: Wow.

Erin Welsh: And initially his death was attributed to septicemia because his leukocyte count was 33,200.

Erin Allmann Updyke: That's very high.

Erin Welsh: Yeah. But at the same time his status as a dissident was well known and so this was ruled a mysterious death.

Matt Candeias: Okay.

Erin Welsh: And Scotland Yard was like, 'Uh uh, we're looking into this.' So they ordered an autopsy. And sure enough they found I think on an X-ray a tiny, tiny metal pellet measuring 1.52 millimeters in diameter, 1.52 millimeters in diameter, buried in his thigh like almost to the muscle. And there was a tiny hole in the middle of the pellet where about 0.2 milligrams of ricin had been placed apparently cause they could test for the residue.

Matt Candeias: No way.

Erin Welsh: And the whole thing had been coated in a waxy material that was designed to melt at 98.6 degrees Fahrenheit or 37 degrees Celsius, human body temperature. So this pellet was injected into Markov either by a spring-loaded pen or umbrella or something like that, probably the guy who left in a taxi hence the common name of this murder being the umbrella murder.

Matt Candeias: Geez.

Erin Allmann Updyke: This is so interesting.

Erin Welsh: Yes.

Erin Allmann Updyke: I did not know that there was a metal pellet involved. That was silly of them. If they had just used something that was radiolucent they never would have gotten caught.

Matt Candeias: What was that word you just used?

Erin Allmann Updyke: (laughs) Something that doesn't show up on an X-ray.

Matt Candeias: Nice. All right.

Erin Allmann Updyke: Right? Yeah.

Erin Welsh: Well so then I was reading though, this was a really fascinating read, it wasn't the autopsy report but it was one of physicians who I think had examined Markov and then one of the physicians who had done the autopsy or the medical examiner who had done the autopsy and he talked about how they had cut out the little sections of the thigh on both sides of the thighs, the back of them and the one that had had the bruising and the red mark.

Erin Allmann Updyke: Yeah.

Erin Welsh: And he was looking at it and he saw a pin pushed to the head in it and he thought oh it's my coworkers just doing that to keep the piece of tissue in place. But then he touched it to make sure and it rolled and he caught it on the table and was like, 'What is this?'

Matt Candeias: Wow.

Erin Welsh: So yeah.

Erin Allmann Updyke: Weird.

Erin Welsh: I don't know, some places have said X-ray, some places...anyway.

Erin Allmann Updyke: How bizarre.

Erin Welsh: How bizarre.

Matt Candeias: The human ingenuity that goes into killing someone.

Erin Allmann Updyke: Murdering someone.

Erin Welsh: Oh yeah, it's really creepy.

Matt Candeias: Yeah I mean it's fascinating up until the whole killing thing and then you're like oh it's gross.

Erin Welsh: Yeah, yeah, yeah.

Matt Candeias: Geez.

Erin Welsh: After news of this was made public, it turns out that this was not the first time that this method of assassination had been attempted and it wouldn't be the last either.

Matt Candeias: Go figure.

Erin Welsh: Yeah. So there was another dissident, a dissident from Bulgaria had heard about Markov's death on the news and he at the time was living in France and he was like, 'Hey, something very similar happened to me a couple of weeks ago.' He was like, 'I was near the someplace and I felt someone bump into me and a sharp pain and stinging and I felt a little bit bad but yeah.' And he went to the doctor and got an X-ray and sure enough they found a tiny little pellet in his back. But this guy had experienced just some of the symptoms like a fever but he was still alive, like this was a couple weeks before Markov had been assassinated. And so they removed the pellet from his back and they were like... So this is how they could actually see the full structure of it because the ricin was still mostly inside the little pellet because the waxy outer surface hadn't melted because it was too close to the surface of his skin.

Matt Candeias: Whoa.

Erin Welsh: Yeah.

Matt Candeias: That's wild.

Erin Welsh: Yeah, it's bizarre. And then in 1981 there was another assassination attempt same way, this time on a Polish double agent who was working with both the CIA and KGB and he was found out at the KGB so he fled to the US He was at the grocery store a couple years later just minding his own business and then he gets shot by an air pellet gun and gets super sick but recovers and then he passes a suspicious-looking kidney stone which turned out to be the ricin pellet.

Matt Candeias: No way.

Erin Welsh: Yeah. It went into his kidney or something.

Erin Allmann Updyke: Whoa.

Erin Welsh: Yeah. And there are at least a couple other instances that I could find.

Matt Candeias: That made me a little squeamish about that.

Erin Welsh

Yeah. So these are sort of isolated assassination attempts but ricin has also been used in more I would say larger bioterrorism plots as well. And also important to say reportedly. The reason I say 'reportedly' is because the use of ricin hasn't been traced to any attack in particular but there have been some stockpiles of ricin that have been found or of castor beans or castor seeds. But it would be nearly impossible to deliver with any efficiency, like you would need literal tons of ricin which would be very difficult to produce and you would be difficult to target, the dispersal area would be very limited, again it would be the inhalation and so on. But it could still be used to create chaos or in targeted attacks as had been suspected in a couple of supposed ricin plots. So there was one that I read parts of a book about called the Wood Green ricin plot in the UK in January 2003.

Matt Candeias

Oh wow, recent.

Erin Welsh

Yeah. And so there were five North African men who were arrested for their involvement in an alleged ricin ring and they were all acquitted except for one. So you have to remember this was a couple years after 9/11, not even a couple years, like a year and a half and tensions were running super high. And so this case that had been brought to court in the UK, people were spending tons of time, tons of money and they really wanted like 'we're being very successful at finding and then getting rid of would-be terrorists'. And it was very shaky evidence that they had, it was like a couple of castor bean seeds.

Matt Candeias

That's it?

Erin Welsh

Basically.

Matt Candeias

Ooh.

Erin Welsh

And there were other alleged poisons and recipes and stuff like that but for the most part it seemed like the people who had been arrested were not in the know. Anyway. And so later in that same year, it was like a year for ricin man because in October in the US a ricin-containing envelope was discovered at a South Carolina mail processing facility, like there was actual ricin in this envelope.

Matt Candeias

That I think I remember.

Erin Allmann Updyke

Yeah.

Erin Welsh

Yeah. And you probably remember it because of this next part which is that a month later a similar, nearly identical envelope showed up at the White House.

Matt Candeias

Oh yeah.

Erin Allmann Updyke

Yeah.

Erin Welsh

So there was definitely ricin on the South Carolina envelope but it seems less conclusive that there was ricin on the White House envelope. But the envelopes were basically the same and they contained similar messages and they're both signed by 'Fallen Angel'. They demanded that the new trucking regulations for the number of hours in the sleeper berth to be reduced. So it had recently changed from 8 hours in the sleeping berth to 10 and Fallen Angel was like, 'No, no, let's get it back to 8.'

Erin Allmann Updyke

So they were like a trucking supervisor and they were worried about the efficiency of their workers or something? (laughs)

Erin Welsh

I think something like that. So yeah. So nothing happened, I mean no one got sick anywhere, I don't think the trucking regulations were changed and no one got poisoned with ricin. But it was definitely like of course as you can imagine 2003, tensions running extremely high.

Matt Candeias

Yeah, a little bit. Little tense back then.

Erin Welsh

I mean ricin has been used as a poison for thousands and thousands and thousands of years and it seems to have made the headlines fairly recently I guess if we're talking about 2003. But a lot of these seem like isolated cases and as I keep saying like oh it would be very inefficient to use ricin as a weapon, blah, blah, blah. But Erin, should we be scared?

Matt Candeias

Uh oh.

Erin Allmann Updyke

Let's talk about it.

Erin Welsh

What does it actually do to you?

Erin Allmann Updyke

What does it do?

Matt Candeias

I'm dying to know.

Erin Allmann Updyke

Oh, don't die.

Matt Candeias

I'm sorry.

Erin Allmann Updyke

Let me tell you. We'll take a quick break and then we'll jump into it.

TPWKY

(transition theme)

Erin Allmann Updyke

Every paper about the biology of ricin starts with the same sentence. So I'm gonna read it to you. "Ricin is a heteroiymeric type 2 ribosome inactivating protein."

Matt Candeias

Duh.

Erin Allmann Updyke

Duh! There's your whole answer.

Matt Candeias

Well at least they're starting with everything you need to know.

Erin Allmann Updyke

Everything you need to know about ricin. Okay. I swear every paper started with that same sentence. What does that mean? It means that ricin is a toxin and in this case it's a protein toxin, so it's a peptide.

Erin Welsh

Is that unusual?

Erin Allmann Updyke

No, it's not unusual. So it's actually a very similar toxin in structure to a toxin that we talked about very recently and that is Shiga toxin.

Matt Candeias Oh really?

Erin Welsh Oh.

Erin Allmann Updyke Yeah. So these are toxins that are made of two peptides strung together by bonds, so two different strands of protein. And these two strands of peptide work in this way. They are kind of like a rocketship, at least how I think a rocketship works. So you know how when a rocket ship launches there's the part that launches the rocket ship into outer space and then there's the spacey part that goes out of the launcher and does the space things?

Erin Welsh (laughs) Yeah, I've seen Apollo 13.

Erin Allmann Updyke Exactly. Okay, so those two pieces, the launchy part and the spacey part... (laughs) Matt can't handle the way I'm describing this.

Matt Candeias (laughs) I love it.

Erin Allmann Updyke That is the same way that this ricin toxin works. There's what's called the B part and that's the launchy part. So that part of the toxin is what allows for this toxin to enter into our cells. So it binds on to carbohydrates, so sugars on our cell's surface and launches the A part of the toxin into our cells.

Matt Candeias What?

Erin Allmann Updyke Yeah.

Matt Candeias Like a virus almost?

Erin Allmann Updyke Yeah so it gets engulfed in a little vacuole just like a virus would in some ways.

Matt Candeias Wow.

Erin Allmann Updyke Yeah.

Matt Candeias That's incredible.

Erin Allmann Updyke And then that part inside of the cell interacts with the ribosomes, so that first sentence, it told us it was a ribosomal inactivating protein. So the ribosome is in these little balls inside of our cells that are made of RNA and protein that are integral in protein synthesis. So this toxin inactivates ribosomes which means it blocks protein synthesis. That's like the main function of a cell.

Erin Welsh Yeah that's really bad.

Erin Allmann Updyke Yeah. If a cell can't make protein, a cell can't function, and the cell will die. So in effect it causes irreversible cell death.

Matt Candeias Wow. So ricin's like, 'Hey I'm here to stop cell things, all of them.'

Erin Allmann Updyke Yeah, all the things. Exactly. (laughs)

Erin Welsh: Real quick, is there reversible cell death?

Erin Allmann Updyke: No but there could be reversible ribosome inactivation.

Matt Candeias: That's zombies, okay. We're getting into zombie territory.

Erin Welsh: I know, that's what I was thinking!

Erin Allmann Updyke: Okay so that is how ricin functions as a toxin. Pretty cool right?

Matt Candeias: Dang, that's pretty wild.

Erin Allmann Updyke: That was fun, I've never used rockets as an analogy before.

Matt Candeias: And you did it so well, too!

Erin Allmann Updyke: Thank you.

Matt Candeias: You know I followed A to B to C, it was all good.

Erin Allmann Updyke: Okay and you learned what that really complicated sentence means.

Matt Candeias: Yeah, you broke it down.

Erin Allmann Updyke: Heterodimeric, so it's two different parts, ribosome inactivating. Cool. Now you can read every paper about ricin.

Matt Candeias: Boom.

Erin Allmann Updyke: What does it mean when you are exposed to ricin? What does that actually look like? Like you kind of mentioned Erin, there are a number of different ways that you can get exposed, right. The most common though would be eating a castor bean.

Matt Candeias: Yeah.

Erin Allmann Updyke: Quick question.

Matt Candeias: Okay.

Erin Allmann Updyke: Is it a bean or would you call it a bean or a seed?

Matt Candeias: It's a seed, yeah.

Erin Allmann Updyke: Okay. Is a bean not a seed?

Matt Candeias: I just associate beans with Fabaceae, so like one type of family, from the fruit of them.

Erin Allmann Updyke: Okay.

Matt Candeias: But I mean they're shaped liked beans, but they're all seeds at the end of the day.

Erin Allmann Updyke: Okay.

Matt Candeias: Yeah.

Erin Allmann Updyke: Yeah, eating a bowl of castor beans would be the easiest way to get exposed to ricin.

Matt Candeias: Don't do that.

Erin Allmann Updyke: Don't do that, you will definitely die. If you ate just a few, here's what would happen. Since the toxin would be entering your GI tract as it's first point of entry, most of your symptoms at the first are gonna be GI symptoms. So we're talking nausea, vomiting, diarrhea, intense abdominal cramping, abdominal pain. These are usually the first onset of symptoms and they're very rapid, so we're talking within a few hours of being exposed.

Matt Candeias: Oh geez.

Erin Allmann Updyke: Those are the kind of symptoms that you're gonna have. In general if somebody has ingested castor seeds and they don't have those symptoms within 12 hours, they're probably safe.

Matt Candeias: Makes sense.

Erin Allmann Updyke: Yeah.

Matt Candeias: For reasons I'll talk about later.

Erin Allmann Updyke: Oh, cool! I'm excited. I just thought that it was like they pooped 'em out by then.

Matt Candeias: It has a lot to do with that.

Erin Allmann Updyke: Okay.

Matt Candeias: But yeah, we'll go into it.

Erin Allmann Updyke: These symptoms progress throughout your body as the toxin leaves your GI tract, gets into your bloodstream, and starts affecting other organs. Because that launcher part of the protein, that B side of the protein, it is very nonspecific so it'll attack any cell that it can essentially.

Matt Candeias: Oh wow.

Erin Allmann Updyke: So as it moves through your bloodstream it'll start causing damage to your liver and it can cause liver failure. Your kidneys, it can cause kidney failure. Most people end up dying from hypovolemic shock, so shock is when you basically don't have enough blood perfusing your organs.

Matt Candeias: Oh really?

Erin Allmann Updyke: And there's a number of different ways that can happen, in this case it's from volume loss.

Matt Candeias	Wow.
Erin Allmann Updyke	So I'm not sure if that's because you're bleeding out from every orifice or if it's just because it's causing such damage to your cells that you are losing volume from your blood plasma.
Matt Candeias	Like literally letting the air out of the balloon so to speak.
Erin Allmann Updyke	Kind of.
Matt Candeias	Wow.
Erin Welsh	Question.
Erin Allmann Updyke	Okay.
Erin Welsh	So you are bleeding out of every orifice?
Erin Allmann Updyke	Well you don't bleed out of every orifice but you can have very bloody diarrhea and nausea.
Erin Welsh	Okay.
Erin Allmann Updyke	Because this is causing cell death and any time that you have cell death, you're gonna have blood probably as well. So that's ingestion. And the poisons, like the murders that you talked about were via injection which is also a little bit different. So that ingestion is the most common route but it's not what keeps the biowarfare division of the United States government up at night.
Matt Candeias	Of course not.
Erin Allmann Updyke	So you can also get ricin poisoning like you mentioned Erin from injection or inhalation. The difference, we'll talk in a second about the difference in potency in ricin between all these different methods but there's also a big difference in how your symptoms manifest as you might guess since you're starting with different organ systems essentially. So if you start with an injection of ricin like in the case of the umbrella murders, then the first symptoms that you're gonna have are localized symptoms where that injection happened. So muscle pain and you actually can have necrosis, so tissue death of the muscle where it was injected and then that toxin will travel through your lymphatic system to your lymph nodes and cause necrosis of your lymph nodes.
Matt Candeias	You need those.
Erin Allmann Updyke	You need those. Then it can get into your bloodstream and end up causing widespread organ failure. So you'll get overall weakness, you can get fever, you also often get vomiting. I think because it has action on protein synthesis in cells it probably has an especially bad effect on rapidly dividing cells like in your GI tract, so that's probably why you see the vomiting really commonly.
Erin Welsh	Oh.
Erin Allmann Updyke	Yeah.

Erin Welsh: So there's these differences in symptoms between ingestion and injection and then I'm sure you'll talk about inhalation. And so those things like the ingestion and the inhalation kind of make sense to me in terms of why they would know these symptoms. But the injection part, is that simply from the murders?

Erin Allmann Updyke: That's a good question. I mean I would guess so. I think once it's in your bloodstream it's going to probably have similar effects on your organs as it would once it's in your bloodstream from ingesting it if that makes sense.

Erin Welsh: Okay.

Erin Allmann Updyke: So a liver infected with ricin is gonna look probably like a liver infected with ricin no matter how it got infected, if that makes sense.

Matt Candeias: Yeah, so it's like a matter of which tissues it hits first.

Erin Allmann Updyke: Yeah.

Erin Welsh: Oh okay, yeah.

Erin Allmann Updyke: Yeah but that's a good question. And similar to ingestion, this is very rapid symptom onset in the case of injection. So very rapid, within a few hours you're starting to have that muscle pain, etc.

Matt Candeias: That explains why these victims were able to get to work and have the wherewithal, it wasn't like a neurotoxin that just...boom.

Erin Allmann Updyke: Exactly, yes. Precisely.

Matt Candeias: Whoa.

Erin Allmann Updyke: And then the scary way of course, the bioterrorism fear, is inhalation. And what's interesting about inhalation, and it's interesting Erin that you said it wouldn't be very efficient, I can think of a couple reasons why it wouldn't be very efficient. One is that it actually doesn't cause the widespread multisystem disease that we see with the other two methods. It's localized to your lungs when you get infected, don't ask me why. Like how come it can't make it into your bloodstream and go everywhere?

Erin Welsh: Yeah.

Matt Candeias: Like so many other things inhaled do.

Erin Allmann Updyke: I don't know but it doesn't seem to.

Matt Candeias: Weird.

Erin Allmann Updyke: The effects are localized to your lungs. Now keep in mind your lungs are pretty dang important.

Matt Candeias: Yeah I kinda need those two.

Erin Welsh

Yeah. So does it cause necrosis in your lungs?

Erin Allmann Updyke

Yeah. So it causes equally deadly symptoms. So the first symptoms that you'll have are like cough and flu-like symptoms and then you'll get respiratory distress, pulmonary edema. Eventually you still will get hypotension, so like your blood pressure will fall and you'll end up dying and you can't breathe, etc. But yeah, as far as I can tell you don't see it affecting other organs as much. But what's interesting and I think this is probably one of the reasons, Erin, there's two reasons why it probably isn't that efficient. One is that the severity of the disease very much depends on the particle size, so small, small particles are gonna have a much more drastic effect than larger particles because they make it down deeper into your airways and larger particles are gonna have less of an effect and sometimes very little effect. And so I think probably to purify the exactly type of ricin, like the particle size of ricin that would be extra deadly is probably difficult, I don't know anything about that.

Matt Candeias

Good question.

Erin Allmann Updyke

And then also there have actually been no confirmed reports of a human ever getting inhaled ricin poisoning.

Erin Welsh

Really?

Matt Candeias

We just know it's possible?

Erin Allmann Updyke

Yes.

Matt Candeias

Okay.

Erin Allmann Updyke

So there's one maybe case report from the '40s where they think maybe a group of people could have been killed by ricin inhalation but not definitively and that's the only one.

Erin Welsh

What were the circumstances surrounding-

Erin Allmann Updyke

I don't know, I didn't read about it. I thought you might talk about it so I didn't want to. My bad.

Erin Welsh

Sorry, sorry.

Erin Allmann Updyke

But yeah, so all of this information that we have about the effects, it's from monkeys.

Erin Welsh

Oh!

Matt Candeias

Oh, that's sad.

Erin Allmann Updyke

Yeah it is sad.

Matt Candeias

I mean I don't want people to die either but monkeys.

Erin Allmann Updyke

I know. So how much does it take to kill you? How much ricin does it actually take to kill you? That's the next question. As little as 500 mcg. Micrograms.

Erin Welsh: Whoa.

Matt Candeias: That's a small amount.

Erin Allmann Updyke: I tried to quantify how small this is, okay.

Matt Candeias: I can see it on your face, it's small.

Erin Allmann Updyke: A quarter teaspoon of sugar, that's your smallest measuring spoon, in 1 gram.

Matt Candeias: Okay.

Erin Allmann Updyke: So half of that, an eighth of a teaspoon is 1/2 a gram.

Matt Candeias: Okay.

Erin Allmann Updyke: That is 500,000 mcg. So 1/10 of that can kill you.

Matt Candeias: Wow.

Erin Allmann Updyke: Yeah, it's incomprehensibly small. But that's by injection or I think in theory by inhalation as well if it was like the right kind of inhaled ricin. But nobody has purified ricin sitting around in your lab. So what about castor beans? How many castor bean seeds do you have to ingest? Turns out not many.

Matt Candeias: I was gonna say that if you didn't! (laughs)

Erin Welsh: It's like 3, right?

Erin Allmann Updyke: Yeah. So it can be as low as 2 or 3 because even though you have to ingest 1000 times more, there's so much per seed I guess that you can die from just a few seeds.

Erin Welsh: Cool.

Erin Allmann Updyke: Okay? Cool.

Erin Welsh: I read some instances cause the seeds are sometimes used as jewelry like beads and bracelets and there were a couple of case reports I came across of a girl who was chewing on her bracelet and one of the seeds like... And she recovered but yeah.

Erin Allmann Updyke: Why would you give it to a child?

Erin Welsh: I think she was like 15.

Erin Allmann Updyke: Still a child.

Matt Candeias: You've both spent time in Panama or gone to any airport, especially in a tropical country and you've seen those beads, they're red with black.

Erin Welsh: Oh yeah, I have a bracelet.

Matt Candeias: Same story there. So these are extremely common.

Erin Allmann Updyke: But those aren't castor beans.

Matt Candeias: No they're not but we'll talk about those too.

Erin Allmann Updyke: Okay.

Erin Welsh: Are they abrin or something like that?

Matt Candeias: Abrin, yeah. Abrus precatorius.

Erin Allmann Updyke: Wow, okay.

Erin Welsh: They're pretty, yeah.

Matt Candeias: Yeah they are.

Erin Allmann Updyke: Well so that's what happens if you get exposed, that's how much it takes to kill you. If you do get exposed, like if you eat a spoonful of castor seeds on a dare then you're ridiculous but go to the doctor. There's no cure, there's no antitoxin, it's all supportive care. There is however very cool research going on with ricin that I want to chat about real briefly because it think it's awesome. First of all there are a couple of different vaccines that are under development, that's how scared the US government is of a ricin attack. Yeah, at least two different vaccines have undergone at least phase 1 trials, that's in humans.

Matt Candeias: That's pretty significant, yeah.

Erin Allmann Updyke: Yeah.

Matt Candeias: Wow.

Erin Allmann Updyke: And it's only for military, like they're never gonna give this to civilians because there's no situation in which it makes sense to do that. So I'm not interested in that actually, what I am interested in is the fact that people are trying to use ricin as a cancer therapy.

Erin Welsh: Yeah.

Matt Candeias: Judging by what you told us, this makes some sense.

Erin Allmann Updyke: Yeah. So because ricin inactivates ribosomes and inhibits protein synthesis, it has very strong effects on rapidly dividing cells like tumor cells.

Matt Candeias: What do you know?

Erin Allmann Updyke: So in theory if you can get ricin into tumor cells you can kill tumor cells really easily. Problem is that launchy part, the B part of ricin is really nonspecific. So how do you get it to only target tumor cells and not your whole body cells?

Matt Candeias: Is it tiny little beads in an umbrella?

Erin Allmann Updyke: (laughs) If only. It kind of is tiny little particles, nanoparticles.

Matt Candeias: Oh no.

Erin Allmann Updyke: So people are trying to conjugate or attach the A part, the toxic part of ricin to tumor-specific particles that will only target tumor cells. And then you can make a highly specific targeted super, super toxin compound to kill cancer cells without affecting other cells in your body. How cool is that?

Erin Welsh: Whoa.

Matt Candeias: That gave me goosebumps, that's so cool.

Erin Allmann Updyke: I know! So I'm not sure if anyone has managed to do it, like how far the research has come. There's at least a few papers that I found that were like, 'We're working on it and we've conjugated it and it works at least in a petri dish' so that's very, very cool. And what's cool is that people are trying to do this with other types of toxins as well but plant toxins, Matt, are like really toxic.

Matt Candeias: They're so bad.

Erin Allmann Updyke: They're like way more toxic than bacterial and fungal toxins in general.

Matt Candeias: Yeah I think a lot of it has to do with plants tend to be more on the menu than bacteria and other microbial organisms.

Erin Allmann Updyke: That makes sense.

Matt Candeias: And they can't run!

Erin Allmann Updyke: They can't run.

Matt Candeias: Yeah.

Erin Allmann Updyke: We always come back to that.

Matt Candeias: I know.

Erin Allmann Updyke: So yeah, so if this could work then you could potentially have a drug that's super potent and very specific. So I think that that's really incredible, so it's very cool work that's going on in the field of ricin cancer research.

Matt Candeias: In a few days actually, maybe after the holiday season I'll have an article coming out with a similar concept, so stay tuned for that.

Erin Allmann Updyke: Oh cool!

Erin Welsh: Ooh.

Matt Candeias: Just subscribe to the blog.

Erin Allmann Updyke: (laughs) I can't wait.

Matt Candeias: Yeah.

Erin Allmann Updyke: So anyways that's the biology of ricin.

Matt Candeias: That is fascinating.

Erin Allmann Updyke: Oh good.

Matt Candeias: And terrifying.

Erin Allmann Updyke: Yeah. Any additional questions?

Erin Welsh: I have so many questions. A lot of my questions revolve around why.

Erin Allmann Updyke: Yeah, why?

Erin Welsh: And I think that's where Matt, you come in.

Matt Candeias: Yeah!

Erin Allmann Updyke: Let's take one quick break and then Matt, tell us all about how these plants are trying to kill us.

Matt Candeias: I can't wait.

TPWKY: (transition theme)

Matt Candeias: After hearing all of this it's easy to think that this is something that would be extremely regulated, at least in this country we regulate a lot less harmful substances that plants produce. But it turns out that this plant, *Ricinus communis*, the castor bean is readily available in most garden centers. I see it all the time planted in town, people love to grow this plant because it is a beautiful plant.

Erin Allmann Updyke: Really?

Matt Candeias: Yeah, yeah. Which is why you mentioned only a couple seeds were found, I was like I probably have a couple of castor bean seeds, am I a terrorist now? You can buy them at the store! Right. So castor bean is a plant that we've established has an incredibly long history with humans, it's thought to have been indigenous to the Southeastern Mediterranean basin, Eastern Africa and India, so some of these stories about Egypt make sense. But because of the aforementioned long history with humans it's been spread all around the globe and anywhere there's a climate that can support it, it's growing in some capacity. It's a member of a family of plants called the spurge family, Euphorbiaceae. And as we're recording this some of you probably have plenty of representatives in your house in the form of a poinsettia.

Erin Allmann Updyke Oh!

Erin Welsh Ooh.

Matt Candeias The spurge family is amazing and it's also extremely toxic in most cases.

Erin Allmann Updyke I know you can't let your cats eat poinsettia.

Matt Candeias Yeah, poinsettia gets overplayed as being toxic.

Erin Allmann Updyke Okay.

Matt Candeias For cats you definitely don't want them to eat it but your kid could make a mistake and be totally fine. So people freak out about it with their kids, poinsettias are fine. Most of the others aren't. The spurge family is huge, it's incredibly diverse and we could have a whole podcast probably devoted to just that. What I will say-

Erin Welsh Spurge.

Erin Allmann Updyke Spurge.

Matt Candeias The spurges.

Erin Welsh What does spurge mean?

Matt Candeias Oh no.

Erin Allmann Updyke Is it like a splurge, like it's such a fancy family?

Matt Candeias It might have something to do with the latex and the fact that you probably shouldn't eat them. Let me actually look that up right now.

Erin Allmann Updyke Erin always asks hard questions.

Erin Welsh I just love etymology.

Matt Candeias I'm really glad you did. Okay. So spurge happens to have Latin roots in the word 'expurgare' which means to cleanse or to purge which actually has roots in the fact that a lot of the toxic latexes from Euphorbiaceae, the spurge family, were used as purgatives.

Erin Allmann Updyke Oh!

Erin Welsh That's cool!

Matt Candeias Amazing. So in thinking about starting to do these crossover podcasts with you all, I thought that my role in all of this was to always come in and go, 'They just don't want to be eaten, this is the story of anti herbivory.' And in every instance I have fun learning that it's not that simple or straightforward. And in this case the story really comes down to seed dispersal.

Erin Welsh

Oh!

Erin Allmann Updyke

Yeah.

Erin Welsh

Oh! Okay. Cool, I'm excited for this.

Matt Candeias

(laughs) So Ricinus produces two types of flowers. There's the male flowers which actually kind of look like the alveoli of your lungs, they're just little tiny highly branched and they all end in little pockets of anthers that carry the pollen on the wind, hence the hay fever issue, this is a wind pollinated plant. And the female flowers have big, chunky ovaries that are covered in spikes and the stigmas stick out just enough to capture pollen on the breeze. And then afterwards the fertilization occurs, the ovaries swell into these big tick-like seeds, and they have this amazing primary dispersal syndrome that is turned ballistic. So the capsules dehisced to a point in which the tension just causes them to rip open along their seams and they catapult the little tick-like seeds out into the environment.

Erin Welsh

Oh.

Erin Allmann Updyke

Are these the ones that you can walk along and touch 'em and they poof?

Matt Candeias

It's not that much, you're thinking of the Impatiens. This isn't that intense but it's still enough to get these fairly large seeds a distance from the parent plant.

Erin Allmann Updyke

Okay.

Matt Candeias

Which when you think about it you don't want your children growing up in the same soil, they're gonna be competing for all of the same nutrients and needs that the parent plant are. So the farther they get away the better. But the parent plant has another trick up its sleeve. Now the reason this is a story of seed dispersal is because there is a preferred and optimum seed disperser for Ricinus.

Erin Allmann Updyke

Ooh, what is it?

Matt Candeias

Can you guess?

Erin Allmann Updyke

It's gotta be something that's not affected by...?

Matt Candeias

Potentially.

Erin Allmann Updyke

Is it a bird?

Matt Candeias

Uh uh.

Erin Allmann Updyke

Is it a lizard?

Matt Candeias

Uh uh.

Erin Welsh

Is it a small mammal of some sort?

Matt Candeias

It is not a mammal but it is small.

Erin Allmann Updyke

Is it a bug?

Matt Candeias

It is a bug. In the generic sense.

Erin Allmann Updyke

What?

Matt Candeias

The seed dispersers for ricin are ants.

Erin Allmann Updyke

No!

Matt Candeias

Yes. This is what we call a myrmecochorous species. "Myrmex" is the root word for ant and "cochory" is the root for dispersal. So ant-dispersed seeds.

Erin Allmann Updyke

Oh my god.

Matt Candeias

If you look at the weird little ticks, right where the tip narrows to the top of the actual seed you'll see this fleshy little structure. It's called an elaiosome, it's full of fats and proteins and it oftentimes will have chemicals that are very attractive to ants. If you wanna mimic this in the forest, all you need is some canned tuna.

Erin Allmann Updyke

Ew.

Matt Candeias

For some reason a lot of the proteins are the same, don't ask me why. It's disgusting to do myrmecochory experiments sometimes. But this brings up the question is why would you want something to disperse your seeds but also make your seeds so darn toxic?

Erin Allmann Updyke

Yeah.

Matt Candeias

It's to protect them so that only the ants are getting them. So they're big, they're fleshy, a lot of seeds are edible, it makes sense that animals would wanna eat them.

Erin Allmann Updyke

And isn't that part on the end, elaiosome, isn't that nutritious too?

Matt Candeias

Yeah so potentially all of it could be a nutritious meal and that's really bad if you want your seeds to germinate and grow into your offspring. So the biggest threats to seeds of this size come in the form of vertebrates. So evolution, through all of this selective pressure of seed predation has imbued these seeds with ricin to counteract any potential threat other than an ant taking seeds away.

Erin Allmann Updyke

That's amazing.

Erin Welsh

Wow.

Matt Candeias

Yeah, yeah. So this is truly like protect thine offspring, invest in the future.

Erin Allmann Updyke

And it's interesting cause when you think about it's gotta be expensive to produce toxins like this, right? So you think why would a tiny seed need something so potent and powerful that it can kill a full-grown human in just a couple of seeds? Cause plants produce a lot of seeds, they don't need all those seeds.

Matt Candeias: Yeah, exactly.

Erin Allmann Updyke: But to be able to kill a human with a few seeds, you're producing a really potent toxin. Why make something so strong?

Matt Candeias: Right. So say a plant, a mature plant would produce 50-100 seeds, a human would be dead within a few hours of eating 10 of those or any animal hypothetically speaking.

Erin Allmann Updyke: Yeah.

Matt Candeias: So make a few more than you need, make sure they're super toxic and you pretty much take care of all of the issues from that point on.

Erin Allmann Updyke: Oh my god.

Erin Welsh: Wow.

Matt Candeias: But ricin isn't alone in producing these proteins at all, in fact this is identical, nearly identical to the toxin produced by the aforementioned abrin, Abrus precatorius which is in the legume family, it's a Fabaceae, it's native to Asia.

Erin Allmann Updyke: That's the red one?

Matt Candeias: Those little red beads with the black spots that you see in jewelry. And they're beautiful but same deal, even just from people eating them but also the people that make those seeds, they're piercing them with needles and if it goes through the seed and into your finger, there's been instances of death or at least severe illness caused from the bead-making factory or companies I guess for that.

Erin Allmann Updyke: Oh my god.

Erin Welsh: Whoa.

Erin Allmann Updyke: Whoa.

Matt Candeias: Yeah.

Erin Welsh: I have a question real quick about these seeds in general. How much does the amount of toxin vary either within a plant or like latitudinally or geographically or anything like that?

Matt Candeias: Those are all incredible questions and I can't answer most of them. But I do know that the ricin content of an actual castor bean seed varies from about 1-10%.

Erin Welsh: Okay.

Erin Allmann Updyke: So like 1-10% of the mass of the seed is ricin?

Matt Candeias: I believe that's the case, yeah.

Erin Allmann Updyke

Dang!

Matt Candeias

Yeah, these are pretty potent.

Erin Allmann Updyke

Yeah.

Matt Candeias

And we talked a little bit earlier about being able to eat them and have them just pass through. So if you have an animal, and this varies especially within mammals and especially with birds, not everything chews and some things just have such large teeth that they're not going to do much damage to a smaller seed. This is a little hypothetical but a lot of the seeds that produce this ricin-like compound or protein similar to this can pass through your gut unharmed if they are not crushed. Crushing the seed destroys the seed but if it can pass through the gut unharmed then it can pass through the gut unharmed, that's not a real threat to this. So a lot of plants will make the seeds toxic but not the fleshy fruit around them. Obviously the elaiosome is totally fine for the ants themselves to consume, birds could hypothetically eat these seeds and pass them through unharmed.

Erin Allmann Updyke

Okay.

Matt Candeias

But it's the chewing, especially the mastication of mammals that they really wanna avoid because that's the end of that seed, any potential it might have had.

Erin Allmann Updyke

So could we just pop 'em like pills and be okay like on a dare?

Erin Welsh

I mean let's not.

Matt Candeias

That's a bored evening if you're resorting to that truth or dare. Yeah and so I love that these proteins have a specific affinity for animal cells because it just goes to show you that the proof is in the pudding. The plant - I'm putting big air quotes here - "knows" what it's trying to avoid.

Erin Allmann Updyke

Yeah.

Matt Candeias

And evolution does not do anything necessarily wasteful in that department when it comes to reproduction.

Erin Allmann Updyke

Fascinating.

Matt Candeias

Yeah.

Erin Welsh

That's so interesting.

Matt Candeias

Yeah. So I mean like you said 1-2 beans has been enough to kill especially smaller mammals. So you think about what's going around, chewing on this forest floor.

Erin Allmann Updyke

And these plants you could just like if we walked around the neighborhood could you show me these plants?

Matt Candeias

Oh yeah, I know a bunch of people around our neck of the woods here that have them in their garden.

Erin Allmann Updyke

Oh my gosh.

Matt Candeias

And the amazing part too is the plant itself isn't all that toxic, especially for a spurge. They do produce these they call 'em foliar phenolics but that's mostly just to get rid of the tiny little caterpillars and moths. There are some specialists that do eat the foliage itself but all of this comes down to ensuring the reproductive effort is conserved and more likely to make it to the next generation. So this one's all about sex for this plant.

Erin Allmann Updyke

Cool. I love it.

Erin Welsh

So you said it grows everywhere that the climate is right for it. What is that climate and is it more of an urban guy or a rural guy or anything and everything inbetween?

Matt Candeias

I think a disturbance lover really when it comes down to it.

Erin Welsh

Okay.

Matt Candeias

And that would make a lot of sense again, so many of the useful plant species that humans have stumbled across over the ages are plants that do well in disturbance, so edge habitat clearings, that sort of stuff. And so this plant is extremely visible on the landscape, it is gorgeous, that's the reason it's got such horticultural value nowadays. It's got these beautiful palmate leaves that get massive, oftentimes the whole plant itself is like a deep burgundy.

Erin Allmann Updyke

Ooh.

Matt Candeias

Yeah, it's a very attractive plant and it looks really exotic, like we mentioned that at the beginning. It truly looks like something that doesn't belong here. But despite hailing from what I would consider Mediterranean or scrubby, arid habitats, if you give it a warm enough season and good draining soil, it'll do well in most countries over the summer. It grows so fast as we mentioned that it does well in the gardens, you just treat it mostly like an annual in temperate climates. And going back to the mole plant name, turns out farmers used to just sprinkle seeds down into mole holes in hopes that a mole would eat one or two of them and that would take care of their mole problem.

Erin Welsh

(laughs) Did it work?

Matt Candeias

The thing with a lot of animals is they're not as dumb as humans are sometimes and tended, whether it's a sense they have, they can smell it or there's just an instinct there, I don't think it's an effective way to take care of your mole issue. But moles are eating pests, so you shouldn't be trying to kill moles. But I think this is another great edition to the devil garden that we have planned for the future.

Erin Welsh

Yes.

Erin Allmann Updyke

Yes!

Matt Candeias

Cause it's easy to grow, it's got a lot of impact visually.

Erin Allmann Updyke

We need a lot of visual impact in our devil garden.

Matt Candeias

And you've really gotta mess up big time to have it harm you. And that's another important message to drive home here is that's the upside of plants, they're sessile beings, they're not getting up and chasing you like a triffid.

Erin Allmann Updyke

Did you say like a triffid?

Matt Candeias

Like a triffid, yeah.

Erin Allmann Updyke

Are those the Dr. Seuss trees that move?

Matt Candeias

No, there's a whole wonderful science fiction book called 'The Day of the Triffids' and I highly recommend it to anyone listening right now, it is a charming scifi and I hope the apocalypse goes as well as that book makes it out to be.

Erin Allmann Updyke

Okay, I'm gonna have to read it.

Erin Welsh

(laughs) The dream apocalypse.

Matt Candeias

Yeah. This is a big call for people to just get to know the plants in your backyard. There's no reason this plant shouldn't be grown or enjoyed in an around the home, you just learn to not eat the seeds.

Erin Allmann Updyke

Yeah.

Matt Candeias

And plants aren't gonna get up and attack you, they're not for the most part setting off volatile compounds that are hurting you without you really having to come into contact here.

Erin Allmann Updyke

It's not The Happening or whatever.

Erin Welsh

Oh god.

Matt Candeias

Yeah, that's pretty far out in left field.

Erin Allmann Updyke

Oh fun!

Matt Candeias

Yeah, this was a cool journey down a road with a plant that I thought I knew.

Erin Allmann Updyke

Oh wow, what a fun episode.

Matt Candeias

Yeah. I love the rabbit holes I go down with you two. It's always a good time.

Erin Welsh

As long as it's not a mole hole-

Matt Candeias

Full of castor beans? (laughs)

Erin Welsh

Castor seeds waiting at the end. (laughs)

Matt Candeias

Well we're smart moles, now.

Erin Allmann Updyke

Yeah, we're smart moles.

Erin Welsh

I love this.

Matt Candeias

Yeah.

Erin Welsh

So I wanted to mention something back to the quarantini that I realized I completely didn't mention again but the whole Ticking Time Bomb aspect was the little waxy coated ball.

Erin Allmann Updyke

Oh yeah, that's what I guessed.

Matt Candeias

Okay.

Erin Allmann Updyke

But I guess you didn't say that out loud.

Erin Welsh

I just felt like I should connect the dots. Also a big shout out to Amanda who suggested that name. Thank you Amanda, I appreciate it.

Erin Allmann Updyke

Woo-woo.

Matt Candeias

Good job, Amanda.

Erin Allmann Updyke

That was fun.

Erin Welsh

That was great.

Matt Candeias

Yeah, thanks for having me.

Erin Welsh

I'm excited for our next crossover, whenever that is, whatever that is.

Erin Allmann Updyke

Oh yeah, we're gonna have a second one this season.

Matt Candeias

Okay, that works.

Erin Allmann Updyke

Yep.

Matt Candeias

Just let me know.

Erin Allmann Updyke

Sources?

Erin Welsh

Sources.

Matt Candeias

I've got those.

Erin Welsh: I read a few, I'll put all these on the website but I wanna shout out a couple in particular. One is by Martha Hale called 'Ricin-From Pharaohs to Bioterrorists and Beyond' and it was a really great overview of the history of ricin. And then there was the discussion of the autopsy that I mentioned and that was by R. Crompton called 'Georgi Markov: death in a pellet'. And then there was that book about the so-called ricin ring in the UK in 2003 called 'Ricin!' So we'll put all of these on the website and yeah. What do you guys got?

Matt Candeias: So I'll send you a more complete list but the three main papers I drew from for my contribution here were 'Plant defence against herbivory and insect adaptations' by War et al; 'General mechanisms of plant defense and plant toxins' by Mithöfer and Maffei, I apologize if I butchered that one, and 'Seed Elaiosome Mediates Dispersal by Ants and Impacts Germination in Ricinus communis' by Sasidharan and Venkatesan et al.

Erin Allmann Updyke: Awesome. I have a number of papers on the sort of toxicology and clinical aspects of ricin. That paper that I found on toxin being used as an antitumor agent is by Diaz et al from 2018 and then there's another review from 2015 just about the status of ricin as an antitumor agent. All of our sources from every episode, a complete list is posted on our website at thispodcastwillkillyou.com under the EPISODES tab.

Erin Welsh: Thanks to Bloodmobile for providing the music for this episode and all of our episodes.

Erin Allmann Updyke: And thank you to Matt for coming on as a guest, we love having you, it's the most fun.

Matt Candeias: Thank you both for having me, it is always a pleasure to be here. Find me on Twitter and Instagram.

Erin Allmann Updyke: Yeah, if you don't already listen to In Defense of Plants you should definitely check it out.

Erin Welsh: What are your handles, Matt?

Matt Candeias: All of them are @indefenseofplants if you just google it you will find it, I promise.

Erin Welsh: There you go, Google's our friend.

Matt Candeias: Yeah.

Erin Welsh: Thank you also to all of you listeners out there listening to us ramble on about-

Erin Allmann Updyke: All the things.

Erin Welsh: Things that could kill you.

Matt Candeias: Yep.

Erin Welsh: We love doing it and you let us keep doing it. So yay, thank you.

Matt Candeias: Can I just say that you have managed to cultivate such an incredible fan base? I absolutely adore hearing from them, they always reach out and tell me that they love everything that they've learned from us and they want us to keep doing it, it is so nice to hear from your fans, they're very nice people.

Erin Welsh

Aw, also nice you said the word 'cultivate'. (laughs) Wink.

Matt Candeias

I keep doing that on my own shows, I keep saying 'no pun intended'. I gotta just stop, embrace it. Lean in.

Erin Welsh

Well with that, wash your hands.

Erin Allmann Updyke

You filthy animals!

Matt Candeias

Don't eat those seeds.